THE USE OF CHILD HEALTH COMPUTING SYSTEMS IN PRIMARY PREVENTIVE CARE: AN EVALUATION

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by

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Dedication of the Thesis

To my wife, Lei, for the love and support
To my daughter, Anna, for the inspiration
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ABSTRACT

This study was undertaken in 10 districts, 5 in North East and 5 in North West Thames. The study subjects comprised a three month birth cohort (n=7841) born between January and March 1990 followed to age 19 to 21 months, and health visitors (n=340), child health managers (n=10) and computing system operating staff (n=68). The study 1) examined the quality of data available in the computing systems, 2) assessed the attitudes of health professionals to the computing systems and relevant aspects of child health services, and 3) evaluated the performance of pre-school immunisation and health surveillance programmes, using computing system data.

In general, data in the computing system were considered accurate, up-to-date and (in terms of what was collected) complete. Certain problems were identified, especially regarding mobile children and families, where information was likely to be missing. As well as limitations in data transfer between localities/systems when children moved, poor standardisation of recording information was identified as a major shortcoming.

Child health managers and system operating staff were satisfied with their presently used computing system in terms of facilitating the organisation of child health activities. However, most health visitors were more or less unsatisfied with the efficiency of the present system. Less than optimal communication between health professionals/localities, poor training of staff and incompatibilities between different computing systems were thought to be the most important factors affecting the performance of the child health systems. The results showed that running more health clinic sessions did not necessarily increase uptake of child health services.

Uptake of immunisations had not met the 90% target in general for this three month birth cohort by the age of 19 to 21 months. Wide variation in uptake was found between groups of children, and cover rates were unacceptably low in certain sections of the child population. By and large, five risk factors were identified for low uptake of immunisations: living in a high deprived inner city district, being “allocated” to an immunisation location other than a general practitioner surgery, moving between districts, living with one parent and living in a larger family. Similar factors influenced surveillance uptake except that children registered to attend general practice were less likely to complete the programme. Variations were found across the study districts in terms of content of health checks at the two target surveillance ages, and the productivity of hearing assessments at six weeks and eight months was low.

Child health computing systems are an important data source; although basically introduced for service, management and financial purposes they provide new epidemiological and research possibilities. Compared with those from “one-off” ad hoc epidemiological surveys, data stored in the systems are routinely collected, and therefore are available at no extra cost. The systems provide ongoing data allowing cross-sectional and longitudinal analyses and, particularly, if standardised and complete data variables can be collected routinely, provide opportunities for ongoing assessments of factors influencing uptake of services. Rapid feedback about the performance of preventive child health activities so allowing for rapid action can then be undertaken to improve uptake of child health services, so completing the research-audit-service loop.
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1.0 PREVIEW

This chapter aims to present a brief review of the functions of computerised child health system and the rationale for this study, followed by the aims and objectives of the project and an outline of the structure of this thesis.

1.1 MAIN FUNCTIONS OF A CHILD HEALTH COMPUTING SYSTEM

Almost 30 years ago the West Sussex County Health Department introduced a computer system for scheduling immunisation appointments for pre-school children [Galloway, 1963]. The system has proved to be efficient and cost effective [Saunders, 1970]. This pilot work was taken up sooner or later by a number of other health authorities and general practices throughout this country. By 1983 child health systems had been computerised in 60% of districts in England and Wales and in three health boards in Scotland [Walker, 1983], and almost all district health authorities or health boards in this country had introduced computers into their routine child health activities by the year 1990 [Ross and Begg, 1991].

Broadly speaking, the aims of developing and using a computerised child health system are three fold: (1) to facilitate the scheduling and recording of preventive child health activities, (2) to provide local statistics on preventive child health services and to provide a data base for regional and national statistics on the services, and (3) to provide a population based data set for clinical, management and epidemiological assessment of the performance of preventive child health services [Child Health Computing Committee (CHCC), 1983; Horne and Roy, 1988; Ross and Begg, 1991]. A child health computing system meets these aims through different modules developed for various parts of child health activities. So far, three main modules have been developed and are used in most districts, and other modules are under development or being piloted in some districts [CHCC, 1983; Horne and Roy, 1988; Ross and Begg, 1991]. The three major modules are child register, vaccination and immunisation, and pre-school.

Child register module

The Child Register is aimed at being a 100% record of all children resident within a health district [CHCC, 1983; Horne and Roy, 1988]. It is the core database for other modules of the system. Statute requires notification of birth to be completed within 48 to 72 hours by a professional who attends the birth, usually the midwife. One copy of the Notification of Birth is sent to the district health authority or relevant provider unit. In districts where a system with "batch" processing mode is used the information is checked and coded by the clerical staff in
the district community health services, and sent by them to the regional computer centre to add to the Child Register. Whereas in districts using a system with “on-line” processing mode the information on the Notification of Birth needs not be re-coded, and data are entered onto the system directly through the computer terminals installed in the district child health offices. (The two types of computing system will be discussed in the next chapter.)

Information for registration can also include data from the Neonatal Discharge Form which paediatric staff complete. Birth data can be transferred from computerised maternity systems as well, e.g., the hospital Patient Administration System (PAS), to child health systems in those districts where linkage has been established. Information is also exchanged with the local Registrar of Births, Deaths and Marriages, to ensure completeness and to check accuracy.

If a child is born outside the health district in which his or her mother is normally resident, the authority in which the child is born produces a notification called a Transfer In, which is sent to the home authority. This is similar to the Notification of Birth Form and is handled in much the same way.

When a child moves into a district from elsewhere subsequent to the birth notification, the previous authority sends to the new responsible district a Movement In Form on which details of the child are recorded. Sometimes the child health system is informed by the newly involved health visitor of a movement-in child and the new authority sends a request to the previous authority for the child’s details. This is similar to the Transfer In Form, but also includes information about events since birth. It is the responsibility of the original district health authority to notify the new resident district of any child who transfers between them.

If a child dies the record will be closed, preferably by the health visitor informing clerical staff, or failing this, by receiving a copy of the Registrar’s return.

Once the child is entered on the Child Register based on the above-mentioned sources of information the health visitor is sent a labelled record card or form for her own use.

For this computer module and all subsequent modules, every effort is made to ensure correct and up-to-date information.

**Vaccination and immunisation module**

This module provides information to ensure that all children on the register attend the immunisation centre of their parents’ (or guardian’s) choice for immunisations when they are due [CHCC, 1983; Horne and Roy, 1988]. The health visitor asks the parents or guardian to sign an Immunisation Consent Form and to indicate the preference for the immunisations to be done at a health clinic or by the general practitioner. The preferred location for immunisations is called the treatment centre or immunisation centre.

The health visitor returns this consent form to the district community child health office, where it is matched with immunisation centre details that are stored as a system file. The computer records are then scanned regularly and immunisation appointments are sent to all pre-school
children in line with the schedules adopted by each health authority and the age of the child. Invitations are automatically produced on postcards. These cards may be sent directly to the parents or guardian, or sent through the general practitioner or clinic. When a child attends the immunisation session and is vaccinated as appointed the information recorded on an Immunisation Return is sent to the child health office. Reasons for failure of a child to be vaccinated are also recorded and returned to the office. General practitioners' payments usually depend on this return.

If a child does not attend—the information is normally available in the Immunisation Return—a second appointment is made and another invitation sent. If the child still fails to attend without any explanation, the system will advise the health visitor who can then do a follow up visit to the child. When a child attends an immunisation centre uninvited, the doctor or other appropriate staff member completes an Unscheduled Immunisation Form and the computer is informed, so that records can be kept up to date.

**Pre-school module**

The Pre-school module operates in a very similar way to the vaccination and immunisation module to schedule the appointments for and to record the information about child health surveillance for pre-school children [CHCC, 1983; Home and Roy, 1988].

Figure 1.1 illustrates the functional mechanism of the child register and vaccination and immunisation modules of child health computer systems. The functions of other modules developed for various purposes of child health activities, e.g., pre-school module, school health module, special needs module, management module and statistical packages, are based on the Child Register.

### 1.2 RATIONALE FOR THIS STUDY

Computers are now accepted as a principal form of health record-keeping, an efficient mechanism for scheduling immunisation and health surveillance procedures for children, and a quick and powerful tool for the identification of defaulters of the services. The use of computers has been claimed to be successful in delivery of child health services [Galloway, 1966; Bussey and Holmes, 1977; Bussey and Harris, 1979; Kelly, 1988]. However, the suggestion that computer systems be universally applied not only presented opportunities for development but also raised concern about possible problems. Among other things [Rigby, 1982], the accuracy of data has been one of the main problems identified in records held in child health computer systems [Rawson, 1980; Scott, 1990; Jefferies et al., 1991]. Previous studies on the accuracy of computer data were primarily evaluating the standard National Child Health computer System (NCHS) which initially used “batch” processing for entry and retrieval of data [Walker, 1980]. Dissatisfaction about delays associated with batch processing and concerns about data accuracy in NCHS were factors which triggered some regional health authorities to move from the national system and develop their own systems [O’Brien, 1986].
Figure 1.1—A diagram showing the functional mechanism of child health computer systems
In 1988 the Regional Computer Centre of North East Thames (NET) Regional Health Authority began to develop a new child health computer system [Home and Roy, 1988]. Districts within the authority started using the new system from late 1988. By the end of 1989 the new system called the Regional Interactive Child Health System (RICHS) had completely replaced the previous systems used, mainly the NCHS, in all but three districts that joined the new scheme in late 1990 [(NET) Regional Computer Centre (RCC) report, 1990]. RICHS functions in much the same way as the NCHS, but uses an “on-line” processing mode, i.e., the system operates in a more decentralised manner than the national system—with data entry and retrieval facilities available for each of the district users.

A small scale evaluation project was undertaken in Islington, a regional pilot district, to evaluate the performance of RICHS, and identified many errors in coding, a lot of missing information and an overall disappointingly low uptake of surveillance in that population [Alberman and Peckham, unpublished report, 1989]. This study provided important insights into the difficulties facing districts, especially deprived inner city districts, in providing an adequate preventive service for the childhood population. Although such an ad hoc study is very useful, it was limited in scale, and comprehensive recommendations were unable to be made. Therefore, there seemed a need for deeper and more consistent evaluation of present activities, and to investigate the usefulness of presently collected data for clinical, management and epidemiological purposes, on a wider district and regional basis.

The usefulness of child health computer systems in recording data about individual children is well documented [Walker, 1983; Riley et al, 1991; Ross and Begg, 1991], and similarly in scheduling appointments, identifying defaulters, and routinely producing aggregated local statistical information on child health services [CHCC, 1983; 1987; Horne and Roy, 1988]. In addition, child health computer systems also allow for routine collection of a variety of data on individual children, their mothers and possibly their families. Such data held in the systems are likely to be of use in answering service management questions such as “which children are less likely to utilise health services”, “what are their characteristics” and “what changes could be made to the services in order to achieve policy objectives of higher levels of service uptake”. These questions are of particular importance in the current situation where uptake of child health services in some parts of this country remains disappointingly low, especially in inner city areas, where, for example, immunisation uptake remains below the 90% targets set by the World Health Organisation (WHO) [Begg and Noah, 1985].

The use of a computerised child health system is by no means confined to making appointments for health care activities, recording the information and producing simple statistics on the activities. One of the objectives of such a system has been to provide a comprehensive and accurate data base for continuous evaluation of the performance of child health services, i.e., to provide routine data for epidemiological assessment of child health activities [CHCC, 1983; 1987; Horne and Roy, 1988]. However, the epidemiological potential of the data held in child health computer systems has been barely considered, particularly in the assessment of performance in preventive child health care, e.g., uptakes of immunisation and surveillance programmes [Scrivens, 1984]. Underlying “causes” of problems in uptake of the preventive health care are often multifactorial and usually require population based information to provide
insights into the "causal" mechanisms [Royal College of Physicians of London (RCP), 1991]. There is no doubt that these mechanisms can be investigated by well-designed \textit{ad hoc} epidemiological surveys. However, compared with using routinely collected data, specific, and usually "one off" epidemiological surveys are likely to be more costly, and to provide slower feed back to the health service providers, hence intervention strategies are less likely to rapidly follow.

Any child health computer system is designed for health workers to use to serve the child population, and should provide easy and user-friendly facilities for the management of child health information. Therefore, the systems should facilitate the collection, recording and forwarding of child health information. More importantly, the development and use of computer systems should improve the exchange of the information between health professionals, which has been considered as a key element in ensuring the effectiveness and efficiency of provision of child health services [Morris \textit{et al.,} 1988]. All information required by child health computer systems for their optimal functions is collected and forwarded to a computer office, i.e., the district child health department, by health workers providing child health services at a "grass-roots" level, e.g., at a general practice, a health clinic, or a hospital. The information collected by field health workers is usually entered into the computer system by staff specifically employed to deal with the editing of computer data, i.e., by computer operating staff. Theoretically, the work load on all these relevant staff, mainly in their handling of health records, would be lessened by computers. On the other hand, these staff are the users of child health computer systems which provide the information the staff need for their daily child health activities. A good child health system should provide staff with the required information as accurately as possible. There seems no doubt that the attitudes to, enthusiasm for and knowledge about child health computer systems of information providers, operators and users of those systems would have a great impact on the system performance [Newman, 1983]. The attitudes, enthusiasm and knowledge of the staff, in turn, would depend very much upon the extent to which they were properly trained in using the system, as well as upon the design \textit{per se}.

Even though almost three decades have passed since the first computerised child health system was introduced in this country and almost all districts now use computers in their child health activities, there seems to have been no evaluation studies to assess the opinion of staff working with the systems. Such evaluation seemed likely to provide useful information to improve the efficient utilisation and the quality of data held in the computer systems.

These points prompted me to undertake this study. Access to data held on child health computer systems in certain districts of NET and North West Thames (NWT) regions and the cooperation of relevant staff in those districts provided an opportunity to explore the potential of computer system records in the evaluation of aspects relevant to the performance of child health services, and to assess the opinion of health professionals about child health computer systems.
1.3 AIMS AND OBJECTIVES OF THE STUDY

The intentions of this study were to examine the extent to which child health records held in the computer systems were accurate and complete for comprehensive use as well as in the provision of aggregated health service statistics, and to investigate the performance of immunisation and health surveillance for pre-school children with the aim of providing recommendations

1) to improve the quality of child health computer system data for more efficient use; and

2) to improve the performance of immunisation and health surveillance for pre-school children.

To achieve these two general aims the following specific objectives were set:

1) to examine the extent to which child health computer records were complete;

2) wherever possible, to examine the consistency of child health system records with the registers of the relevant Family Health Services Authority (FHSA);

3) to investigate uptakes of immunisation and health surveillance and their variation;

4) to test or re-test hypotheses that certain factors are associated with uptakes of immunisation and health surveillance;

5) to evaluate the attitudes of health professionals to the performance of child health computer systems; including child health managers, health visitors and clerical staff working directly with child health computing systems, i.e., computer system operating staff; and

6) to compare performance outcomes of and attitudes of health professionals to NCHS and RICH systems.

1.4 STRUCTURE OF THE DISSERTATION

This dissertation, comprising nine chapters, aims to present the basis and results of the research project and to discuss relevant issues. Each chapter begins with a preview which summarises the aims of the chapter followed by applicable methods, results, discussion, summary and recommendations.

Chapter One, the present chapter, comprises a general introduction to the project, including a brief review of the functional mechanisms of a child health computing system, the rationale for this study and a description of the structure of the thesis.

Chapter Two is devoted to a review of the literature on the topics relevant to the areas concerned in this study, including the development and progress of the computerisation of child health system in this country, and the current situation of immunisation and health surveillance
PROGRAMMES FOR BRITISH PRE-SCHOOL CHILDREN.

Chapter Three describes the detailed design of the project, including the study subjects, general points of study methodology and procedures.

The main results are presented in Chapters Four, Five, Six and Seven. In each of these chapters, specific methods, not covered in Chapter Three, are introduced, the findings obtained from collected data are presented, followed by discussion with explanation and implications of the findings.

Chapter Eight comprises a theoretical consideration of the study design per se, including discussion of possible bias, limitations of the design and of the statistical methods used in the study, together with the implications of the results obtained from statistical analysis. In this chapter, some topics which have not been tackled in this study and which need future study are discussed.

Summarised results and conclusions of the project are drawn in Chapter Nine, together with recommendations made from the findings.

References quoted in this thesis are listed in alphabetic order by author(s) in the References section; these do not include personal communications which are quoted in the text.

Listed in Appendices are a list of tables and figures, copies of the questionnaires for child health managers, health visitors and computer system operating staff, which were used as tools to collect the relevant data. Publications during the study period—by-products of this project—are also appended.
2.0 PREVIEW

Since computers were first introduced into the childhood immunisation programme in West Sussex County some thirty years ago, tremendous progress has been made in developing and exploring the potential of computer-assisted child health systems in Great Britain. Almost all district health authorities in this country now have computerised child health systems. Computers are playing a very important part in facilitating child health record-keeping and in promoting health services for children. The use of computers in routine child health activities has proved to be efficient in the management of child health data. Encouraging outcomes in many fields of preventive child health care have been reported to be associated with computerisation which is believed to be cost-effective. However, child health computer systems do, at present, have their unsolved problems. Efforts are being made to overcome these problems in order to maximise the multi-functional power of computers in the facilitation of preventive child health activities.

Immunisation and health surveillance comprise the two major parts of preventive child health care activities. Although the cost-effectiveness of some health surveillance programmes in Great Britain needs to be evaluated to ascertain their benefit, routine immunisation procedures provided for all eligible children have, there is no doubt, proved very effective in markedly reducing the incidence of the communicable diseases immunised against; there is clear evidence, worldwide, demonstrating that the decline in the incidence of major childhood infectious diseases, e.g., whooping cough, measles, diphtheria and tuberculosis, has been attributable in large part to the introduction of effective vaccines against these diseases. Countless young lives have been saved and millions of disabilities and handicaps have been prevented. Despite the acknowledged benefit of immunisations and targets for immunisation uptake being set in this country, Britain's performance in achieving a high uptake of immunisations was for many years less satisfactory than many other Western countries. Studies have identified some factors associated with low uptake of immunisation procedures.

In recent years, pre-school health surveillance programmes have received much attention particularly as more general practitioners have committed themselves to the pre-school surveillance programmes. Some parts of the prevention programme, e.g., procedures for the early detection of certain disorders such as pre-symptomatic phenylketonuria and hypothyroidism have proven their benefit. However, many surveillance procedures require to have their effectiveness proved, particularly in relation to their costs.

This chapter aims to review the literature on the computerisation of child health systems in this country and on the current situation regarding immunisation and health surveillance program-
mes for pre-school children, with the main focus on the uptake rates of immunisations and factors associated with low uptake, and a discussion on certainty and uncertainty about pre-school health surveillance programmes.

### 2.1 COMPUTERISATION OF CHILD HEALTH SYSTEMS

#### 2.1.1 Development and progress

Despite a long history of computer science and technology it was not until the early 1960s that computers were introduced into preventive child health services in Britain. In late 1962 the County Medical Officer of Health in West Sussex County Council took the opportunity to computerise the local child register and recall system for vaccination and immunisation when the County Council installed a data processing system [Galloway, 1963]. This earliest computerised child health system recorded the basic information, i.e., the name, address and date of birth of children, details of the general practitioner (GP) or county health clinic, immunisation session time in GP surgery or clinic, immunisation schedules and migration of children between GPs or clinics. Based on this key information the system produced monthly, for every clinic and participating GP, a list of children due for immunisation procedures and the time of appointment, and an invitation card with details of the date, time and place of the appointment for each child due for the immunisation procedure. The system was also able to generate the amount of fees due to doctors for the services provided, and to prepare statistics on immunisation uptake rates.

This successful pioneer work was subsequently copied by other local health authorities [Francis, 1968; Adams, 1977; Bussey and Holmes, 1977; Farries, 1977; Williams, 1977; Sutherland and Young, 1978]. Some individual general practices and child health clinics also introduced computer-assisted systems into their child health activities either by participating in the general computer assistance scheme of the health authority [Galloway, 1966] or by developing their own systems [Polnay and Elphick, 1984; Kelly, 1988].

In the mid-1970s the Department of Health and Social Security (DHSS) commissioned for the design of a computer system for health care for children and this became the national Child Health System (NCHS) which was produced by the Welsh Health Common Services Authority on behalf of the National Health Service (NHS). The system was developed during 1974 and early 1975. During the latter half of 1975 and into 1976 it was on trial in ten Area Health Authorities [CHCC, 1983]. Two modules (child register and vaccination & immunisation) were generally available in the system and were operating in 60% of district health authorities in England and Wales and in three health boards in Scotland by the year 1983 [Walker, 1983]. In addition to the child registration and vaccination and immunisation modules, the pre-school (for health surveillance of pre-school children) and school health (for health surveillance of school-age children) modules of NCHS were subsequently developed and running live in some district health authorities by 1987. By 1991, this national computer system was being used by 138 of the 199 districts in England and Wales and all four health boards in Northern Ireland [Ross and
Begg, 1991]. Meanwhile, some health authorities had gone it alone and developed their own computing systems, e.g., the NET region [Horne and Roy, 1988], in part because of dissatisfactions with available systems.

2.1.2 Outcomes and costs

**Efficiency**
Positive outcomes have been reported to be associated with the computerisation of child health systems [Galloway, 1966]. But one of the chief characteristics of a computer-assisted system is its efficiency. The computer eliminates the hand-sorting of records, manual preparation of appointment lists and the writing of appointment cards. In a manual system a great deal of administrative, clerical and professional time and skills is consumed in maintaining a child register and immunisation recall scheme, and work is usually laborious and complicated but essentially repetitive. By diminishing or even removing these time-consuming tasks, the computer is able to free valuable staff time and professional skills for other health activities such as health education for at-risk groups.

**Immunisation outcomes**
It has been claimed that computer-assisted systems improved immunisation uptake rates [Bussey and Holmes, 1978]. According to a West Sussex report, the immunisation/vaccination indices in the county were roughly the same as the national rates before the introduction of computer-assisted arrangements. Between 1962 and 1968 the indices in West Sussex steadily improved to the point where they exceeded those for England and Wales by 16% for diphtheria immunisation and 47% for smallpox vaccination [Saunders, 1970]. In 1974 - 1976 the national decline in pertussis immunisation rates was accompanied by a “ripple effect” producing a national decline in uptake rates for other primary immunisations; this “ripple effect”, however, did not occur in West Sussex [Bussey and Holmes, 1977], nor in two other local authorities—the West Riding of Yorkshire and Durham, that were using computer-assisted schemes [Williams, 1977; Sutherland and Young, 1978].

A similar improvement in immunisation uptake rates after the computerisation of child health systems has also been demonstrated in some individual general practices. Kelly [1988] compared the uptake rates before and after the introduction of a microcomputer into the immunisation clinic of his general practice and demonstrated a steady increase in uptake of pertussis immunisation, rising from 43% in 1980 to 82.5% in 1986.

More convincing evidence of the positive effect of computers on childhood immunisation rates was the results reported by Newman [1983]. In 1974 a number of practices withdrew from a computerised scheme. Those practices that remained in the scheme maintained the previous high levels of immunisation uptake, while those which opted out showed a decline in uptake rates.

One of the immediate outcomes of increasing immunisation/vaccination indices associated with the computerisation of child health systems was a decrease in the incidence of notified measles. In England and Wales, the incidence fell more rapidly in computer serviced populations than in
non-computer serviced populations between 1971 and 1976 [Bussey and Harris, 1979] (Figure 2.1). This difference was statistically significant, and remained so even when the urban and rural components of the populations were examined separately. Bussey and Harris concluded in their paper that it seemed reasonable to infer that computer assistance contributed to the low incidence of measles in the computer serviced population. They further estimated that had the mean rate of notification for the computer population been achieved in England and Wales as a whole, approximately 144,000 notified cases (with 140 cases of measles encephalitis) would have been prevented and 142 deaths from measles reported in the years 1971 - 1976 might not have occurred.

It seems possible that the improvement in immunity indices related to the more efficient system of call and recall, and the ability of a computer rapidly to identify defaulters. However, not all districts with a computerised child health system have experienced such an improvement in immunisation uptake rates. In Rotherham, for instance, the part of the area serviced by a computerised system experienced a decline in uptake rates for primary immunisations between 1974 and 1976, whereas uptake rates rose in the manually serviced sector [Adams, 1977]. In Bolton, no improvement in immunisation/vaccination indices was noted in the eight years following the introduction of a computerised child health system [Farries, 1977].

These contradictory results regarding the effectiveness of computerisation are likely to be associated with other factors, apart from computer assistance, which also affect immunisation rates, such as the enthusiasm of the health professionals, the socio-economic status of the population serviced and the presence and absence of health education programmes. The factors influencing uptake of immunisations will be discussed in greater detail later in this chapter.
**Information feedback to users**

Computerised child health systems are able to produce large amounts of comprehensive, up-to-date information for feedback to the computer users. This information, which is required by individual general practitioners, health visitors and child health clinics, as well as for demographic statistics, is produced and fed back regularly or is available as a standard request from the statistics package of child health systems [CHCC, 1987; Home, 1990]. The statistical information currently available can be categorised into the following groups:

- Statistics of children who were born, resident or treated in the district;
- Changes to the above child population;
- Statistical profiles of birth data for resident children;
- Congenital malformations and other selected factors for resident children or children born in the district;
- Patterns of immunisation consent;
- Immunisation statistics;
- Health surveillance statistics;
- School health statistics including those for special education needs.

As well as the specific programmes available in some child health computer systems [Homer-sham, 1990], data can be extracted for more complicated and comprehensive analysis as in the present study.

**Costs**

Studies on this topic seem to have been scanty. In a detailed assessment of the cost of the first five years (1963 - 1968) of the West Sussex computerised immunisation scheme, Saunders [1970] demonstrated that by 1968 the cost was considerably lower than the national average for servicing immunisation programmes. In the report the expenditure per completed procedure (unit cost) rather than the expenditure per 1,000 population was estimated, because unit costs allowed for the fact that higher immunisation rates would result in higher costs. Saunders assessed the saving in local-authority, executive-council and general practitioner clerical work, and concluded that the unit cost of the West Sussex scheme was 2s. less than that of England and Wales (3s. 6d. compared with 5s. 6d.). It was estimated in the paper that if the scheme was introduced nationally there could be a reduction of about £753,000 per year in the cost of immunisation in childhood.

There are claims for additional cost savings relating to the removal of the need for conventional health education, a reduction in staff and storage space used for manual records, and the simplification and centralisation of administration [Galloway, 1966].

However, against these claimed savings must be set the considerable time and effort expended in changing from a manual system to a computerised one, particularly in retraining. The initiation of new systems and retraining of staff is expensive [Walker, 1982]. Unfortunately, there is minimal information available on the cost-effectiveness of present child health computer systems in this country.
2.1.3 Problems and future possibilities

**Flexibility**

The early computerised child health systems had the advantage of being flexible. Changes in the approved schedule of procedures could be easily introduced. Unscheduled appointments and the migration of patients between doctors within the county could be dealt with without difficulty [Galloway, 1963; 1966]. However, one of the major criticisms of the later introduced NCHS which is presently being used in most health districts, is its lack of flexibility [Rigby, 1982]. This criticism relates to the system being initially designed to operate in "batch" processing mode. The system was centralised in the regional health authority computer centre, and operated batch by batch with no remote data capture facilities, i.e., district users did not have direct input or output access to the data through computer terminals. The Derbyshire study found batch processing to be inflexible; there were problems fitting it to the practical working of health visitors, resulting in inefficiencies and delays [Hopton et al., 1982].

The "on-line" systems, that usually operate in a more decentralised form with computer terminals available in user sites, are likely to overcome most of these difficulties [Walker, 1980]. The types of system will be discussed in more detail in Section 2.1.4.

**Quality of data**

Some computer systems claimed to produce accurate and up-to-date information which could be retrieved and fed back to users for different purposes [Galloway, 1963; 1966; Riley et al, 1991]. In their article Riley and colleagues [1991] stated that "effectively, the (computerised) child health data were shown to provide sufficiently accurate information for our needs". Williams and Dajda [1980] were also in favour of child health computer data "provided that sufficient time is allowed for the relevant information to reach the computer". Statistical data derived from computerised child health systems have been the main source of local and national statistics for child health services, notably immunisation uptake rates [Begg et al, 1987].

On the other hand, some studies have looked at the quality of data available from the computerised child health systems, and cast some doubts on its validity [Rawson et al, 1980; Davison et al, 1981; Scott, 1990; Jefferies et al., 1991; Rao, 1992]. Scott [1990] found in a retrospective survey that of children recorded in the child health system as not being fully vaccinated, 46% had already received their immunisations and only 2.5% were confirmed definitely not vaccinated. Jefferies and colleagues [1991] also identified some inaccuracies of the child health data held in the computer system.

It seems likely that quality of data is a problem with both manual and computerised child health systems, although there might be some specific problems which apply to computer systems. A common problem experienced by computer system users has been the difficulty of keeping track of changes of name and address which often happen during the first years of a child's life. For instance, in Hampstead Health District, 25% of children change their addresses during the first year of life, and five per cent their surname; about 20% of children change their surname between birth registration and the pre-school booster [Olsen, 1989]. Such a high child population turnover imposes great challenges to the updating and accuracy of computerised
data, particularly when the system is operated in batch processing mode [Walker, 1980; Hopton et al., 1982; Rigby, 1982]. The completeness of computerised data was not found to be a problem with respect to the child register in the Derbyshire study [Hopton, 1982].

**Future possibilities**

Most district health authorities in England and Wales are now running live on child register, vaccination and immunisation and pre-school modules of a child health computer system. Other modules are available and are being used in some districts, or will be available in the future. Examples are school health, special needs and data management modules [Homersham, 1990; Horne, 1990; Ross and Begg, 1991].

Recently, there has been discussion on some aspects of child health computer systems, especially the NCHS; some of the topics are political rather than technical [Walker, 1982; Aylett et al., 1991; Ross and Begg, 1991]. It has been recognised by most health professionals that computer systems will become the principal form of health record keeping in the future. It is also generally accepted that, on balance, there are benefits from using computers in the provision of child health services. The question debated is, therefore, not whether computers should be used but how they can be used properly in order to maximize the potential and to ensure the most cost-effective performance of the systems.

Hewett [1991] criticised the national system for being centralised and unresponsive to local needs and suggested that "all call and recall functions are managed locally by general practitioners and not imposed centrally by the district health authority". However, as Ross and Begg [1991] argued, such a policy might not be realistic, at least at the present stage, since most local users do not have the resources to develop their own systems. Also, much child care is provided in hospitals and by community services as well as in general practice, and migration turnover is high especially in inner city areas. It would be very difficult and probably impossible to co-ordinate a child health service with individual, generally incompatible, computer systems operating in many different premises. It is unlikely that information held in these separately operated systems would be adequately shared between professionals [Walker, 1980]. It seems, therefore, that some centralisation is required with a "difficult" child health computer providing accurate and up-to-date information for local management of services as well as comprehensive and reliable data for the epidemiological assessment of child care activities. Meanwhile, the system should also provide correct information for the purposes of GP payments for child health services [Ross and Begg, 1991].

A new more flexible version of the NCHS has been developed and has been operational in some local health authorities since late 1990. This new version allows increased local flexibility while retaining the financial advantage of sharing the heavy development costs among user districts [Ross and Begg, 1991].

Child health services involve a multi-disciplinary group of professionals, e.g., community paediatricians and clinical medical officers, general practitioners, health visitors, community nurses, sometimes hospital medical staff and other child health workers. It has been noted that information flow between these professionals is often sub-optimal [Morris et al., 1988; Aylett et
This poor communication is likely to have serious effects on the provision of child health services. An important deficiency relates to communication between District Health Authority (DHA) and Family Health Services Authority (FHSA) child registers. Some steps have been taken to deal with the problem. The development of electronic links between child health and FHSA’s systems is presently being piloted in Stockport and Avon [Ross and Begg, 1991] and in some NET districts [Home, 1990; Homersham, personal communication, 1991]. Future developments will include a single register (probably the FHSA) and direct linkage to general practitioners’ microcomputers.

Linkage between child health systems and hospital computer systems such as the PAS has already been established in some district health authorities and proved successful (See Chapter Four). Work is also in progress to link the child health systems to community nursing systems such as COMCARE and COMWAY, which log health visitors’ visits and other community work [Home, 1990; Ross and Begg, 1991]. The child health systems are being further developed to record activities like neonatal biochemical screening, a growth monitoring programme, special needs, especially those related to children’s education, social services “needs” related to the Children Act 1989, and computerised parent held records. Some of these functions are already available in some child health computer systems [Home, 1990]. There is also a strong case for extending the child health systems to provide a total community register for recording health care events in adults (such as cervical and breast cancer screening) [Ross and Begg, 1991].

2.1.4 “Batch” versus “on-line” processing

Generally speaking, child health computing systems can be grouped into two types: systems with “batch” and those with “on-line” processing mode as defined by Walker [1980].

Although the purpose of the two types of processing mode is broadly the same—to facilitate the accurate recording and retrieval of health records for child health activities, they differ in several important respects. The essential difference is that with batch processing, written information is sent to a central service, normally the regional computer centre, for conversion to computer language for processing, i.e., “raw” data in the form of documents completed by hand, in itself a transcription exercise, are sent to a data preparation facility where non-medical staff, quite often contract staff, must read, understand and transcribe that information into a format which can be understood by the computer. Whereas on-line systems individual users can enter and retrieve the information using his or her own keyboard and visual display unit (VDU), i.e., no transcription of information is necessary, and no person need be involved other than those responsible for the authorship and filing of that information. Data entry and retrieval take place at the user level for the on-line systems and at central level for the batch systems, and there may be no electronic connection between users and central facilities in some districts set up for batch systems.

In a review of these two types of processing system, Walker [1980] explored the relative merits and disadvantages of each mode. Whereas batch processing allows more information to be
shared by a greater number of people and may be less expensive, an on-line system is more secure, more flexible, requires no coding clerks, and provides information which is more up-to-date, and possibly more accurate. RICHS and the original NCHS could be considered as typical examples of these two types of system.

2.2 CHILDHOOD IMMUNISATION STATUS IN BRITAIN

2.2.1 Uptake

As part of the policy for achieving health for all by the year 2000 the WHO European Regional Committee has adopted the goal of eliminating indigenous measles, poliomyelitis, neonatal tetanus, diphtheria and congenital rubella. To achieve this goal a target of 90% was set for the primary immunisation rates for all children under two years of age in the region by the year 1990 [Begg and Noah, 1985]. In Britain the Joint Committee on Vaccination and Immunisation set the same immunisation target for British pre-school children [DHSS, 1984]. Unfortunately, Britain's immunisation performance has been worse than most industrialised nations and even some developing countries; by 1989 only a handful of health districts had achieved the 90% target for the primary immunisation course and few districts had reached the target of 90% coverage for measles vaccine [Nicol et al, 1989].

Current schedule for routine immunisations

The schedule of immunisations currently adopted in this country aims to protect all children (other than those with genuine contraindications to receiving a particular vaccine) against diphtheria, tetanus, pertussis, poliomyelitis, measles, mumps, rubella and tuberculosis. The actual schedule varies from time to time [DHSS, 1988; DH, 1990; 1992 (to include Hib)], and the ages at which the immunisation procedures are recommended may also vary between local district health authorities [Begg and White, 1987; Peckham et al, 1989]. However, the Joint Committee on Vaccination and Immunisation has recommended a schedule of immunisations for nationwide adoption from May 1990 [DH, 1990] (Table 2.1).

<table>
<thead>
<tr>
<th>Age (other than those with genuine contraindications)</th>
<th>Vaccine</th>
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<tbody>
<tr>
<td>At 2 months—1st dose</td>
<td>Diphtheria/tetanus/pertussis (DPT) Polio</td>
</tr>
<tr>
<td>At 3 months—2nd dose</td>
<td>Diphtheria/tetanus/pertussis (DPT) Polio</td>
</tr>
<tr>
<td>At 4 months—3rd dose</td>
<td>Diphtheria/tetanus/pertussis (DPT) Polio</td>
</tr>
<tr>
<td>At 12-18 months</td>
<td>Measles</td>
</tr>
<tr>
<td>(usually before 15 months)</td>
<td>Mumps</td>
</tr>
<tr>
<td></td>
<td>Rubella (MMR)</td>
</tr>
</tbody>
</table>

Source: Department of Health (DH), 1990.

Note: From 1st October 1992, the primary schedule at 2, 3, 4 months includes Hib (Haemophilus influenzae B) immunisation (DH, 1992).
Calculation of uptake

This issue is not unimportant since variation in the calculation methods can provide different outcomes and, of course, will make comparisons between localities difficult. Unfortunately, there has been no well-established calculation method adopted across this country. In a national survey undertaken in England and Wales, Begg and White [1987] found that 65% of the participant district health authorities were using “resident children on a child register” and 26% were using “live births” as the denominators. Although live births is a convenient denominator for the calculation of immunisation uptakes, it is inappropriate for district use as it may be substantially affected both by fluctuations in the birth rate and movements in and out of the district.

Numerators used also varied from district to district [Begg and White, 1987]: some district health authorities included “non-district residents vaccinated in the district” in the numerators when calculating the rate, while others did not; some excluded resident children vaccinated in other districts from the numerators.

The most appropriate method recommended must fulfil the following criteria which were found to have been entirely fulfilled by only 44% of the districts studied in the 1986 national survey [Begg and White, 1987]:

— Number of children resident in a district who have been vaccinated, wherever they were vaccinated, as numerator;
— Total number of children resident in that district as denominator.

In order to fulfil these two criteria when calculating immunisation uptake rates, a district should therefore (a) maintain a fully updated child register, from which a denominator, i.e., resident children, can be derived; (b) identify non-district-resident children who have received immunisations inside the district and exclude them from the numerator (and denominator); and (c) identify and include in the numerator (and denominator) district resident children who have been vaccinated in other districts.

Uptake trends in Britain

During the last decade or so Britain has seen a gradual improvement in the level of immunisation uptake for pre-school children, but uptake in many individual districts remains below the set target or even below the 80% level [White et al, 1992]. Figures 2.2 shows the trend of uptake rates for polio, whooping cough and measles vaccines in children under two years of age in England from 1983 to 1991.
Factors influencing immunisation uptake

There has been recent renewed interest in the investigation of factors associated with low uptake of immunisation in this country, probably prompted by the fact that the uptake in some areas has been unsatisfactory. This section reviews some of the results derived from recent studies undertaken in this country; some were based on local populations and others on national data.

Regional variation

The recent “COVER” (Cover of Vaccination Evaluated Rapidly) data [White et al., 1992] show wide regional variation in both primary and measles immunisation coverage. Even though the regional level of uptake has reached or is approaching the 90% target for many areas, coverage of immunisations has been disappointingly low in many individual districts, particularly for pertussis and measles vaccines. In general, uptake of immunisations has been greater in rural than in urban areas for all vaccines, and the variation between areas appeared to be related to social factors, notably with Jarman score [Jarman, 1984].

Begg and White [1987] reported that districts with high social deprivation (i.e., with higher Jarman score) had significantly lower uptake rates, compared with those with lower Jarman score, although there was little difference between districts with low and medium social deprivation. The uptakes for measles and pertussis immunisations, for instance, were over 90% in low deprivation areas compared with under 80% in high deprivation areas. A similar trend was also identified for diphtheria immunisation. Jarman and colleagues [1988] demonstrated a negative correlation between uptake of immunisation and Jarman score; this factor “alone” contributed 35% of the variation in the uptake rate. The Jarman score, consisting of eight factors, was initially developed as an indicator to reflect the potential workload with which
general practitioners are burdened [Jarman, 1984; Smith, 1991; Talbot, 1991]. However, there must have been other more directly associated factors lying between the score and uptake of immunisations, i.e., the variation in immunisation uptake rates between localities was likely to be more directly related with other social and primary care factors than to this aggregated score.

**Ethnic group**

Ethnic group of a child for epidemiological purposes is usually taken as referring to the ethnic origin of the head(s) of his/her family [Haskey, 1988; 1989]. Appreciable differences between populations from different ethnic groups in both childhood morbidity and mortality, and in the utilisation of health care and education have been well documented [Davison et al., 1983; Baker et al., 1984]. Children from minority ethnic groups in general face more problems in well-being and in the uptake of health care and education services [Osborn et al., 1984].

Differences in uptake rates of immunisation have been shown among children from different ethnic origins in some studies. In Bradford, significant differences in uptake rates were found between children from the British group and those from other ethnic groups—notably Pakistani, Indian, and especially the “half-Negro” groups [Baker et al., 1984]. In a larger survey in England involving 128 district health authorities, ethnic group (represented by the proportion of people from the New Commonwealth and Pakistan) was found to be negatively correlated with uptake rate; this factor contributed 24% of the variance in the rate [Jarman et al., 1988]. These differences in uptake indicated that health services offered to all in this country were not being taken up evenly across the whole community.

**Social class**

Despite the fact that child health in this country has improved considerably as indicated by the reduction in overall infant mortality rates, the differences in well-being of children from higher and lower social classes have remained virtually unchanged over recent decades and the gap may even have widened [RCP, 1991].

Children from lower social classes were found to be less likely to utilise immunisation services as well as other service facilities [Osborn et al., 1984]. In Peckham’s report [1989] the uptake rates for measles were demonstrated to be 90%, 86%, 82% and 75% for children from families of social classes I/II, III, IV/V, and other (student, unemployed and armed forces), respectively; the corresponding rates for pertussis were 87%, 85%, 79% and 77%. Multivariate analysis showed that the odds ratios of being vaccinated were 1, 0.81 and 0.76 for children from social classes I/II, III, and IV/V for measles, and correspondingly 1, 0.96 and 0.83 for pertussis.

**Family size**

Theoretically, family size refers to the number of persons living in what is defined as a “family” [Haskey, 1989]. In practice, from a child health point of view, family size is usually indicated indirectly by the number of children in the family or by the number of persons per room. Peckham et al [1989] reported that for both measles and pertussis immunisations the presence of older siblings had a significant negative relationship to uptake. Measles uptakes were found to be 90%, 85% and 76% for only child, for children with one older sibling and for those with...
two or more older siblings respectively; the corresponding rates for pertussis were 88%, 84% and 75%. By using a logistic regression analysis they found that for every extra child in the family the odds of having a baby vaccinated were reduced by a factor of 0.76 for measles and 0.68 for pertussis.

Jarman and colleagues [1988] also found that an overcrowding factor—more than one person per room—had a strong negative correlation with diphtheria immunisation uptake, with the $R^2$ (proportion of the variance explained) being 0.48.

**Maternal age and single-parent family status**

Maternal age and the type of family are two important social and environmental factors associated with the development of health problems in childhood. Children born to mothers at extreme ages and those living in single-parent families [Haskey, 1989] are more likely to have ill-health problems [RCP, 1991] and are less likely to utilise the available health and social welfare facilities [Osborn, 1984] including immunisation services. In a study in Maidstone Health District in South East Thames region it was found that younger mothers were at greater risk of not having their babies vaccinated against measles, for both the 1979 and 1980 birth cohorts [Scrivens, 1984]. Again in Jarman’s national survey [1988] the factor single-parent was found to have “explained” 36% of the variance in diphtheria uptake rate.

**Population mobility**

Population is quite unstable in some localities in Britain, especially in inner city areas. There has been no convincing evidence to support or rule out population mobility as a factor associated with uptake of immunisation even though some district health authorities have attributed low uptake to the instability of their populations. It is true that immunisation call and recall systems rely very much on correct demographic information of children, and any changes of address (and surname) of children, without notifying the child health computer system, will adversely affect the call and recall system causing difficulties in forwarding immunisation appointments to children whose family moves from one area to another. This effect of mobility can certainly compromise the effective function of a computer system (see Figure 1.1).

Riley *et al* [1991] identified “frequently moving or homeless” as one of the most important factors delaying childhood immunisations. When asked the reasons why their children were not vaccinated, fifteen of the 56 children’s parents presented this factor as an excuse. In a national survey undertaken in 16 district health authorities in England and Wales [Peckham *et al*., 1989] it was found that non-immunisation in 15% of the 449 children who had not been vaccinated against measles was due to “no appointment received” by the parents. Even though the authors did not discuss why these parents had not received the appointments it is likely that a considerable proportion of appointments failed to reach these parents because of change of their address. Jarman *et al* [1988], however, did not find in their national study any significant association between uptake of immunisation and the mobility of the population.

**Immunisation location**

Pre-school immunisations are normally done either in community child health clinics or by general practitioners. Some immunisation procedures, however, are given opportunistically in
hospitals [Riley et al., 1991] or by health visitors [Begg and White, 1987; Jefferson et al., 1987], or even at home by immunisation nurses [Ramaiah, 1990]. In the national survey done by Begg and White [1987] it was found that the pre-school immunisations were routinely given by health visitors, clinic nurses and practice nurses in 21%, 23% and 48% of the studied district health authorities respectively. Whoever administers immunisations, most of immunisation procedures for British children are routinely carried out in general practice surgeries or at community child health clinics.

The performance can differ between immunisation locations. Alberman and colleagues [1986] compared the outcomes of immunisation services in three types of location—general practice, health centre and child health clinics. They found that GP surgeries seemed to be more effective in providing immunisation services than the other two locations, in terms of higher uptake and earlier age of immunisation.

Professional attitudes and knowledge
Pre-school immunisation programmes involve health visitors, general practitioners, clinical and community medical staff and hospital medical staff [Nicoll et al., 1989]. Their attitudes to and knowledge about immunisation and the diseases have been shown to be related to uptake of immunisation in childhood.

It has been shown in previous studies that quite a few health professionals had doubts about the infectivity and severity of the communicable diseases involved even when children were not vaccinated. In a national study of immunisation uptake in childhood, 4 and 6% of the general practitioners surveyed thought that it was not likely that an unvaccinated child would catch measles or pertussis, respectively, and 56% and 32% of the surveyed paediatricians considered measles and pertussis to be "not serious" diseases [Peckham et al., 1989].

However, what emerges repeatedly in many earlier studies undertaken across this country is the existence of considerable uncertainty amongst health professionals in their interpretation of contraindications to immunisation, especially those to measles and pertussis [Adjaye, 1981; Hull, 1981; 1987; Campbell, 1983; Kemple, 1985; Nicoll, 1985; Moules, 1987; Peckham, 1987; Bedford, 1988].

The official contraindications to measles and pertussis immunisations are moderately clear-cut [DHSS, 1988; DH, 1990; 1992]. "Real" contraindications to pertussis using older and less stringent criteria, were identified in less than seven per cent of children in a survey by Jelley and Nicoll [1984]. In practice, however, there are still apparently a number of grey areas which tax the clinical judgment of nurses and doctors [Hull, 1981; Peckham, 1987], resulting in a considerable proportion of eligible children missing their immunisations.

In a study [Nicoll and Begg, 1985] of 40 health visitors, for example, it was found that a considerable proportion of these health visitors experienced uncertainty about contraindication to pertussis vaccine. These uncertainties are often generalised to encompass other immunisations such as measles [Campbell, 1983; Ryan, 1984]. The recent clarification of contraindications [DH, 1992] may improve the situation in this regard.
Attitudes and knowledge of parents

Although very few parents (or guardians) object on principle to vaccines for their children, professionals' attitudes to and knowledge about immunisations and the diseases must inevitably be transmitted to the parents or guardians they are advising. The majority of parents have a good appreciation of the benefits and risk of, say, the pertussis vaccine and accept that there are uncertainties and that some things are not known; but they were perplexed by the confusing and contradictory messages they have received from local health advisers and national authorities [Harding and O’Looney, 1984].

It was found that in general, social classes I, II and IIIa sought their family doctor’s advice, but classes IIIb, IV and V tended to turn to health visitors for guidance [Market and Opinion Research International Limited (MORI), 1985]. Even in underprivileged inner city areas, over 95% of parents have signed a consent form for the immunisation programme for their children [Alberman et al, 1986]. Peckham and colleagues [1989] demonstrated that 28%, 27% and 22% of the surveyed parents stated that their decision about immunisation was influenced by health visitors, general practitioners and health education materials respectively. Other studies have stressed the important effect of health professionals and health education on parents' decision about immunisations [Bate et al, 1984; Kemple, 1985].

The effect of professional and parental attitudes, knowledge and health education on immunisation uptakes may also be strongly evidenced by the fact that a sharp decline of pertussis immunisation coverage occurred after the report which linked the vaccine with serious neurological damage [Kulenkampff et al, 1974]; and this decline in the uptake resulted in major epidemics of the illness in the years 1977 - 1979 and 1981 - 1983. The uptake of this immunisation improved again associated with a return of confidence in the safety of pertussis vaccine [DHSS, 1981; Pollock and Morris, 1983].

Other factors

The influence of the computerisation of child health systems on immunisation uptake rates has been discussed in previous sections. Some other factors associated with immunisation coverage among pre-school children have also been revealed by earlier studies. For example, Roper and Day [1988] demonstrated an effect associated with low birth weight; a considerable initial delay in immunisation uptake for infants weighing less than 2,000 grams at birth compared with heavier babies despite almost identical coverage rates between the two groups by 18 months of age. They also found a similar delay when infants were born before the 37th week of gestation compared with full term babies.

The presence of a chronically ill child in the family, the educational levels of parents, the organisation of immunisation clinics, the type of general practitioner (singlehanded, partnership, or group), age of general practitioners and community health services expenditure have also been identified as being associated with childhood immunisation uptake [Begg and White, 1987; Jarman et al, 1988; Peckham et al, 1989].

It has to be borne in mind, however, that the factors presented above were identified in individual investigations. Methodologically, most of these studies assessed only one or two
factors without considering (or controlling in epidemiological terms) other factors possibly interacting with or confounding the factors studied. These studies were undertaken in different areas in this country, at different times and employed differing methodologies, hence it would be hard to apply all these findings to every area in the country or to say which factor was more important than others in influencing immunisation uptake, since the situation varies from area to area, from time to time, and the results may vary if different methods of analysis were used.

Another important point is that while these social, environmental or biological factors may impose effects on the uptake of childhood immunisation independently, quite often however, they interact to affect the uptake. The overall effect of such factors can be additive; for instance, a child from lower social class is more likely to be born low birth weight, to an unmarried mother with low educational levels, and to have more siblings in his/her family [Haskey, 1989].

Table 2.2 lists chronologically the recent studies carried out in this country into the associations between immunisation uptake and factors, with (first) author, study setting, sample size, data source and the main factors identified as being related to immunisation uptake.

2.3 CHILD HEALTH SURVEILLANCE PROGRAMME IN THE U.K.

2.3.1 Definition

Despite repeated attempts at classification, confusion still surrounds the meaning of the terms used in the practice of preventive health care of pre-school children [Court committee, 1976; Royal College of General Practitioners (RCGP), 1983; Lancet, 1986]. The following phrases are all to be found in the mainstream literature: surveillance, health surveillance, development surveillance, assessment, developmental assessment, developmental screening, developmental examination, examination, screening, preventive health care, developmental monitoring. These phrases have been used interchangeably in the recently published literature. The same phrases may be used to define different sets of activities, and different phrases may be used to denote essentially similar tasks. Do these terms mean the same thing? Or do they mean different things? There is not yet consensus about the terms and meanings to be used in discussions about the preventive health care of pre-school children. The current terminological impasse is likely to obstruct progress towards a widely acceptable reformulation of the role of the community child health services, and without a wide measure of agreement on basic terminology, fruitful discussion of the underlying concepts will be impossible, as Stone [1990] has pointed out. However, the following definitions have been proposed in some recent literature, notably the most recent review on child health surveillance [Butler, 1989] and will be the definitions used in this thesis.

Preventive child health care

Preventive child health care has been defined in Butler’s [1989] report, as an umbrella term to describe all the activities of primary care that are concerned with the prevention of disease and
<table>
<thead>
<tr>
<th>Publishing year</th>
<th>First author</th>
<th>Setting</th>
<th>Sample</th>
<th>Data source</th>
<th>Main factors associated with uptake</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966</td>
<td>Galloway</td>
<td>West Sussex</td>
<td>1962-1964 birth cohorts</td>
<td>computer system</td>
<td>computerisation</td>
</tr>
<tr>
<td>1970</td>
<td>Saunders</td>
<td>West Sussex</td>
<td>1962-1968 birth cohorts</td>
<td>computer system</td>
<td>computerisation</td>
</tr>
<tr>
<td>1977</td>
<td>Bussey</td>
<td>West Sussex</td>
<td>1970-1975 birth cohorts</td>
<td>computer system</td>
<td>computerisation</td>
</tr>
<tr>
<td>1977</td>
<td>Williams</td>
<td>S. Yorkshire</td>
<td>1974-1975 birth cohorts</td>
<td>computer system</td>
<td>computerisation</td>
</tr>
<tr>
<td>1978</td>
<td>Bussey</td>
<td>57 AHAs</td>
<td>1974 birth cohort</td>
<td>questionnaire</td>
<td>computerisation</td>
</tr>
<tr>
<td>1978</td>
<td>Sutherland</td>
<td>Durham DHA</td>
<td>—</td>
<td>—</td>
<td>computerisation</td>
</tr>
<tr>
<td>1980</td>
<td>Williams</td>
<td>W. Glamorgan AHA</td>
<td>352 children</td>
<td>AHA records</td>
<td>accuracy and completeness of data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GP records parents</td>
<td></td>
</tr>
<tr>
<td>1981</td>
<td>Hull</td>
<td>Britain</td>
<td>167 HPs</td>
<td>questionnaire</td>
<td>professional knowledge</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>attendance form</td>
<td></td>
</tr>
<tr>
<td>1984</td>
<td>Baker</td>
<td>Bradford DHA</td>
<td>1980 birth cohort</td>
<td>computer system</td>
<td>ethnic group</td>
</tr>
<tr>
<td>1984</td>
<td>Bate</td>
<td>Salford DHA</td>
<td>101 children</td>
<td>—</td>
<td>parental and professional attitudes</td>
</tr>
<tr>
<td>Publishing year</td>
<td>First author</td>
<td>Setting</td>
<td>Sample</td>
<td>Data source</td>
<td>Main factors associated with uptake</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------</td>
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<td>---------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1984</td>
<td>Scrivens</td>
<td>Maidstone DHA</td>
<td>4937 children</td>
<td>computer system</td>
<td>maternal age, parental attitudes</td>
</tr>
<tr>
<td>1985</td>
<td>Kemple</td>
<td>a HC in Bristol</td>
<td>43 children</td>
<td>questionnaire</td>
<td>professional knowledge</td>
</tr>
<tr>
<td>1986</td>
<td>Alberman</td>
<td>3 HCs in a DHA</td>
<td>456 children</td>
<td>computer system</td>
<td>immunisation location</td>
</tr>
<tr>
<td>1987</td>
<td>Begg</td>
<td>193 DHAs</td>
<td>—</td>
<td>questionnaire</td>
<td>regional variation, computerisation, social deprivation, data feedback, professional and parental attitudes</td>
</tr>
<tr>
<td>1987</td>
<td>Jefferson</td>
<td>Oxford City</td>
<td>148 children</td>
<td>interview</td>
<td>practice organisation, social deprivation, professional attitudes</td>
</tr>
<tr>
<td>1987</td>
<td>Moules</td>
<td>Cheltenham</td>
<td>Caseload of a HV</td>
<td>HV records</td>
<td>professional attitudes</td>
</tr>
<tr>
<td>1988</td>
<td>Jarman</td>
<td>128 DHAs</td>
<td>—</td>
<td>DHSS, DHA records</td>
<td>overcrowding, single parent family, ethnic group, social deprivation, singlehanded GP, etc.</td>
</tr>
<tr>
<td>1988</td>
<td>Kelly</td>
<td>a GP clinic</td>
<td>775 children</td>
<td>computer system</td>
<td>computerisation</td>
</tr>
<tr>
<td>1988</td>
<td>Morris</td>
<td>Maidstone</td>
<td>532 children</td>
<td>computer system</td>
<td>information flow between HPs</td>
</tr>
<tr>
<td>1988</td>
<td>Roper</td>
<td>Newham DHA</td>
<td>3502 children</td>
<td>computer system</td>
<td>low birthweight, pre-term delivery</td>
</tr>
<tr>
<td>1989</td>
<td>James</td>
<td>HC in Bristol</td>
<td>HC’s caseload</td>
<td>HC records</td>
<td>organisation of immunisation clinic</td>
</tr>
<tr>
<td>1989</td>
<td>Peckham</td>
<td>16 DHAs</td>
<td>1793 HPs, 3394 parents</td>
<td>questionnaire</td>
<td>professional and parental attitudes, family and social factors, practice organisation</td>
</tr>
<tr>
<td>Publishing year</td>
<td>First author</td>
<td>Setting</td>
<td>Sample</td>
<td>Data source</td>
<td>Main factors associated with uptake</td>
</tr>
<tr>
<td>----------------</td>
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<td>-------------------------------------</td>
</tr>
<tr>
<td>1990</td>
<td>Hodes</td>
<td>HC in Islington</td>
<td>1984-1986 birth cohorts</td>
<td>computer system</td>
<td>immunisation campaign</td>
</tr>
<tr>
<td>1990</td>
<td>Scott</td>
<td>Riverside DHA</td>
<td>487 children</td>
<td>computer system clinic records HV's records</td>
<td>accuracy of data</td>
</tr>
<tr>
<td>1991</td>
<td>Jefferies</td>
<td>Parkside DHA</td>
<td>659 children</td>
<td>computer system FHSA's records</td>
<td>accuracy of data</td>
</tr>
<tr>
<td>1991</td>
<td>Riley</td>
<td>a paediatric ward</td>
<td>296 children</td>
<td>parents computer system</td>
<td>mobility, parental attitudes</td>
</tr>
<tr>
<td>1992</td>
<td>Lewis</td>
<td>95 GP practices in Grampian region</td>
<td>all children aged 2 or 5 years old</td>
<td>computer system</td>
<td>change of immunisation policy (introduction of new GP contract)</td>
</tr>
<tr>
<td>1992</td>
<td>Rao</td>
<td>Sandwell HA</td>
<td>3292 children</td>
<td>computer system HV's manual records</td>
<td>accuracy of data</td>
</tr>
<tr>
<td>1992</td>
<td>White</td>
<td>118 DHAs in England and Wales</td>
<td>2096 and 1601 quarterly district evaluations for diphtheria and measles</td>
<td>“COVER” data (mainly from computer systems)</td>
<td>previous year (1988) coverage deprivation, change of computer system, child population size</td>
</tr>
</tbody>
</table>

AHA: Area Health Authority; DHA: District Health Authority; GP: General practitioner; HP: Health professional; HC: Health clinic/centre; HV: Health visitor; DHSS: Department of Health and Social Security; —: Not available; COVER: Cover of vaccination evaluated rapidly.
the promotion of health in the pre-school child, which includes the more restricted range of activities described below.

**Primary prevention**

Primary prevention is aimed at the promotion of good health by reducing the *incidence* of disease and other departures from good health. In the case of the pre-school child, primary preventive measures would include dental and infectious disease prophylaxis (e.g., immunisations); the prevention of accidents; the prevention of child abuse; health education for the child; and education, advice and support to the parents about the health aspects of child-rearing. This heading includes the concept of health promotion involving diverse, community-based activities concerned with enhancing all aspects of child growth and development [Ashton and Seymour, 1985; Speller, 1985; Tannahill, 1985; Nutbeam, 1986; Pledger and Watson, 1986].

**Secondary prevention**

Secondary prevention involves actions taken to reduce the *prevalence* of disease and other departures from good health by shortening the duration or diminishing the impact of the condition. Examples include:

(a) *Child health surveillance* denotes the systematic and ongoing collection, analysis and interpretation of indices of child health, growth and development in order to identify, investigate and, where appropriate, correct deviations from predetermined norms [WHO, 1973]. Child health surveillance may be of two kinds: *population surveillance*, which is used in the public health sense to describe the ongoing observation and recording of the spatial and temporal incidence of the diseases and conditions of childhood in order to highlight public health problems requiring collective action, and *individual (or clinical) surveillance* which is aimed at *early detection* of abnormality in individual pre-school children to allow prompt and effective intervention. The process involves clinical, laboratory and behavioural tests for specific problems, e.g., vision and hearing disorders. The main purpose of surveillance is the gathering of information to facilitate reaching a diagnosis.

(b) *Screening* is not intended to be diagnostic, but is the presumptive identification of unrecognised disease or defects by the application of tests, examinations and other procedures [Commission on Chronic Illness, 1957].

(c) *Examination* is the action of establishing the clinical state of a child by means of a combination of questioning, testing and observing the child in the context of a professional relationship [Whitmore and Bax, 1988]. It conveys no implicit or explicit purpose, but may be diagnostic, preventive, therapeutic or administrative. Consequently, it serves no useful function other than as a description of data collection undertaken by a professional [Stone, 1990].

(d) *Assessment* denotes the follow-up of children who are found, through screening, to be positive or suspicious regarding the problem being assessed. Assessment is a specialist problem-solving function, aimed at reaching a definitive diagnosis and plan of management, and leading on to the treatment, care and after-care of children confirmed as having acute or chronic conditions and handicaps [Butler, 1989; Stone, 1990].
Tertiary prevention

Tertiary prevention is aimed at preventing an established condition (disability) becoming a handicap, i.e., minimizing the suffering caused by existing departures from good health, and promoting the child's (and the parents') adjustment to conditions that cannot be ameliorated.

2.3.2 Debate on health surveillance of pre-school children

In addition to the terminology of child health surveillance which remains to be clearly and precisely clarified without confusion or misunderstanding, other fundamental issues are also under debate. These include the questions ‘is a pre-school surveillance programme clinically effective?’ and ‘is it economically worthwhile in relation to its yield, i.e., is it cost effective?’

Even though health surveillance programmes for pre-school children have been widely regarded as good practice throughout the Western world [Hull, 1989], little scientific evidence exists to justify many of the activities undertaken and there are few data available to indicate whether surveillance programmes reach the whole child population and, more importantly, lead to improved health.

Is it clinically effective?

The broad value of health surveillance, in promoting the optimal health and development of children, seems to be clear to the many health professionals in favour of surveillance programmes for pre-school children [Hooper and Alexander, 1971; Hutchison, 1973; Bain, 1974; Whitmore and Bax, 1982; Johnson, 1984; Hull, 1989]. Many writers have pointed out that early screening for the pre-school child can identify or detect disorder or departure from normal and hence intervention can be introduced at an early stage in order to “allow a probable cause to be detected and remedied before development in that area becomes frankly abnormal’’ [Barber, 1982] or to minimise consequent disability or handicap.

In a recent published paper, Colver [1990] demonstrated that coverage of health surveillance in Northumberland Health District had increased to over 90% of eligible children, and the age at which congenital deafness diagnosed declined from 25 months in 1973-75 to 9 months in 1983-85, “leading” to wearing of hearing aids at an earlier age from 30 months to 15 months during the same period of time. Colver concluded that the “striking recent improvement bears an exact temporal relation to the introduction and evaluation of the agreement (on surveillance programmes) in Northumberland’’.

It has been recognised that, even though parents are usually the first people to note abnormal signs in the physical and mental development of the pre-school child [Bain, 1974; WHO, 1980], some defects are unlikely to be recognised even by the most astute parents and will only be detected by health professionals through surveillance programmes [Johnson, 1984; Hull, 1989].

However, despite the broad value of health surveillance recognised by many health professionals there is widespread scepticism among many others, both doctors and nurses. The most fundamental objection against surveillance is simply that its effectiveness and value remain unproven [Roberts and Khosla, 1972; Lancet, 1975; Carne, 1976; WHO, 1980; Bain et al,
1983]. Some health professionals doubt whether many of the ‘positive’ conditions detected through screening would lead to significant disadvantage or handicap for the child if undetected. Others argue the uncertain predictive value of unstandardised and poorly validated screening procedures, and the inadequate training of people who administer the tests and interpret their findings. Others again think that even if a positive or suspicious result is obtained it may not be possible to do anything about it because of the unavailability of effective treatment [Butler, 1989].

Roberts and Khosla [1972] studied 386 infants aged 11 to 13 months and demonstrated that 92% of all subjects with neurological defect were classified, through the screening tests, as abnormal, but only 40% of those with abnormal hearing and no infants with visual defects were classified as abnormal. They thus concluded that “developmental examination has only limited effectiveness when applied during infancy”, and that medical and paramedical personnel currently engaged in the routine application of this type of developmental examination might not be effectively deployed.

Is it economically worthwhile?

There seem hints in some literature that health surveillance programmes for pre-school children are not only effective; but also economically worthwhile in the sense that the costs of the programme can be justified by future savings from the treatment and care that would otherwise have to be given to children with chronic conditions and handicaps, especially with such “hard” conditions as phenylketonuria, hypothyroidism, congenital dislocation of the hip and maldescent of testes. Barnes [1985] pointed out that “for neonatal thyroid screening it is possible to estimate costs with some accuracy and, however the benefits are computed, the ratio is overwhelmingly favourable”.

It has been estimated that child health clinics which included primary preventive activities as well as surveillance, were less costly if run by general practitioners than by district health authorities; the average cost of a community health clinic session was about £93.55—at 1983 prices—compared with an “allocated” cost for a GP session of £80.85. [General Medical Services Committee (GMSC), 1983]. But calculations of this kind are often extremely difficult to do properly.

However, many health professionals argue that the cost of surveillance is unacceptably high in relation to its yield, and the financial and other costs may not be justified by the benefit accruing to the small number of positive cases detected. Bolden [1976] estimated that the cost of the developmental screening carried out among the 150 children under the age of five in his West country practice in 1974 amounted to £2,250, yielding only two speech defects and one squint. He stated that “if one assumes that the children with the speech problems would have presented to the general practitioner, then this leaves one squint which might otherwise have been missed. Therefore, this squint cost the local authority £2,250 for identification”.

The costs would be even higher for screening a condition with a low frequency in the population. Aspinall and Hill [1984] presented a hypothetical example of a condition with a frequency in the population of 0.5%, and a screening test with a 99% level of sensitivity and a
99% level of specificity. In these circumstances, the probability of a child with a positive result having the condition is only 0.33—that is, two out of three children with a positive result will not have the problem. Furthermore, since screening offers no more than a presumptive diagnosis, these children will require follow-up assessments in order to arrive at a definitive diagnostic conclusion.

The costs involved in surveillance are by no means confined to those of a monetary nature; there will also be the opportunity costs of the doctors’ and nurses’ time [Roberts and Khosla, 1972]. In a three-doctor practice of 9,000 patients, the work load of the doctor specialising in surveillance could increase by as much as 25% [Curtis Jenkins, 1976]. There are also the probable adverse effects on individual children and family relationship where a normal child “fails” a developmental or other surveillance check. False positives can lead to children being regarded unjustifiably as slow or otherwise unsatisfactory.

Thus, “the belief that developmental examinations will identify most health problems remains unproved, and more objective reports of the outcomes as well as the methods of screening are needed” [Bain, 1977], and “the recommended programme of surveillance has only limited research support and a great deal remains to be done in evaluating the effectiveness of various surveillance procedures and in measuring their cost and the benefit that accrues from them” [Court Committee, 1976].

### 2.3.3 Pattern of surveillance programme

Unlike immunisation procedures [DHSS, 1988; DH, 1990; 1992], no surveillance schedule for the pre-school child has been widely accepted nationwide in this country in terms of the ages at which children are subject to screening procedures and tests which ought to be carried out to screen for certain medical conditions of the pre-school child, with the possible exception of a small number of disorders, e.g., phenylketonuria, hypothyroidism, congenital dislocation of the hip, defects of hearing and vision, squint and maldescent of the testes. Individual reports have demonstrated large variation in the screening ages and the tests which should be done at each of the screening ages. Recent guidelines from the NHS Management Executive [NHS, 1992] suggest a “core” programme based on the revised second Edition of “Health for all children: a programme for child health surveillance” [Hall, 1991].

**Surveillance ages**

There has been great variability in surveillance ages between localities where health surveillance is implemented, as with professional opinion about the ages at which the screening ought to be carried out. Butler [1989] analyzed 35 literature reports on surveillance programmes of preschool children and found that these 35 references involved 14 separate screening ages between six weeks and five years, utilising no fewer than 24 different combinations of screening ages; only four of the ages are mentioned in more than half of the references—6 weeks, 6 to 9 months, 16 to 18 months and 30 to 36 months.

In a survey done by Curtis Jenkins [1976], where 27 child health ‘experts’ in the United Kingdom were asked about their opinion on child health surveillance, it was found that, with
the exception of the neonatal examination, fewer than half of the experts agreed on the desirability of routine surveillance at any of the specified ages, and concluded that "research is urgently required to test the truths of these assumptions about key age examinations".

The variety of surveillance ages was also demonstrated in Connolly's [1982] study which involved 90 area health authorities (AHAs) in England. Connolly noted that a total of ten different "assessment" ages between two weeks and four years were incorporated into the AHAs’ policies, of which only four ages were common to the policies of half or more of the authorities—six weeks (52% of AHAs), six months (57%), 18 months (61%) and three years (63%).

The consensus of opinion and practice about the target ages for surveillance of pre-school children has been so limited as to make it almost impossible to see any relationship between a disorder for which children are tested and the age at which the test should be carried out. If the chief purpose of surveillance is to detect specific disorders or anomalies at the ages at which they can best be identified and treated, the different combinations of surveillance ages mentioned in the literature can not be equally appropriate; some ages must be more suitable than others for testing for particular disorders.

"There is clearly little value in detecting disease in advance of the usual time of diagnosis unless such detection precedes the last critical point beyond which treatment would be unsuccessful and/or permanent damage would be done" [WHO, 1980].

**Tests**

There seems a small core of agreement about the particular conditions or disorders for which screening is considered to be justified, with considerable disagreement surrounding screening for others. There appears to be almost unanimous agreement in the literature that babies should be examined at, or shortly after, birth for the presence of physical anomalies, and they should also be screened for metabolic disorders, principally phenylketonuria and hypothyroidism. Hall [1989] pointed out that neonatal examination is of high yield, and "it is accepted and expected by parents, and there seems little doubt that they value the reassurance of normality at this time".

Less agreement has been reached about the value of screening at around the age of six weeks. As has been previously presented, screening at this age was carried out in only 52% of the 90 AHAs in England in the early 1980s [Connolly, 1982], and it was selected as a target screening age by only 26% of the 27 child health "experts" involved in Curtis Jenkins' [1976] survey. However, where the six-week check is performed the following tests are recommended by the Joint Working Party on Child Health Surveillance [Hall, 1989]: any parental concerns; physical examination, weight and head circumference; congenital dislocation of hips; vision and hearing; eyes (e.g., squint). Even though some writers emphasised the importance of inclusion of parental questioning as part of the examination, most do not—they may simply take it for granted that such questioning will be done without mentioning [Butler, 1989].

As the child grows and develops beyond the sixth week, the number and variety of tests to
which he or she might be subjected expands. With little agreement about which screening tests ought to be done at which ages, unclear and ambiguous language to describe the purpose of the tests in both the literature and practice, and a lack of convincing evidence from evaluation in the field, it is difficult, on the basis of the literature, to put together a modern programme of pre-school child health surveillance.

Various health surveillance programmes have been described and recommended [Hutchison, 1973; Colver and Sterner, 1986; Hutchison and Nicoll, 1988; Hall, 1991], but they are far from being a "practical manual" widely adopted. Explanations for the pronounced variability in surveillance programmes include, firstly, "the scientific basis of much childhood screening is as yet insufficiently precise to identify the 'correct' or 'optimal' target ages for different screening tests", secondly, "in the absence of any objective indicators, screeners select the ages with which they are most familiar, or which correspond most closely to their clinical experience, or which are mandated by the particular test schedules that they, or their health authorities have chosen to adopt", and thirdly, it "may be not that the 'correct' or 'optimal' ages have yet to be established, but that they simply do not exist" [Butler, 1989].

2.3.4 Coverage of health surveillance

There is also debate about this in the literature. The main point which needs to be clarified is whether any particular screening test should be aimed at all children in the appropriate age range, or whether the target population should be deliberately restricted in some way, i.e., targeting the population at risk of developing certain abnormal conditions. Another point is that, if the whole population is involved, how the coverage rate should be calculated and how significant a low coverage rate might be.

Targeting

Some health professionals have felt that in a surveillance programme universal screening of all children may not be practicable because of its high cost and low yield, and have recommended keeping children 'at risk' under surveillance until their development is seen to be progressing entirely normally. There are thus recommendations that health authorities keep 'at risk' registers of vulnerable children for health surveillance purposes [Lindon, 1961; Sheridan, 1962; WHO, 1967; Freer and Ogunmuyiwa, 1977].

In their study evaluating 'at risk' registers, Alberman and Goldstein [1970] demonstrated, by a mathematical model, that in situations of resource constraint the greatest benefit could be achieved by a selective approach to screening, especially "in areas with few resources per head, the keeping of a risk register and selective screening of these children are still the best policy". Freer and Ogunmuyiwa [1977] also suggested, having found a very high defaulting rate and low yield (an abnormality detection rate of three out of 192 children per year) of pre-school surveillance, that "in the present economic climate it may be that with improved and more uniform definitions of 'risk' groupings and a disciplined implementation, selective screening could provide a more realistic alternative to the pre-school screening of all children".

Although the original 'at risk' register concept generated much enthusiasm and confidence
[Hutchison, 1973; Holt, 1974], it was introduced without pilot studies and the registers were not designed to permit easy continuing evaluation. Experience soon revealed discrepancies and shortcomings [Oppé, 1967; Richards and Roberts, 1967].

The most substantial argument about the use of 'at risk' registers in pre-school screening concerned the definition of criteria. The original assumption of 'at risk' theory was that, among a cohort of children developing a particular disorder or handicaps, a very high proportion would have had the risk factor(s) selected as being the precursor(s). However, various pieces of evidence suggested that the assumption was indeed misplaced [Rogers, 1968; Hooper and Alexander, 1971; Starte, 1976]. Another argument against risk registers was the lack of uniform implementation of these criteria [Oppé, 1967].

Having faced many problems, 'at risk' registers were criticised so strongly that the Committee on Child Health Services [1976] reiterated an approach to surveillance in which health care staff should be alert to any child displaying evidence of a greater than average risk of ill health, developmental disorders or handicaps. It was pointed out that we should "avoid a categorisation of children 'at risk' on account of selected social factors" [Court Committee, 1976], and that 'at risk' registers "should not be used to restrict the coverage of the basic surveillance programme" [DHSS, 1980]. The main argument against 'at risk' registers is that they "have in the past proved unsuccessful in accurately identifying children at risk of developing handicaps" [DHSS, 1980].

After many concerns about 'at risk' registers had been raised, another selective screening approach was proposed by Nicoll [1984], in which children could be selected not on the basis of pre-defined risk factors but on the basis of a health visitor's concern about some aspects of the child's health and development, i.e., children are examined only if the health visitor is worried about their health and development. Nicoll's study suggested that this approach of "pre-screening" by a health visitor is a highly efficient way of using the time of a screening doctor. The results of this study, however, have not yet been reproduced elsewhere.

There is ongoing interest in the concept of 'at risk' in the literature [National Children's Bureau, 1987]. The debate on these key issues of health surveillance of pre-school children (i.e., targeting and objectives) is far from complete.

**Coverage**

Coverage rate is the proportion of the target population that is actually screened within the relevant time. If the aim of surveillance is to reach all children within the relevant age ranges for each individual screening test, the coverage rate is one indicator of the effectiveness of a screening programme, but by no means the only one—because, firstly, if a high coverage is obtained, the yield of positive cases may be considered too low to justify the cost of screening for them; secondly, the proportion of false positive or false negative results may be unacceptably high; and thirdly, even if these indicators are within tolerable limits, screening programmes may not confer any distinctive or worthwhile advantages upon the children passing through them [Butler, 1989].
Besides these points, calculation of coverage rate per se may be misleading. The fundamental problem in the calculation are deficiencies in both the numerators and denominators of the rates. Since the children may be screened either in general practice or community child health clinics, unless the records from both sources are merged, no overall picture can be built up of the total number of children in a community experiencing different components of a surveillance programme. On the other hand, the denominators in the calculation of the rate could also be problematic. Fraser [1978] has raised major doubts about the reliability and validity of age-sex registers in general practice, which have been widely kept and used as true population denominators [Burke and Bain, 1986]. Heward and Clayton [1980] compared health visitors' records, age-sex registers and the immunisation and vaccination computer appointment files and found that about 15% of children aged between birth and four years no longer resided at the address given for them in any of the three registers, and a further eight to 12% of children in the age group were not on the registers at all. They concluded that the practice age-sex registers were the least accurate of the three.

With the recent introduction of computers into child health systems on a national scale [Walker, 1983; Ross and Begg, 1991], this difficulty ought to be alleviated: the pre-school module of the computerised child health systems allows the creation of a centralised record for each child into which details of all developmental and other examinations can be fed, whether conducted in community child health clinics or general practitioners' surgeries [CHCC, 1983].

The second difficulty is the interpretation of coverage rate. Unlike immunisation uptake for which a concrete target has been set [Begg and Noah, 1985], there are no hard-and-fast rules for determining the cut-off point below which the coverage rate of surveillance is evidence of the failure or unacceptability of a screening programme. Evaluating the coverage rate for a screening programme raises an important question—that is, the extent to which coverage is likely to produce a biased selection of attenders. The relevance and importance of coverage rate will depend upon the extent to which the attenders of a screening programme contain the children in the target population who are truly affected by the condition that the test is seeking. It is obvious that if the attenders were so biased as to contain all the children in the target population who are truly affected the yield would be high, however low the coverage rate might be. At the other extreme if the attenders were so biased as to contain none of the children in the target population who are truly affected the yield would be zero, however high the coverage rate might be. The real situation is that the attenders who present for screening generally contain a proportion of truly affected cases between these two extremes [Pill et al, 1988]. In this circumstance, greater coverage rate and a larger proportion of truly affected cases would normally generate a higher yield of a screening test.

However in practice, the situation has been far from satisfactory—a large bias exists in the selection of attenders. Having studied and compared high and low risk groups comprising 1,878 children, Zinkin and Cox [1976] concluded that “a larger proportion of children not brought to child health clinics, and thus not using available services, are in a group with a higher risk of developmental problems than in the study population as a whole”, and “even high clinic attendance rates are not grounds for complacency. More of the children who do not attend are those in greatest need”.

REVIEW OF THE LITERATURE
As to coverage rate itself, Butler [1989] reviewed 25 references that were mainly from general practice. These 25 references revealed the following patterns. First, there was no evidence of any trend towards higher coverage rates over the ten years 1974 - 1984; second, there were marked variations in coverage rates from different reports (ranging from under 60% up to over 90%); third, there was great variability in the rates at individual screening ages (the median rate being from about 60% to 80%); and fourth, there seems a tendency for coverage rate to go down as the screening age goes up (the median rate being from just over 80% for six-week screening down to just over 60% for 48- to 54-month screening). Up until now no national figures of the coverage rate have been available.
3.0 PREVIEW

In this chapter the design of this research project is described, with details of study subjects and methodology.

3.1 STUDY SUBJECTS

3.1.1 Selection of study districts

**Districts from NET region**

There were sixteen (now 15, two district health authorities merged in late 1990) districts within the NET Regional Health Authority boundaries. These 16 districts varied from each other, but were categorised, on their fundamental geographic and demographic determinants and Jarman score [Jarman, 1983], as low deprived (Jarman score < 0) rural and suburban, and high deprived (Jarman score ≥ 0) inner city districts. It was decided not to study all these 16 districts but to select five from the region. Rationale for selecting these districts will be discussed in Chapter Eight.

The following five districts from NET region were thus included for study: West Essex (abbreviated in the subsequent text as WEX), Barking, Havering and Brentwood (BHB), Hampstead (HAM), Islington (ISL), and City and Hackney (CHK). The first two districts were located in rural and suburban areas and the latter three in inner city areas.

**Districts from NWT region**

There were fourteen districts in NWT Regional Health Authority. Since one of the intentions was to compare outcomes of child health computer systems in the two regions using two different systems, the selection of districts in NWT region depended mainly upon the districts chosen from NET region. Each district selected from NET region was paired with the one from NWT which shared most characteristics in terms of the proportion of the population under five years of age, district location (rural, suburban or inner city) and Jarman score.

The five districts selected from NWT region were North West Herts (abbreviated in the subsequent text as NWH), Harrow (HAR), Riverside (RIV), Brent (BRT) and Paddington and North Kensington (PNK). Table 3.1 lists the characteristics considered in the process of district selection in the five pairs of study districts. The main determinants were similar between the districts in each pair of the districts even though not exactly the same. These similarities were
hoped to minimize possible confounding effects on the main comparison results between the two regions.

Table 3.1—Comparative data on characteristics^ in the five pairs of district selected from NET and NWT regions

<table>
<thead>
<tr>
<th>Pair of district</th>
<th>Total population</th>
<th>Population under five (%)</th>
<th>Area location</th>
<th>Jarman Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Essex</td>
<td>249,877</td>
<td>16,159</td>
<td>Rural</td>
<td>-19.30</td>
</tr>
<tr>
<td>N/W Herts</td>
<td>261,441</td>
<td>16,777</td>
<td>Rural</td>
<td>-20.69</td>
</tr>
<tr>
<td>B.H.B</td>
<td>453,136</td>
<td>28,436</td>
<td>Suburban</td>
<td>-13.00</td>
</tr>
<tr>
<td>Harrow</td>
<td>197,138</td>
<td>13,308</td>
<td>Suburban</td>
<td>-13.17</td>
</tr>
<tr>
<td>Hampstead</td>
<td>108,401</td>
<td>6,102</td>
<td>Inner city</td>
<td>24.68</td>
</tr>
<tr>
<td>Brent</td>
<td>257,213</td>
<td>18,726</td>
<td>Inner city</td>
<td>18.67</td>
</tr>
<tr>
<td>Islington</td>
<td>169,164</td>
<td>11,776</td>
<td>Inner city</td>
<td>38.68</td>
</tr>
<tr>
<td>Riverside</td>
<td>276,025</td>
<td>15,646</td>
<td>Inner city</td>
<td>31.76</td>
</tr>
<tr>
<td>City/Hackney</td>
<td>193,307</td>
<td>15,752</td>
<td>Inner city</td>
<td>41.00</td>
</tr>
<tr>
<td>P.N.K</td>
<td>116,456</td>
<td>8,178</td>
<td>Inner city</td>
<td>44.88</td>
</tr>
</tbody>
</table>

^ Data sources:
Population data: 1988 OPCS mid-year population estimates.
Jarman Score: North East and North West Thames Regional Health Authorities (1981 Census).

3.1.2 Study subjects

Children
The study children were those born between January and March 1990 (a three month birth cohort) and recorded in the child health computer systems as current residents in the ten districts at the end of October 1991. Their relevant data were extracted from the computer systems on November the 15th 1991. Thus, these children were 19 to 21 months of age by the time the data were obtained from the systems.

The reasons for selecting this three month birth cohort and the time of data extraction were (1) this research project started in February 1990 and was expected to be completed in June 1992; (2) all children born into this three month cohort would be 19 months or older by then, at which time primary and measles-mumps-rubella (MMR) vaccines should have been completed, and the surveillance screening tests at six weeks and eight months carried out; and (3) a three month birth cohort would provide a sufficient sample size in each district for statistical analysis.

Health professionals
This research project included health professionals involved in using the child health computer systems, to assess their opinions about the systems and relevant aspects of general child health activities within their areas. These health professionals included:

— All child health department/system managers responsible for the central office in the ten districts;
— All health visitors currently working in each of the ten study districts;
— *All* child health clerical staff working directly with child health computer systems in the central office of the district child health departments, i.e., the computer system operating staff.

Initially, representative general practitioners working within ten districts were planned to be included in the study. However, attempts were abandoned after many difficulties were encountered, mainly the poor response from those general practitioners who were approached and a less than sufficient cooperation from FHSAs and Local Medical Committees in some areas.

### 3.2 STUDY PROCEDURES AND METHODS

Study procedures and methods are described under the following headings but were not necessarily separated exclusively one after another in the course of the work.

#### 3.2.1 Preparation of the project

**Drafting the study design**

After the general area to be covered had been outlined, a draft study design was prepared. This draft of the study proposal was then discussed with responsible staff in the computer centres in both NET and NWT regional health authorities, members of the computer systems Project Steering Groups, experts in the Public Health Laboratory Service and other academic health professionals specialising in public health, epidemiology, statistics and computing. The topics discussed included the general feasibility of the study and the general aims the study might achieve.

Having undertaken these invaluable discussions a more detailed study proposal was designed including aims and objectives to be met, geographic areas to be covered taking into account resource and time constraints, study population to be approached and methodology to be used in the project.

**Consent from the relevant responsible staff**

After the detailed draft of the study design had been drawn-up relevant responsible staff in the ten study districts were approached by letter together with a brief outline of the proposed study and their consent was asked and cooperation sought.

— District general managers in the selected district health authorities were contacted and their written permission for using the child health data in their districts was obtained.

— Directly responsible staff for child health computer systems (child health managers, computer system managers or equivalents) in the study districts were visited and details of the project were discussed, including the aims and objectives, study subjects and specific information required. Their consents were also obtained for the investigator to have direct access to the child health data held in their computer systems.
— District general nursing managers and the locality (or patch) nursing managers were contacted for permission to approach their health visitors for the questionnaire study. The managers were shown the draft questionnaire for comments and all provided name lists of health visitors in their areas.

— The computer system managers in the regional computer centres in both NET and NWT regions were also contacted for discussions about technical issues in extracting data from child health computer systems (in NWT) and physical links between the personal computer (PC) of the investigator and the child health systems of the study districts (in NET), whereby data would be able to be extracted directly through physical connection between the PC and the child health system.

— General managers of the relevant FHSAs were asked to allow the child registers in their computer systems to be used in this study for the purpose of comparison between the data held in child health computer systems and the system in their authorities. Unfortunately, only one FHSA responsible for general practitioner data in two districts agreed to cooperate. The two districts were Hampstead and Islington in NET region.

Consents from all these responsible staff were obtained before the use of their relevant child health data and for the questionnaire studies.

Progress of the study design
This process comprised three steps. Firstly, a draft of the study design was discussed with the above mentioned staff, and further consultations were held with the academic professionals to evaluate the scientific value as well as the feasibility of the research project. Comments were taken into account for modification to the draft.

Secondly, an on-field practical pilot study was conducted in Hampstead, where the investigator was based. Small data-sets were extracted from Hampstead's and other districts' computer systems for testing the format and the readability of extracted data by the statistical packages which would be used in the formal data analysis. Much effort was put into testing and validating the questionnaires designed for child health managers, health visitors and computer system operating staff. Details of the questionnaires were discussed with experienced health workers, health visitor managers, health visitors and computer system operating staff working in non-study districts, and with information officers who would not participate in the final study. The concrete procedures of questionnaire data collection were discussed and determined during this pilot study.

Thirdly, the study design, including the format and contents of and the language used in the questionnaires, was finalised after the pilot study was completed, taking into account the comments and suggestions made by participants in the pilot study.

3.2.2 Formal study
The formal research project comprised four parts. Part one aimed to evaluate some aspects of
the quality of child health computer systems; part two was to assess the attitudes of health professionals to child health computer systems and the performance of relevant general child health activities in their localities; part three, to examine immunisation status for children in the study cohort resident in the ten study districts; and part four, to investigate health surveillance programmes provided for the children.

In this section only some general points in terms of study procedures and methods are described. The methodology used in the four parts of study is detailed in chapters four, five, six and seven which, respectively, present the results of the four parts of study.

**Extracting data from child health computer systems**

Specifically developed programmes available in the child health computer systems enabled the extraction of data from the systems. Data were firstly extracted and downloaded onto floppy disks in the personal computer and then transferred into the main frame computer for formal statistical analysis.

There were hundreds of variables recording information on each individual child in the child health computer systems. Only 112 were used—those considered necessary to achieve the study objectives. Generally, there were two types of variables, numerical (N) and alphabetic (A). Table 3.2 lists these 112 variables with their description, length and type. Variables 1 to 28 recorded socio-demographic and general information about the children; 29 to 68 recorded information about immunisation status; and 69 to 112 recorded information on health surveillance programmes.

**Child registers from the FHSA**

One FHSA relevant to two NET district health authorities agreed to participate in this study and provided access to their child register listing name, current address, sex and NHS number of the children. Records for children born between January and March 1990 and recorded as residents in the two districts at a certain period of time were obtained which enabled a comparison between FHSA and child health computer system registers.

**Assessment of health professionals attitudes**

This part of the study was to assess the attitudes of child health managers, health visitors and computer system operating staff to the child health computer systems and some aspects of general child health performance in their areas. The data for this study were obtained through staff's response to the questionnaires.

**Investigation of immunisation status**

This part of the study was aimed to examine uptake of immunisations and the variation among different groups of children. Information about the immunisation status of the three month birth cohort resident in the ten study districts was obtained by the data extraction procedures outlined in the previous section. Immunisation status examined in this study included the primary course (i.e., three doses of diphtheria, (pertussis), tetanus and polio) and measles, mumps and rubella vaccines. Uptake rates for these immunisation procedures were calculated as the number of children recorded in the child health computer systems as having been vaccinated, expressed as
Table 3.2—Variables extracted from the computer systems for the study

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Description</th>
<th>Length</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Date of birth</td>
<td>8</td>
<td>N</td>
</tr>
<tr>
<td>02</td>
<td>Date of notification</td>
<td>8</td>
<td>N</td>
</tr>
<tr>
<td>03</td>
<td>Sex</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>04</td>
<td>Record status</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>05</td>
<td>Clinic code</td>
<td>4</td>
<td>A</td>
</tr>
<tr>
<td>06</td>
<td>Health visitor code</td>
<td>4</td>
<td>A</td>
</tr>
<tr>
<td>07</td>
<td>GP code and NHS number</td>
<td>12</td>
<td>A</td>
</tr>
<tr>
<td>08</td>
<td>Immunisation centre code</td>
<td>4</td>
<td>A</td>
</tr>
<tr>
<td>09</td>
<td>Ethnic group</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>10</td>
<td>Current district code</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>11</td>
<td>Examination centre code</td>
<td>4</td>
<td>A</td>
</tr>
<tr>
<td>12</td>
<td>Date of address</td>
<td>8</td>
<td>N</td>
</tr>
<tr>
<td>13</td>
<td>Mother’s date of birth</td>
<td>8</td>
<td>N</td>
</tr>
<tr>
<td>14</td>
<td>Previous live births</td>
<td>2</td>
<td>N</td>
</tr>
<tr>
<td>15</td>
<td>Previous still births</td>
<td>1</td>
<td>N</td>
</tr>
<tr>
<td>16</td>
<td>Previous miscarriages</td>
<td>1</td>
<td>N</td>
</tr>
<tr>
<td>17</td>
<td>Previous pregnancy</td>
<td>2</td>
<td>N</td>
</tr>
<tr>
<td>18</td>
<td>Transfer code</td>
<td>1</td>
<td>N</td>
</tr>
<tr>
<td>19</td>
<td>Gestation period (weeks)</td>
<td>2</td>
<td>N</td>
</tr>
<tr>
<td>20</td>
<td>One parent family</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>21</td>
<td>Birth weight (grams)</td>
<td>4</td>
<td>N</td>
</tr>
<tr>
<td>22</td>
<td>Live/still born</td>
<td>1</td>
<td>N</td>
</tr>
<tr>
<td>23</td>
<td>Mode of delivery</td>
<td>1</td>
<td>N</td>
</tr>
<tr>
<td>24</td>
<td>Place of birth</td>
<td>6</td>
<td>A</td>
</tr>
<tr>
<td>25</td>
<td>District of birth</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>26</td>
<td>District of residence at birth</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>27</td>
<td>Previous residence code</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>28</td>
<td>Previous residence district code</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>29</td>
<td>Information on immunisation status including</td>
<td>6</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>vaccination received</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>on what date</td>
<td>8</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>where</td>
<td>4</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>result source</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>69</td>
<td>Date of examination received</td>
<td>8</td>
<td>N</td>
</tr>
<tr>
<td>70</td>
<td>Examination code</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>71</td>
<td>Examination centre for the examination received</td>
<td>4</td>
<td>A</td>
</tr>
<tr>
<td>72</td>
<td>Examiner for the examination received</td>
<td>6</td>
<td>A</td>
</tr>
<tr>
<td>73</td>
<td>Result source for the examination received</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>74</td>
<td>Height at examination (centimetres)</td>
<td>5</td>
<td>N</td>
</tr>
<tr>
<td>75</td>
<td>Weight at examination (grams)</td>
<td>5</td>
<td>N</td>
</tr>
<tr>
<td>76</td>
<td>Head circumference (centimetres)</td>
<td>4</td>
<td>N</td>
</tr>
<tr>
<td>77</td>
<td>Information on each category of examination</td>
<td>2</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Category code</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Result</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Referral</td>
<td>3</td>
<td>N</td>
</tr>
</tbody>
</table>

† N: Numerical variable; A: Alphabetic variable.
a percentage of the total number of eligible children; numerators were children (born from January to March 1990) in a specific group who were recorded as current residents in the study district (i.e., excluding those who lived outside but who might have received their immunisations within a study district) and as having received a vaccine by the end of October 1991, no matter where the procedures were done. The denominators were the total number of children (vaccinated and unvaccinated) resident in the district. The calculation of uptake rate was based on this formula:

\[
\text{Immunisation uptake rate (\%) = } \frac{\text{No. of resident children vaccinated}}{\text{Total number of resident children}} \times 100\%
\]

**Study of health surveillance programmes for the children**

The age range of this cohort of children was 19 to 21 months. Therefore, it was only possible to study the outcomes of surveillance programmes at the two target ages, six weeks and eight months. As with immunisation uptake, the coverage rates of health surveillance programmes were calculated as the number of resident children who had attended for the programmes (wherever the screening tests were received) expressed as a percentage of the total number of resident children, i.e.,

\[
\text{Coverage of health surveillance (\%) = } \frac{\text{No. of resident children attended}}{\text{Total number of resident children}} \times 100\%
\]

### 3.2.3 Data analysis

**Data transferring**

Data were extracted directly from child health computer systems in the five NET districts through the connection between the personal computer and the child health system and held on floppy disks. Data were then transferred into the mainframe computer at the computer centre of the Royal Free Hospital School of Medicine. Data for children in the five NWT districts were extracted and downloaded from the child health computer system by technical staff in the NWT regional computer centre, and floppy disks holding the data were sent to the investigator, for data transfer into the main computer for analysis.

Data from the pre-coded self-administered questionnaires were entered into the personal computer in ASCII format through the WordStar Non-document file editing programme. Edited data were then checked twice to ensure no errors existed, then transferred into the main computer for formal analysis.

**Data analysis**

Except for the comparison of child register data between FHSA's and child health computer systems, where analyses were mainly undertaken manually, all computing, tabulation and analysis were carried out using three software packages—Statistical Package for the Social Sciences-X (SPSS-X) [SPSS Inc., 1988], Statistic Analysis System (SAS) [SAS Institute Inc., 1985] and Generalized Linear Interactive Modelling-release 3 (GLIM3) [Aitkin et al., 1990].
Statistical methods employed in the analysis of data comprised: data description of frequencies and proportions, cross-tabulations, chi-square test, chi-square test for trend, analysis of variance (one-way and involving two- or three-way interactions), non-parametric analysis, correlation, logistic linear regression and survival time data analysis. When doing a comparison involving the test of a null hypothesis, 95% confidence intervals (limits) as well as the associated $p$ values were presented wherever applicable [Gardner and Altman, 1989]. All $p$ values presented in the results were two sided unless specifically stated otherwise. Theoretical consideration of these statistical procedures, particularly logistic linear regression and survival time data analysis, is discussed in more depth in Chapter Eight.

3.2.4 Results reporting and writing up

The investigator was required to report interim as well as final results to the sponsor of this project—NET Regional Health Authority.

Drafting of this dissertation began in January 1992 and was finalised in January 1993. During this time necessary complementary data analysis work was undertaken after comments and suggestions from experts in various subject fields. The reports and this dissertation were word-processed using WordPerfect® version 1.0.6 on a Macintosh IIx computer, with all graphs drawn on the same computer using Cricket Graph® version 1.3.
4.0 PREVIEW

Both RICHS and NCHS are child health databases where large amounts of information are stored for the purposes of management, statistics and epidemiology in child health activities. Information stored in “system reference” files includes details of the health clinics, general practitioners, immunisation schedules, street and postal codes. The mainstream of the computer system database contains detailed information on each individual child such as the most recent information regarding demographic characteristics, birth conditions, immunisation status and records of preventive health surveillance. Based on the system reference files and the information about each child, the computer systems schedule the health care procedures due for each eligible child, record the results of health care procedures—given or not given, produce local statistics on child health services and provide basic data for national statistics on relevant child health performance [CHCC, 1983; 1987; Home and Roy, 1988; Ross and Begg, 1991]. It has long been recognised and confirmed by many studies across the country that such computer systems are effective for health record-keeping and are an efficient mechanism for scheduling immunisation and health surveillance procedures for the target populations; they are a quick and powerful tool for the identification of defaulters of service uptake [Galloway, 1963; 1968; Saunders, 1970; Bussey and Holmes, 1977; Bussey and Marris, 1979; Kelly, 1988]. Meanwhile, the data in child health computer systems have also been used for epidemiological purposes on a population basis [Scrivens, 1984; Roper and Day, 1988; Li and Taylor, 1991]. However, there is no doubt that the effective performance of a computerised health system and its value in epidemiological assessments depends fundamentally on the quality (i.e., the accuracy, updating and completeness) of data held in the system [Rawson et al., 1980, Scott, 1990].

This chapter aims to demonstrate the results of an evaluation of the data stored in both RICHS and NCHS, and the findings of comparisons, wherever possible, made between these two systems. Results will also be presented of the comparisons of the child health computer data with the data from the database from an FHSA relevant to two district health authorities.

4.1 METHODS

4.1.1 Sources of data

*Child health computer data*

This has been presented in Chapter Three.


Data from FHSA Registers

Permission to use their register data was obtained from one FHSA that covered the general practitioners in two district health authorities—Hampstead and Islington in NET region. Data were extracted from the register on children born during the time selected for the study cohort. The FHSA's Register data were compared with the data held in the child health computer systems in the two district health authorities to examine the consistency and any discrepancies between these two sources, based on the matching of name, sex, address, and where available, the NHS number of the children.

4.1.2 Data completeness assessment

The child health computer databases were evaluated in terms of their completeness by examining some variables considered to be important in ensuring satisfactory performance of the computer systems and in providing statistical and epidemiological information about the child population. The variables examined were categorised as (a) fundamental demographic variables, including date of birth, sex and current residence status of children; (b) health service management variables, e.g., health visitor's code and treatment centre code; and (c) variables of statistical and epidemiological value—birth weight, previous live births, mother's date of birth, one-parent family status and ethnic group origin.

A variable providing specific information is usually recorded in the computer system with pre-defined codes. In this investigation of computer system data, two definitions have been used: an invalid recording referring to a variable which had not been recorded at all, i.e., "blank", or which was recorded but not with the pre-defined coding used in that particular district for that variable, i.e., "illegally" recorded, and a valid recording which was one without either of these two types of recording error. For instance, the variable SEX has only two valid codes—"F" for girls and "M" for boys, and a blank recording or a recording with any other codes ("illegally" recorded) were not acceptable and were considered as invalid recording. If ethnic origin for a child resident in Hampstead, where a numeric coding was used for ethnic status, was recorded with an alphabetic letter (e.g., an "A") this recording was considered illegal and was included in the category of invalid recording of this variable (see Table 4.6). For some variables with numerical codes the recorded numbers can be checked for logic. Take birth weight as an example: only those recorded birth weights lying within a biologically acceptable range, taken as 500 to 5,900 grams, could be considered as a valid recording, with any other figures outside this "normal" range, plus blank recordings, assigned to the category of invalid recording of this variable.

The proportions of the total children with invalid variables were calculated, and compared between groups. It has been assumed in the assessment that all examined "valid" variables recorded accurate (true) information about individual children. For instance, if the variable SEX for a child was recorded as "F" that this child was a girl and if her birth weight was recorded as "3500" that this was her true birth weight. Only those variables that had been recorded with blank or illegal coding were considered as invalid.
4.2 RESULTS

4.2.1 Components of records

The total number of children born within the three months and recorded as resident in the systems of the ten districts was examined. In RICHS, a child was recorded as a resident (coded as R) if currently living in the district, either an at-birth resident if born inside the district and mother recorded as resident at that time, a transfer-in birth if born outside but mother registered as residing in the district, or a movement-in resident if the child had moved into the district having previously resided and probably been born outside. A child was recorded as non-resident (N) if born in the district but resident in another. Movement-out (M) was recorded if a resident child moved out of the district. The systems also recorded died (D) and stillborn (S). The categorisation of current status in NCHS was more complicated, but was substantially the same as that for RICHS:

- District child, born in the district (coded as 0);
- Transfer in birth (1);
- Transfer out birth (2);
- Movement in (3);
- Movement out (4);
- Died (5);
- Deleted (used to remove a duplicate record, coded as 6);
- Stillborn (7);
- Resident outside but treated inside (8);
- Resident inside but vaccinated outside, having pre-school screening outside, or going to school outside (9).

The main focus of this study was those children currently living inside the study districts, i.e., those recorded as R in RICHS or those as 0, 1, 3 and 9 in NCHS. Children recorded as residents in a district were divided in the computer systems into three main categories according to their birth place and their previous residence location:

- At birth residents—children who were born inside the present residence districts;
- Transfer-in residents—children who were born outside the present residence districts but whose mothers were registered at the time as residents; and
- Movement-in residents—children who previously lived outside and had moved into the present residence districts.

Details of residents in these three categories were examined in the ten districts and compared between districts located in different areas, i.e., rural, suburban and inner city areas, and between the two regions. Table 4.1 shows the frequency of the three types of resident in districts located in rural/suburban (R/S) areas and in inner city (City) areas in the two regions.
Table 4.1—Frequency (%) of three types of resident recorded in the ten districts, by region

<table>
<thead>
<tr>
<th>Region</th>
<th>Location</th>
<th>At-birth</th>
<th>Transfer-in</th>
<th>Movement-in</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NWT</td>
<td>R/S</td>
<td>922 (62.3)</td>
<td>341 (23.1)</td>
<td>216 (14.6)</td>
<td>1479 (40.8)</td>
</tr>
<tr>
<td></td>
<td>City</td>
<td>1026 (47.9)</td>
<td>597 (27.8)</td>
<td>520 (24.3)</td>
<td>2143 (59.2)</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>1948 (53.8)</td>
<td>938 (25.9)</td>
<td>736 (20.3)</td>
<td>3622 (100.0)</td>
</tr>
<tr>
<td>NET</td>
<td>R/S</td>
<td>1832 (84.2)</td>
<td>226 (10.4)</td>
<td>119 (5.5)</td>
<td>2177 (51.6)</td>
</tr>
<tr>
<td></td>
<td>City</td>
<td>1229 (60.2)</td>
<td>555 (27.2)</td>
<td>258 (12.6)</td>
<td>2042 (48.4)</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>3061 (72.6)</td>
<td>781 (18.5)</td>
<td>377 (8.9)</td>
<td>4219 (100.0)</td>
</tr>
</tbody>
</table>

"Movement-in" children must obviously not be included in the denominator when calculating the proportion of births to resident mothers taking place outside the residence districts (transfer-ins), and the calculation of the proportion of movement-in residents should take all current residents into account. Table 4.2 shows the observed proportions of transfer-in births and movement-in residents in different district locations and in the two regions. Since the children in the cohort were 19 to 21 months old for the main analyses, the proportion of movement-in residents could be considered as the prevalence of movement-in child population over 19 to 21 months.

Table 4.2—Proportions (%) of transfer-in births and movement-in residents in inner city and rural/suburban districts, by region

<table>
<thead>
<tr>
<th>District</th>
<th>Location</th>
<th>Transfer-in†</th>
<th>Movement-in‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>NWT</td>
<td>Rural/suburban</td>
<td>27.0</td>
<td>14.6</td>
</tr>
<tr>
<td></td>
<td>Inner city</td>
<td>36.8</td>
<td>24.3</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>32.5</td>
<td>20.3</td>
</tr>
<tr>
<td>NET</td>
<td>Rural/suburban</td>
<td>11.0</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>Inner city</td>
<td>31.1</td>
<td>12.6</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>20.3</td>
<td>8.9</td>
</tr>
</tbody>
</table>

†: Proportion = Transfer-in/(At-birth + Transfer-in).
‡: Proportion = Movement-in/(At-birth + Transfer-in + Movement-in).

By stratified analysis, it was found that births to inner city mothers were more likely to take place outside the present residence districts than were those to mothers in rural and suburban districts. This was the case in both NET and NWT regions ($\chi^2_{NWT} = 30.4, P < 0.001; \chi^2_{NET} = 237.8, P < 0.001$). There also appeared a considerable regional variation, i.e., the proportion of outside-births in NWT was greater than in NET, the difference being more distinct in rural and suburban districts ($\chi^2 = 140.7, P < 0.001$) than in inner city districts ($\chi^2 = 11.9, P < 0.001$). Similar patterns of difference were found in the proportions of movement-in residents between rural/suburban and inner city districts and between the two regions; rural and suburban child populations were less mobile than those in inner cities ($\chi^2_{NWT} = 49.0, P < 0.001; \chi^2_{NET} = 65.7, P < 0.001$); NWT child population appeared to be more unstable than NET population ($\chi^2_{RS} = 87.3, P < 0.001; \chi^2_{City} = 91.6, P < 0.001$).
4.2.2 Completeness of variables in system records

The fundamental variables

Date of birth, sex and current residence status were thought to be fundamental demographic variables. They provide basic information about a child and are crucial for the computer systems to make and send off appointments for child health services. Any incomplete or incorrect recording of these variables would result in the failure of these tasks by the computer systems.

Child’s date of birth and sex were found to be recorded with valid codings for all children in the two systems of the ten districts, and the current residence was well recorded in the five NWT districts. However, 48 children recorded as current residents (recorded as R) in the five NET districts were also recorded as “Transfer-out” births in the variable transfer status, among whom were 11 from the rural and suburban districts, and 37 from inner city districts, the ratio being 0.5% and 1.8%, respectively, relative to the total numbers of residents in these two types of district (2,177 and 2,042).

By examining the addresses and postal codes recorded in the computer systems all these 48 children were found to be living outside the recording districts. According to definitions in the RICHS documentation [Home and Roy, 1988], a “transfer-out” child is one whose mother is living outside but delivers inside the recording district. Since these 48 children were recorded as transfer-outs, they could not be current residents at the same time in the same district. These children had only been born in the recording districts and were excluded from the subsequent analyses. Since the interest of this study was only in the resident children this exclusion of “non-resident” from the study would not influence the comparison results of the analyses, but as will be discussed later in this chapter, this fundamentally incorrect recording of residence status would result in wrong appointments for these children, e.g., immunisation procedures, with implications for the uptake figures.

Other important variables

Six other important variables were also examined and the extent of their completeness among different groups of children was evaluated. These variables were the recordings of: the responsible health visitor, the treatment centre that the child registered to attend for health care procedures, birth weight, previous live births of the mother, mother’s date of birth and whether the child was currently living in a one-parent family. This information should all be collected and recorded as soon as the child was registered in the computer system, and should be updated whenever there were changes.

Firstly, the overall completeness of these six variables was compared among three groups of children—at-birth residents, transfer-in births and movement-in residents, by looking at the proportions of record with all the six variables completed, with any five, with any four, with any three, with any two, with any one or with none of them recorded in the child health computer systems. Figure 4.1 shows that the records of movement-in resident children were far less complete than those of at-birth and transfer-in residents; only 22.3% of movement-in children had all these six variables completed, compared with 84.1% and 93.7% of transfer-in
and at-birth resident children, respectively. It was also found that 4.8% of movement-in children had only one variable completed, and 0.3% without any of the six variables recorded in the systems.

Figure 4.1—Proportion of records with the variables completed among three groups of resident children in the ten study districts

Figure 4.1 also shows that 52.0% (579 of 1,113) of movement-in resident children had only two variables completed in the computer system, among whom were 576 (99.5% of the 579) who had only their current health visitor code and treatment centre code recorded. This was because these two variables were usually the route by which the child was identified as having moved into the new district, and so did not depend on the availability of information on the Movement-out Form issued by the previous district health authority of residence.

Secondly, the completeness of records for different groups of children in different district locations was investigated in greater detail, by examining individually the six variables. Figure 4.2 illustrates the proportions of children whose records for these six variables were incomplete among different groups. Some general patterns appear: (a) the proportion of at-birth and transfer-in resident children with uncompleted records was below five per cent for all the six variables in the NWT districts; (b) in the NET districts, four variables were well completed, (i.e., greater than 95% completed) for at-birth and transfer-in residents in both rural/suburban and inner city districts; the exceptions were previous live births and one-parent family status for inner city children; (c) records of inner city children were less complete than those of rural and suburban residents; (d) the proportion of movement-in children with uncompleted records was much higher than transfer-in and at-birth residents in both types of district and in both regions; (e) generally, health visitor code and treatment centre code appeared to be the best completed variables for all groups of children; and (f) the completeness of these six variables seemed to be poorer in NET than in NWT regions for at-birth and transfer-in births, but better for movement-in resident children.
To compare quantitatively the difference in the proportion of uncompleted records between groups of children with different types of residence, between district locations and between the two regions, paired t-test for two means (here the mean values of the proportion of uncompleted records) was employed, where the two compared samples were of equal size and the individual members of one sample were paired with particular members of the other sample, i.e., the individual difference in the proportions between each two paired groups was calculated and the mean difference of all these paired groups was then worked out [Armitage and Berry, 1990]. For instance, when the records of movement-in and at-birth residents were compared, differences in the proportion of uncompleted records for the six variables in both regions were separately worked out, giving 12 individual values of difference on which the calculation of \( t \) value was based.

It was found that the proportion of uncompleted records for movement-in children was, on average, 37.5% over that for at-birth residents, and 4.8% for inner city children over that for children who were resident in rural and suburban areas. No significant difference was identified in the mean proportions between transfer-in and at-birth residents (\( P > 0.05 \), 95% C.I. -0.1% to 3.4%). When NWT and NET regions were compared, the overall mean difference in the proportions of uncompleted records was not significant at the \( \alpha = 0.1 \) level (95% C.I. -1.0% to 8.9%). However, as Figure 4.1 has revealed, the differences in the proportion appeared to vary greatly among the three types of resident; the proportion of uncompleted records for movement-in children was far larger in NWT than in NET, while for at-birth and transfer-in residents the proportions seemed to be greater in NET than in NWT. Therefore, the comparisons between the two regions were undertaken separately at three levels— at-birth residents, transfer-in births, and movement-in children.

Table 4.3 shows that the records of at-birth residents were better completed for NWT children...
than for NET's; the mean difference in the proportions of uncompleted records was nearly 2% which is marginally significant at the $\alpha = 0.05$ level (95% C.I. 0.02% to 3.5%). The records of movement-in children in NWT were far less complete compared with those in NET; the proportion of uncompleted records in the former region was 17.1% (95% C.I. 5.3% to 28.7%) over that in the latter region. No significant regional variation in the completeness of records was found between the transfer-in births ($P > 0.2$, 95% C.I. -8.5% to 1.7%).

Table 4.3—Comparisons of mean proportions (%) of uncompleted variables between groups of record

<table>
<thead>
<tr>
<th>Between groups</th>
<th>Mean difference $(d)$</th>
<th>95% CI of $d$</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement-in v. at-birth</td>
<td>37.5</td>
<td>45, 50.5</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>City v. Rural/suburban</td>
<td>4.8</td>
<td>1.8, 7.8</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Transfer-in v. at-birth</td>
<td>1.7</td>
<td>-0.1, 3.4</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>NWT v. NET regions</td>
<td>3.9</td>
<td>-1.0, 8.9</td>
<td>&gt; 0.1</td>
</tr>
<tr>
<td>At-birth</td>
<td>-1.8</td>
<td>-3.5, -0.02</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Transfer-in</td>
<td>-3.4</td>
<td>-8.5, 1.7</td>
<td>&gt; 0.2</td>
</tr>
<tr>
<td>Movement-in</td>
<td>17.1</td>
<td>5.3, 28.7</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

Variable of ethnic group

This variable was evaluated because it has been shown to have a great deal of influence on the utilization of health and social welfare facilities by children [Baker et al., 1984; Osborn et al., 1984]. It was studied separately from those mentioned above because its recording has not yet been made mandatory in the child health systems by all the study district health authorities in these two regions, and also because it was expected to present a clear example of the importance of standardization of variable codings for child health computer systems across the country.

All five districts studied in NWT and one in NET required this variable to be recorded if the information was available (i.e., a mandatory recording variable). Table 4.4 lists the numbers and percentages of children whose ethnic origin was recorded with valid coding. A similar pattern, in terms of completeness, to the variables previously assessed can be seen; the records of at-birth residents were the most complete and those of movement-in children the worst, with transfer-in births in the middle—the proportion of children with complete records ranging from 34.1% to 89.8% of children in the six districts. The overall proportion of children with completed records seemed to be higher for the children resident in the two rural and suburban districts than for those in the four inner city districts.

Why had the variable not been recorded? To answer this question some in-depth investigations were conducted. Firstly, coding systems used in these districts were examined to see the validity of recording for this variable. In the five NWT districts a coding system with alphabetic letters was used to record different ethnic origins, while in Hampstead (an NET district) numerical numbers were assigned. It was found that in these six districts some 1,184 children (accounting for 30.4% of the total resident in the districts) had their ethnic group invalidly
recorded (93.9% with blank coding and 6.1% illegal coding). There was a considerable difference in the proportion of invalid recording of this variable among at-birth, transfer-in and movement-in resident children ($\chi^2 = 1,613.2$, $P < 0.001$ on 2 degrees of freedom); the proportion invalid was 81.5% for movement-in residents, compared with 42.3% for transfer-in births and 5.8% for at-birth residents, respectively (Table 4.5). The table also reveals that illegal recording contributed some 14.5% of all invalid recording of ethnic groups for transfer-in births, compared with 5.7% for at-birth residents and 0.3% for movement-in children ($\chi^2 = 90.5$, $P < 0.001$ on 2 degrees of freedom).

Table 4.4—Numbers (%) of children with valid recording of ethnic group in the six districts, by type of resident

<table>
<thead>
<tr>
<th>District</th>
<th>At-birth</th>
<th>Transfer-in</th>
<th>Movement-in</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harrow*</td>
<td>418 (99.3)</td>
<td>114 (89.8)</td>
<td>43 (39.8)</td>
<td>575 (87.7)</td>
</tr>
<tr>
<td>N/W Herts†</td>
<td>499 (99.6)</td>
<td>77 (36.0)</td>
<td>16 (14.8)</td>
<td>592 (71.9)</td>
</tr>
<tr>
<td>P.N.K</td>
<td>194 (98.0)</td>
<td>30 (44.8)</td>
<td>26 (17.0)</td>
<td>250 (59.8)</td>
</tr>
<tr>
<td>Riverside</td>
<td>403 (80.4)</td>
<td>31 (34.1)</td>
<td>20 (12.0)</td>
<td>454 (59.8)</td>
</tr>
<tr>
<td>Brent</td>
<td>316 (96.6)</td>
<td>334 (76.1)</td>
<td>40 (20.0)</td>
<td>690 (71.4)</td>
</tr>
<tr>
<td>Hampstead</td>
<td>139 (97.2)</td>
<td>32 (36.0)</td>
<td>0 (0.0)</td>
<td>171 (64.0)</td>
</tr>
</tbody>
</table>

†: Rural/suburban districts.

Table 4.5—Data showing source of invalid coding of ethnic group in the six districts

<table>
<thead>
<tr>
<th>Type of residents</th>
<th>0*</th>
<th>1*</th>
<th>3*</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. of children</td>
<td>2091</td>
<td>1027</td>
<td>771</td>
<td>3889</td>
</tr>
<tr>
<td>No. (%) with blank coding</td>
<td>115 (94.3)</td>
<td>371 (85.5)</td>
<td>626 (99.7)</td>
<td>1112 (93.9)</td>
</tr>
<tr>
<td>No. (%) with illegal coding†</td>
<td>7 (5.7)</td>
<td>63 (14.5)</td>
<td>2 (0.3)</td>
<td>72 (6.1)</td>
</tr>
<tr>
<td>No. with invalid coding‡</td>
<td>122</td>
<td>434</td>
<td>628</td>
<td>1184</td>
</tr>
<tr>
<td>Proportion of invalid coding (%)</td>
<td>5.8</td>
<td>42.3</td>
<td>81.5</td>
<td>30.4</td>
</tr>
</tbody>
</table>

* : 0, 1 and 3 denote at-birth, transfer-in and movement-in residents, respectively.
†: Numerical codings in Hampstead and alphabetic codings in the five NWT districts.
‡: Sum of blank and illegal codings.

These results suggested that movement-in children were less likely to have their ethnic origin recorded in child health computer systems compared with at-birth and transfer-in residents; this trend was similar to that identified for other variables. Some six per cent of invalid recording of ethnic origin was caused by illegal recording, most likely associated with poor standardisation of the category. It was found that in NET districts at least five different coding systems were currently used to record ethnic origins, the coding differing from that currently used in NWT where letters A, B, C, E, I, W, and Z represent African, British, Chinese, European, Indian, West Indian, and other [Bennell, personal communication, 1992]. Table 4.6 presents three of the NET coding systems. The difference in the coding of the variable is apparent; some with numerical numbers, some with letters, and even with the same coding meaning different things. For instance, letter A refers to "African" in the regional coding system, but to "British" in the Enfield system. The categorisation of ethnic origins also varied between the coding systems,
and was not homogeneous with that used in the 1981 Census [Census 1981 Small Area Statistics].

<table>
<thead>
<tr>
<th>Coding</th>
<th>Regional code</th>
<th>Enfield code</th>
<th>Hampstead code</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>African</td>
<td>United Kingdom</td>
<td>—</td>
</tr>
<tr>
<td>B</td>
<td>Bangladeshi</td>
<td>Eire</td>
<td>—</td>
</tr>
<tr>
<td>C</td>
<td>Caucasian</td>
<td>European</td>
<td>—</td>
</tr>
<tr>
<td>D</td>
<td>—</td>
<td>Cypriot</td>
<td>—</td>
</tr>
<tr>
<td>E</td>
<td>—</td>
<td>Indian</td>
<td>—</td>
</tr>
<tr>
<td>F</td>
<td>—</td>
<td>Pakistan</td>
<td>—</td>
</tr>
<tr>
<td>G</td>
<td>—</td>
<td>West Indian</td>
<td>—</td>
</tr>
<tr>
<td>H</td>
<td>—</td>
<td>African</td>
<td>—</td>
</tr>
<tr>
<td>I</td>
<td>Indian</td>
<td>Italian</td>
<td>—</td>
</tr>
<tr>
<td>J</td>
<td>—</td>
<td>Greek</td>
<td>—</td>
</tr>
<tr>
<td>K</td>
<td>—</td>
<td>Others/unknown</td>
<td>—</td>
</tr>
<tr>
<td>L</td>
<td>—</td>
<td>Bangladeshi</td>
<td>—</td>
</tr>
<tr>
<td>M</td>
<td>Mixed</td>
<td>Mixed</td>
<td>—</td>
</tr>
<tr>
<td>N</td>
<td>—</td>
<td>Turkish</td>
<td>—</td>
</tr>
<tr>
<td>O</td>
<td>Oriental</td>
<td>Oriental</td>
<td>—</td>
</tr>
<tr>
<td>U</td>
<td>Unknown</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>W</td>
<td>West Indian</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>X</td>
<td>Other</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>African</td>
<td>—</td>
</tr>
<tr>
<td>1</td>
<td>—</td>
<td>Asian</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>—</td>
<td>Caribbean</td>
<td>—</td>
</tr>
<tr>
<td>3</td>
<td>—</td>
<td>UK European</td>
<td>—</td>
</tr>
<tr>
<td>4</td>
<td>—</td>
<td>Chinese</td>
<td>—</td>
</tr>
<tr>
<td>5</td>
<td>—</td>
<td>Cypriot</td>
<td>—</td>
</tr>
<tr>
<td>6</td>
<td>—</td>
<td>Eire</td>
<td>—</td>
</tr>
<tr>
<td>7</td>
<td>—</td>
<td>Jewish</td>
<td>—</td>
</tr>
<tr>
<td>8</td>
<td>—</td>
<td>Other European</td>
<td>—</td>
</tr>
<tr>
<td>9</td>
<td>—</td>
<td>Other</td>
<td>—</td>
</tr>
</tbody>
</table>

* * : Horne and Card, 1990.

Did the system operating staff also contribute to invalid recording of this variable in addition to the poor standardisation of the coding system? An investigation was undertaken in Hampstead (where the investigator was based) by examining the consistency of records held in the computer system and those recorded in the original documents (i.e., Notification of Birth). In order to eliminate the effects of variation in coding systems only the 143 at-birth residents were included in this investigation; the status of recording of ethnic group in the computer system was compared with that recorded in the original documents for these at-birth resident children where a homogenous coding system was applied. Table 4.7 shows that there were 11 children whose ethnic group was validly recorded in the original documents but *not* in the computer system. The null hypothesis that the recording of this variable in computer system is identical to that in original documents was rejected by McNemar's test [Armitage and Berry, 1990]; Z value was 3.32 with the *p*-value smaller than 0.001. The overall difference in the proportions of invalid recording of ethnic group between the records held in the computer system and those on the original documents was \((26/143 - 15/143=) 0.08\) with the 95% confidence interval from 0.03 to 0.12.
Table 4.7—Distribution of the recording of “ethnic group” in computer system and in original documents for the 143 at-birth residents in Hampstead

<table>
<thead>
<tr>
<th>Computer system</th>
<th>Valid</th>
<th>Invalid†</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original documents Valid</td>
<td>117</td>
<td>11</td>
<td>128</td>
</tr>
<tr>
<td>Invalid†</td>
<td>0</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>117</td>
<td>26</td>
<td>143</td>
</tr>
</tbody>
</table>

† Including blank and illegal recordings.

Therefore, we may link invalid recording of ethnic origin in child health computer systems to at least three factors: (1) the unavailability of such information on the original documents on which the computer data were based; Hampstead’s data revealed that some 58% (15/26) of invalid recording for the 143 at-birth residents were attributable to the information not being available on the original documents (Table 4.7); the observation that over 80% (626/771) of movement-in children in the six districts had their ethnic origin not recorded also suggests such unavailability (Table 4.5); (2) variation in the coding systems used between districts; data from the six districts indicated that illegal recording of ethnic group was responsible for 6.1% of all invalid records and for some 14.5% for transfer-in births (Table 4.5); and (3) input errors by computer system operating staff; the data in Table 4.7 suggested that ignorance by computer system operating staff of the information available on the original documents was responsible for nearly half (11 of 26) of the invalid recording in the computer system, according to Hampstead’s data. It is probable that ethnic data were worse than other computer data variables in this respect because of operating staff knowing that adjacent districts in the region did not systematically record this variable which therefore might be considered less important than other data.

4.2.3 Notification of children to the computer system

The recording of “date of notification” to the computer system in RICHS enabled an examination of the time elapsed for a birth to be notified to and registered in the child’s home district. This notification time was studied because it was viewed as an indicator of the adequacy of communication between birth attendants and the staff in the child health office. In this investigation, some factors associated with the notification time were studied to provide some evidence why communication between health professionals has not been satisfactory in some areas [Morris et al, 1988; also see Chapter Five].

The notification time (in days) was compared firstly among children in rural/suburban, inner city districts and a district where electronic linkage between the hospital Patient Administration System (PAS) and RICHS has been set up whereby birth information could be transferred directly from the former system to the latter, secondly, between at-birth and transfer-in births, and thirdly, between children who weighed less than 2,000 grams and 2,000 grams or more when they were born.
Figure 4.3(a) shows that rural and suburban residents were notified to and registered in the computer system earlier than inner city children; it took less than two days for 50% of the births to be notified to the system in the former areas and nearly five days in the latter districts, and 95% of children had been registered in the computer system of rural and suburban districts before the fifth day of their births compared with the 11th day in inner cities. Interestingly, in CHK, a typical inner city district, but where PAS and RICHS has been electronically linked, the time elapsed when 50% of children were registered in its child health computer system was even shorter than that in rural/suburban districts, whereas the time for 95% of children to be notified to the system was similar to that in the other two inner city NET districts (about 11 days after birth). It has been demonstrated in this study that, generally, inner city districts had a higher proportion of transfer-in births (see Table 4.2) and it would take a longer time to have this proportion of transfer-in children notified to the child health system in their resident districts. Therefore, the notification time was compared between at-birth residents and transfer-in children.

![Figure 4.3(a)](image1)

![Figure 4.3(b)](image2)

![Figure 4.3(c)](image3)

Figure 4.3—Cumulative proportion of children notified to and registered in RICHS (a) between three types of district, (b) between two types of resident, and (c) between children with birth weights of < 2,000 and ≥ 2,000 grams

Figure 4.3(b) illustrates the great variation in notification time between these two groups of children; the time when 50% of children had been registered in RICHS was approximately 1.5 days for at-birth residents compared with around 5.5 days for transfer-in children, and the time
when 95% of children had been notified to the computer system was about 4.5 days for the former group of residents compared with almost two weeks for the latter group of residents.

It was suspected that children with birth weight less than 2,000 grams would be more likely to stay in hospital for a period of intensive or special neonatal care, and hence be notified to the child health system later. The notification time for these children was compared with those of birth weight 2,000 grams or more. Figure 4.3(c) reveals that the distribution of cumulative proportions of children notified at different days between these two groups was very similar.

To compare the notification time allowing for all these three factors together, a three-way analysis of variance was employed to see the effects of each factor and of the combinations of the factors. To carry out this analysis the raw data were log transformed to meet the assumptions underlying the analysis of variance, i.e., the normality of the distribution and the equality of the variances among the study groups [Armitage and Berry, 1990]. The main outcomes of the analysis are listed in Table 4.8.

<table>
<thead>
<tr>
<th>Variable</th>
<th>F-value</th>
<th>DF</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main effects</td>
<td>515.1</td>
<td>4</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Type of district</td>
<td>184.0</td>
<td>2</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Type of resident</td>
<td>951.3</td>
<td>1</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Birth weight</td>
<td>0.5</td>
<td>1</td>
<td>= 0.3</td>
</tr>
<tr>
<td>2-way interaction</td>
<td>56.6</td>
<td>5</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>District/resident</td>
<td>141.1</td>
<td>2</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>District/Birth weight</td>
<td>0.4</td>
<td>2</td>
<td>= 0.7</td>
</tr>
<tr>
<td>Resident/Birth weight</td>
<td>0.01</td>
<td>1</td>
<td>= 0.9</td>
</tr>
</tbody>
</table>

To simplify the interpretation of results, the 3-way interaction has been excluded from the analysis. It was found that the notification time related to the two variables—district location and resident type but not to birth weight, and also to the particular combination of district and resident types. The theory tells us that once the presence of interaction has been established, it is not particularly useful to continue hypothesis testing for the effect of the two individual factors involved in the interaction since the two variables jointly affect the dependent variable [Norusis, 1988]. The F-value associated with the district and resident interaction was 141.1 on 2 degrees of freedom and the observed significance level clearly smaller than 0.001. Therefore, it appeared that an interaction existed between the two variables. What does this mean? Figure 4.4, which is a plot of the cell means of notification time on a log scale among different groups of children, provides an clear explanation.

The figure suggested that the difference in notification time between children in the three types of district was not identical for transfer-in and at-birth residents. The line representing inner city districts is nearly parallel to, but above that representing rural and suburban districts, indicating that inner city children (both at-birth and transfer-in) were generally more likely to be registered in the computer system at a later time than those resident in rural and suburban districts, and the
difference in the notification time between transfer-in and at-birth residents was similar in these two types, indicated by nearly parallel lines. However, the line for CHK crossed the other two lines, suggesting that transfer-in births in that district were, on average, notified to the computer system rather later than those in rural/suburban and the other two inner city districts, while its at-birth residents were registered in the system earlier than those in the other districts.

The crossing of the lines was due to the fact that at-birth residents' birth records were transferred directly from the hospital maternity computer system (i.e., PAS) onto the child health system shortly after the children's births. If there were no such connection between the two computer systems the notification time for at-birth residents in CHK might have increased to a point that would make its line parallel to that representing the other two inner city districts (Figure 4.4).

4.2.4 Recording of non-residents

The comparisons presented in the last section appeared to indicate that transfer-in residents were generally notified to and registered in their home districts' child health computer systems later than at-birth residents, in both rural/suburban and inner city districts. It might be argued that this later notification of children to child health computer system for transfer-in births was due to longer postal times required to exchange birth information between districts than within a district, where no electronic links had been established between the systems in different districts. Did other factors also contribute? This question prompted an investigation of non-resident records held in the computer system in the five NET districts where such data were available.

From Figure 4.5 it can be seen that a large proportion of non-residents' records had been held in the system of districts where the children did not live. The ratio of non-residents to residents (N/R) was as high as 1.24 in Hampstead, indicating that more than half of the records held in
Hampstead child health system were on children not living in the district. The ratios ranged from 0.21 to 0.53 in the other four districts, revealing that around one fifth to one third of the total number of records held in their computer systems were non-residents'.

![District Proportion Chart](image)

**Figure 4.5—Relative proportion of residents and non-residents registered in RICHS of the five NET districts**

The present situation is that when a non-resident child is born in a district, the birth attendant usually forwards the Notification of Birth to the “born-in” rather than to the “resident-in” district authority. The former authority registers this child in its child health system as a non-resident, and then prepares the birth document and sends it to the district authority where the child to be resident. Undoubtedly, the transfer of birth information between the birth place and the resident district by way of another district would increase the time for the child to be notified to the system of the child’s own district. Therefore, it seems very likely that duplicating registration in a non-resident district might be a key factor associated with late notification to the resident district for transfer-in children.

### 4.2.5 Comparison of two child registers, RICHS and FHSA

It was found that 317 children in the three month birth cohort were registered in the FHSA’s computer system as Hampstead district *residents* as of the 12th October 1990. These children were broken down into the following categories, according to their matching with the residence status in the child health computer system: 225 residents, 28 moved out, 10 non-residents, 15 children who were not on RICHS but living inside Hampstead as indicated by the addresses recorded on FHSA’s records, and 27 who were not registered on RICHS, nor living in this district by checking the addresses. It was also found that 37 children were recorded only on RICHS as Hampstead residents but not on the FHSA register. The numbers in the corresponding categories for Islington district are shown in Table 4.9.

From the point of view of the child health system, we were mostly concerned about the children who were registered in the FHSA’s system as living *inside* a district but whose records were not on the child health computer system of that district assuming that the recording of addresses in the FHSA system for these children was correct. It was found that 15 and 19 children who
were living in Hampstead and Islington and who should have been registered in these two districts were missing from the child health systems. Thus, the total number of Hampstead resident children, in the study cohort and during that period of time, should have been at least \((225+37+15=) 277\), giving a minimal proportion of under-registration of 5.4% (15 out of 277). Here the word “minimal” is used since it is believed that there were some children who might be registered in neither of the systems. The corresponding figures for Islington were \((485+161+19=) 665\) and \((19/665=) 2.9\%\).

Table 4.9—Comparison of child registers of Hampstead & Islington RICHS with those of Camden & Islington FHSA as of the 12th October 1990

<table>
<thead>
<tr>
<th></th>
<th>Hampstead</th>
<th>Islington</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matched with FHSA’s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residents</td>
<td>225</td>
<td>485</td>
</tr>
<tr>
<td>Non-residents</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Moved out</td>
<td>28</td>
<td>15</td>
</tr>
<tr>
<td>Total matched</td>
<td>263</td>
<td>510</td>
</tr>
<tr>
<td>Unmatched with FHSA’s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In FHSA’s only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living inside</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>Living outside</td>
<td>27</td>
<td>20</td>
</tr>
<tr>
<td>In RICHS only (as residents)</td>
<td>37</td>
<td>161</td>
</tr>
</tbody>
</table>

It was also noted in both districts that some children, who were recorded as not living in or having moved out of the districts, were recorded in the FHSA’s system as being “residents” in these districts. This was mainly because the FHSA records were based on the location of general practitioners’ premises where children were registered regardless of the health authority residence, and might also reflect difficulty in updating FHSA records since it was recognised that not all general practitioners “removed” quickly the records of children who had moved out of their area to a different district. Thirty-seven and 161 children who were recorded as living in Hampstead and Islington, according to the child health systems, were not on the FHSA’s registers at all. Why was that? The data listed in Table 4.10 might help explain. The data suggested that the main reason for resident children in a district not being recorded in the relevant FHSA’s register was that they were registered with a general practitioner outside their resident district. Another possible factor associated with under-registration in the FHSA’s records was that some children might be registered with a private doctor, who are not recorded in FHSA systems.

Table 4.10—Distribution of children (%) who were recorded in child health system as residents but not on the relevant FHSA’s registers, by location of GP premise

<table>
<thead>
<tr>
<th>District</th>
<th>No.</th>
<th>Outside GP</th>
<th>Inside GP</th>
<th>GP unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100.0%</td>
<td>75.7%</td>
<td>8.1%</td>
<td>16.2%</td>
</tr>
<tr>
<td></td>
<td>100.0%</td>
<td>83.9%</td>
<td>5.6%</td>
<td>10.5%</td>
</tr>
<tr>
<td>Total</td>
<td>100.0%</td>
<td>82.3%</td>
<td>6.1%</td>
<td>11.6%</td>
</tr>
</tbody>
</table>
4.3 DISCUSSION

4.3.1 The quality of records in child health computer systems

Child health computer systems were designed for facilitating child health services and for providing data for statistics on child health activities and epidemiological assessment of the services, to achieve the objectives of high uptake of child health care in the child population [CHCC, 1983; 1987; Home and Roy, 1988; Ross and Begg, 1991]. Any incorrect or incomplete recording of the information can seriously damage the function of the computer systems.

It was found that 48 children in the five NET districts had been wrongly recorded as residents although they were not living inside the districts. Correct and consistent identification of a child’s residence status is one of the key elements for scheduling immunisation, surveillance and other health services for the child. Such incorrect recording would have three main adverse effects. Firstly, since these 48 children were recorded as residents the computer systems would keep sending unnecessary appointment cards for the due health care procedures possibly without any response because they were living in a different district. Secondly, the subsequent non-keeping of the wrongly forwarded appointments would result in difficulties in organising child health service sessions for general practice or child health clinics where the appointed procedures are expected to be done, and which largely rely on the appointments generated by child health computer system. Thirdly, the recording of non-resident children as “residents” on the system of a district might cause under-estimation of the local statistics on uptake of health services by including these non-resident children in the population denominator. The latter factor is likely to be one of the major factors associated with the “false” poor immunisation uptake rates in some localities [Fraser, 1978; Begg and White, 1987].

The possible reason for this incorrect recording of residence status is the lack of built-in self-data-checking facilities in the systems; when the staff in a district child health office receive the copy of Notification of Birth of a child who is born inside but not living inside the district, and record this child wrongly as a resident, the system is unable to identify these inputting errors. I believe that this sort of error would be avoided by some revision to the computer system programmes. A built-in automatic input checking facility should be made available whereby any illegal inputs can be identified and accordingly a warning signal is shown on the screen to notify the system operator to re-enter the information. For instance, when the current address of a child is entered into the computer system the checking facility would be able to identify, by system default, whether the child is a resident or not in the district. If a residence status code is entered, which does not match a street code and postal code, the system will not accept the input and require a correct coding. Still better, when the address is input the built-in data-checking facilities should automatically record him/her as a resident if the address is within the responsible district’s boundary regardless of where the child is born. If a child has moved out, the new address should be able to be recognised, by the system, in the district where the child has moved to, and accordingly the system would automatically change the residence status.
This work could be easily dealt with by the computer system since system files of “street code” and “postal code” already exist.

This recommended solution may apply to other situations as well. As presented in Section 4.2.2, some variables had been illogically recorded. This sort of illegal inputting error could also be avoided by system data checking programmes. Take mother’s date of birth as an example, when this date is entered the system should be able to check the validity of the information. If the date input is out of a valid range, i.e., the subtraction of the child’s date of birth from the mother’s reveals a ridiculous maternal age, say, under 10 or over 70 years, the system should not accept the information but give a warning to the staff to check the information, and re-enter (I found some mothers born in 1990!). Birth weight, gestational age and other variables could also be set with a “normal” range or valid codings which the system would only accept, or a warning be given on the screen. This strategy would greatly improve the validity and quality of the computer system data.

4.3.2 Transfer of child health data

One of the main findings from examining the completeness of records in child health computer systems was that records for movement-in resident children were far from satisfactory compared with those for at-birth and transfer-in residents. This was because the present format of the Movement-in Form was not detailed enough to provide adequate information about a child who moved from one district to another. The Movement-in Form should include all the same information as that recorded on the Notification of Birth plus any updated information, e.g., change of address, immunisations received, where and when, and other relevant data on health care procedures received. An alternative or complement in this regard would involve a copy of Notification of Birth being provided together with a specifically designed form on which information about events since birth was recorded, both to be sent to the child’s new resident district health authority; the former would provide basic demographic and birth data, with all information about health care events since birth recorded on the latter form. It was found that even the currently used Movement-in Form was not well completed by staff; many forms only provided the date of birth, name and address of the child, some with immunisation status but with most of the listed variables left blank. The provision of complete available information on transfer could improve greatly the completeness of computer data. The incompleteness of data for movement-in children is of even greater importance in inner city areas where the population is highly mobile compared with rural and suburban districts. As more children move between districts the overall completeness of the computer system data is likely to become worse if no steps are taken to solve this problem. The ideal (and realisable) solution would be to link computer systems between districts across the country so enabling comprehensive information to be transferred electronically between different systems.

The benefit of direct linkage of a child health system with other health care systems can be seen with the shorter notification time of children to the child health computer system in CHK where RICHS has been linked with PAS. City and Hackney is located in an inner city area, sharing the adverse features of other urban districts. As illustrated in Figure 4.3, the notification time would have been much longer if there had been no such connection between the two systems.
whereby birth information could be transferred directly from maternity wards into the child health office.

Why does it take a longer time for children in inner city areas to be notified to and registered in a child health system, not only transfer-in births but also at-birth resident children? It might be that not all birth attendants in some inner city areas recognise the importance of forwarding the Notification of Birth “within 48 to 72 hours”. By personal discussion and communication with child health managers and staff in the inner city districts, I noted that in some hospitals the birth attendants forwarded Notification of Birth “batch by batch” or “regularly”, say, once a week, rather than immediately after a child’s birth. I did not find any difference in notification time between babies with birth weights of less than 2,000 grams or more, suggesting that prolonged stay in hospital for neonatal care could not be a major excuse for late notification for inner city children where low birth weight is more likely. Instead, the human element appears to play the crucial part in causing delays, as will be further indicated by the views of health visitors in inner city areas about the timing of notification of birth (relevant results will be presented in Chapter Five).

4.3.3 Recording of non-resident children

It was found that up to nearly 60% of the records kept in the computer systems were children who did not live in the corresponding district (Figure 4.4). It was suggested in Section 4.2.4 that “duplicating” registration in a non-resident district might be a key factor associated with late notification to the resident district for transfer-in births. The recording of non-resident children in a district where the children do not live also has other effects. As discussed above, inputting of the data of non-resident children might cause incorrect recording of residence status and result in unnecessary forwarding of appointments, resulting in disorganisation of service sessions in general practice and child health clinics, as well as producing under-estimated local statistics on child health activities, e.g., immunisation uptake rates by including non-resident children in the population denominator. Another effect which should not be ignored is staff time. The staff responsible for the child register module, whose main duty is to enter relevant information into the computer systems, might spend up to 60% of their working time dealing with non-resident records. How valuable are the non-resident records for the district that holds little responsibility for these children in terms of management of their preventive health care? The non-resident children are living outside, the majority of them attend health care outside, and they will not receive appointments from the non-resident district’s system. The main reason for recording these non-resident children is because they are born within the district. It was noted that less than 10% of these non-resident children had their key information, e.g., immunisation and health surveillance, even partly recorded in the district system.

Do non-resident children need to be recorded in the system of a non-resident district? This question has been raised by staff, particularly in inner city districts where a larger proportion of non-residents are recorded in the systems. Some staff do not think it is necessary from a child health point of view, but others argue that the recording of non-resident children may provide useful information for local registrar and birth statistics. However, birth records could and should be only kept in hospital or birth attendants files. To accelerate child health computer
registration, if a child is born in a non-residence district, his/her Notification of Birth should be forwarded directly to the health authority of the child's resident district rather than the district where the child is born. Obviously, if the child is to receive health care, e.g., immunisation, health surveillance or treatment in the non-resident district, his/her record should be added to that system as an exceptional case.

4.3.4 Standardization of coding for variables

A tremendous variation in recording ethnic group was found in different districts (Table 4.5). This variation could result in adverse outcomes. For instance, if an Enfield district resident child whose parents originated from Africa, was born in Hampstead, the ethnic origin would have been recorded as “0” on the Notification of Birth. When the Notification of Birth was sent to Enfield, the recording “0” would be meaningless there. The staff might just leave the coding blank or copy “0” for the variable producing an illegal recording. If the child was from a Jewish family no category would match at all—the staff have to leave it blank or record it as “K” (others/unknown). The more worrying situation would be where, e.g., an Enfield child was born in a district where the regional coding system was used. If “A” (African origin) was recorded in the birth district, the staff in Enfield might copy the letter “A” into the computer and this child would have become of British origin! (“A” refers to United Kingdom in Enfield.) The same situation could occur for children who moved between districts where different codings for some other variables are used.

Many births take place outside the resident district and the infant population is very mobile in this country. As a result information has to be transferred from one locality to another. If the transfer takes place between two localities where different coding systems are employed the outcomes as presented above could happen with adverse effects on the accuracy of the information.

Therefore, it is highly recommended that the recording of all information variables in health care systems should be standardized and only one coding system should be used across the country—that is, a national standard coding system should be established for all health computer systems for all localities to adopt. Any local subclassification should accord with the “core” national classification.

4.3.5 Training of computer operating staff

Only when operating staff are properly trained can child health computer systems function most efficiently and effectively, and data be kept in the highest standard of quality. Present findings suggest that some data errors may have been caused by the quality of staff work per se. Some non-residents were wrongly recorded as residents, mothers were recorded as born in 1990, birth weight was greater than 7,000 grams and a considerable proportion (nearly half) of at-birth residents in Hampstead with no record of ethnic group, were caused by the operating staff. All these errors relate to the quality of the computer operating staff.

As will be presented and discussed in Chapter Five, overall less than 60% of the computer
operating staff had ever received formal training to operate the present computer systems and
nearly 85% of them were trained for less than six hours. Some health visitors also complained
that the computer operating staff were not able to cope with the child health systems because
they had not been well trained. Thus, the operating staff should be provided with initial
training. Updating training is also crucial when any new module or version of the system
programmes is introduced. In some districts the child health systems have been decentralised
down to clinic level. Some field staff are able to obtain and even to edit the data directly
via computer terminals available in health clinics. Undoubtedly this availability of facilities in health
clinics can be beneficial, i.e., to enable field health workers to access the system, to reduce
duplicative paper work, and to speed the flow of information exchange between health clinics
and child health offices. However, if the field staff are not properly trained the quality of data in
the system could worsen. Some child health managers were concerned that wide accessibility to
amendment programmes and poor training of users might result in the data held in the system
being “deleted or ruined”. Because field staff are less tightly administrated and organised than
system operating staff in a centralised district child health office, the quality of data input by
field staff is likely to be sub-optimal unless they have been properly trained, particularly when
systems are without self-data-checking facilities.

4.3.6 Child population registers

Ross and Begg [1991] anticipated that child health systems could be extended to provide a total
community register. There is a long way to go to meet this objective. The results obtained from
the available data in the present study indicated that there was a certain proportion of children
not registered in a child health system; the minimum under-registration was 5.4% and 2.9%
respectively, in Hampstead and Islington. These results obtained from two inner city districts
and therefore represent the extreme case. However, this finding appeared not to support results
reported by Jefferies et al [1991] that FHSA registers were more accurate than child health
systems. The present comparison suggested that under-registration of FHSA data was much
more likely than child health system data. The possible reasons for the lower registration in
FHSA’s systems include (a) a considerable proportion of children register with a general
practitioner outside their resident districts; (b) some children are registered with a private
doctor, hence are less likely to be on the FHSA’s register; and (c) up to 15% of children in
inner city districts are not registered with a general practitioner at all [Ross and Begg, 1991].

The aim of the registration module in a child health system is to register all district resident
children in the system and to serve as the basic database for other modules [CHCC, 1983;
1987; Home and Roy, 1988]. These aims can only be achieved by close collaboration between
district child health offices and all other units or staff relevant to a child population register,
e.g., local Registrar, FHSAs, hospitals, health visitors, and private doctors. This collaboration
should be backed up by legislation. In the short term there is an urgent need to link child health
systems with those of FHSAs and with community nursing systems. In the long term the
compatibility of all child health systems, and possibly all systems relevant to child health
services, may need to be established between districts and areas across the country, to enable
child health service information to be interchanged directly and electronically. Communication
between district child health staff and private doctors can be important in certain areas but might
only be ensured by legislative requirement.

In the present assessment of the completeness of computer data it has been assumed that all examined “valid” variables were accurate, i.e., that they provided the true relevant information. Theoretically speaking, in such an evaluation study, when one aspect is assessed other aspects are usually assumed to be in satisfactory state. This assumption, of course, needs to be validated.

The data stored in child health computer systems are routinely collected by all the various health staff involved in child health activities, rather than obtained in specifically designed epidemiological surveys. These data “collectors” and “inputters” of the computer system and other relevant staff are very likely not to have been trained as those involved in a formal epidemiological survey, and there might be no quality control during the collection and inputting of the data as there are usually during a survey. Thus, it is likely that the accuracy of the variable data might not be so high as that of data collected by a survey. From an evaluation point of view, assumptions need to be validated, but validation is only possible when a “gold standard” is available for comparison. This standard could only be the information obtained by approaching the subjects themselves. For example, to validate that a child recorded in a computer system is living at the computer’s address the family would have to be directly contacted. If the family confirmed the address then it can be accepted that this information recorded in the computer system is valid. Such an independent assessment of the accuracy of such data is desirable but beyond the scope and time scale of the present study.
5.0 PREVIEW

Health professionals have a key role in providing effective health services for children, and their attitudes to service activities can certainly affect efficient uptake of the services [Peckham, 1989]. Child health computer systems have been confirmed to have advantages over manual and semi-manual systems in respect of record-keeping, more efficient appointments, quicker identification of non-attenders and the promotion of uptake of child health services. However, their potential in all these fields largely relies on health staff, both those providing information for the systems and those who utilise the information from the systems. Therefore, these health professionals, together with the design of the systems per se, are fundamental factors ensuring optimal functioning of the systems. The information required by computer systems is routinely collected from various sources involving many different health professionals. Input into the computers is by specially trained computer operating staff. Health staff involved in child health activities are both providers and frequently also users of information. There seems no doubt that their attitudes to, enthusiasm about and support for the system could have a great deal of impact on its implementation and performance [Newman, 1983; Morris et al., 1988]. Despite the fact that computers were introduced into child health activities almost three decades ago in Great Britain, evaluation studies on the opinions of the relevant staff about the systems seem to have been scanty.

This chapter presents the results derived from a qualitative study using questionnaire information obtained from health professionals. This study was designed to investigate what these health professionals thought about various aspects of the computerised child health system and associated child health services in their localities in order to provide some information as a basis for taking necessary measures to improve the performance of child health computer systems.

5.1 METHODS

5.1.1 Study respondents

The selection of the ten districts from NET and NWT regions and the participants approached in the districts have been described in Chapter Three. The intentions of this qualitative study were not only to investigate the attitudes of health professionals from the different district locations within the region, but also to assess differences in the attitudes of those between the two regions where two different child health computer systems were being used.
5.1.2 Study procedures

Questionnaires
All questionnaires were pre-coded, self-administered, and were designed separately for health visitors, child health managers and the system operating staff. Information obtained from the questionnaires included the attitudes to the child health computer systems presently used in their district, data quality and questions about the effectiveness of the system. The staff's opinions about relevant aspects of general child health services provided in their localities were also investigated.

Generally, the questions were designed as three types: (1) multiple choice question under which possible answers were listed for the respondents to choose from; (2) gap-filling question under which space was provided (together with guiding words) for the respondents to fill in their response; and (3) scaling question under which a five-point scale from “low” to “high” marks was drawn for the respondents to grade on. At the beginning of the questionnaire a brief introduction to the study was presented, which was followed by examples showing the types of question to help the respondents understand how to complete the questionnaire. Questions were listed categorically in order that the respondents could see more easily what they were about. At the end of the questionnaire a “free comments” section was provided for the respondents to provide any additional comments on the relevant aspects. Copies of questionnaires for the health professionals are attached as Appendices.

Pilot study
Prior to commencing the definitive study the questionnaires were piloted, refined, and discussed with experienced public health workers, health visitor managers, health visitors of other districts or senior staff and information officers in the participating districts, who were not involved in the final study. This was to test the appropriateness (contents, format and language used) of the questionnaires. Modification to the questionnaires was made, and further discussion and modification followed until no negative comments were made on the final questionnaires which were then used for the formal study. The concrete methods of the collection of the data were also discussed and determined during this period of time.

Collection of questionnaire data
All health visitors, child health managers and the operating staff in the ten districts were targeted for inclusion in this study. In order to get as high a response as possible, it was decided to utilize the health visitors' regular meetings for the collection of questionnaire data. The investigator attended each of their patch meetings—around 30 individual patch meetings were involved in these ten districts, and the health visitors were introduced to the study and instructed how to complete the questionnaire at the meeting. Each health visitor present at the meeting was asked to complete and return the questionnaire within seven days. For those who happened to be absent from the meeting the responsible patch manager was provided with spare copies of questionnaire based on the name list of health visitors within her patch, and was politely reminded twice (two weeks and 30 days after) by letters or phone, if any of her health visitors did not return the questionnaire, to get it back.
The questionnaire for health visitors was completed anonymously for locality, an arrangement confirmed during the pilot study to be more acceptable to health visitors. Each health visitor was given a unique two digit code at the meeting, which was written down on the cover page of each health visitor's questionnaire. Only the investigator and the patch manager kept copies of the name list on which the code was matched with each health visitor. In this way the investigator would be able to trace possible non-respondents, and also comparisons between respondents and non-respondents could be made.

For child health managers and the computer system operating staff, the district administrative office of the child health department in each district was visited by the investigator (ten premises were visited). Prior to the formal study the date and time of visiting by the investigator was discussed with the child health manager and arranged so that all or most of his/her staff could be present so ensuring as high a response rate as possible. As with the health visitors, the manager and relevant staff were introduced to the study and instructed how to fill in the questionnaires which were collected after completion in the office at the time. Questionnaires for those not present at the meeting were collected by the manager and sent to the investigator, and if not, the managers were reminded.

5.2 THE QUALITY OF COLLECTED DATA

5.2.1 General response

The total number of health visitors currently employed and working in each individual district was obtained from the name lists of health visitors provided by district general nursing managers and locality (or patch) nursing managers. The information about whether they were working full time or part time, and their working years as health visitors was also provided on the name lists. Questionnaires were received from 340 of 388 health visitors working in the ten districts, giving an 87.6% of overall response rate. Table 5.1 shows the general response rate for health visitors from the ten NET and NWT districts.

<table>
<thead>
<tr>
<th>Region</th>
<th>Total number</th>
<th>Number responded</th>
<th>Response rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NET</td>
<td>212</td>
<td>187</td>
<td>88.2</td>
</tr>
<tr>
<td>NWT</td>
<td>176</td>
<td>153</td>
<td>86.9</td>
</tr>
<tr>
<td>All</td>
<td>388</td>
<td>340</td>
<td>87.6</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 0.05 \quad \text{degree of freedom (df) = 1} \quad 0.75 < P < 0.9 \]

A high response rate was obtained, leaving 48 (12.4%) who did not respond to the questionnaire. The response rates were not significantly different between the two regions (\( \chi^2 = 0.05, P \))
Comparisons were made between the 340 respondents and the 48 non-respondents in terms of the working years as health visitors, location of work (rural/suburban or inner city) and their post type (full time or part time). The results of the comparison showed no significant non-response bias that would have affected the main results. Details of discussion on possible bias will be fully presented in Chapter Eight.

For both child health managers (10 in total) and their clerical staff working as computer system operators (68 in total), a response rate of 100 per cent was obtained from all the ten districts in the two regions.

5.2.2 Specific response

Specific response refers to the extent to which individual questions are completed with a valid answer, i.e., the data can be used for the final analysis [Abramson, 1984]. This specific response can be crucially affected by the proportion of the respondents answering "don't know" or presenting blanks (i.e., no answer without reasons). Specific response rates were found to be more than 95% for most items eligible to be answered by the respondents. Specific response rate for individual question will be presented separately in the relevant Results sections.

5.3 RESULTS

HEALTH VISITORS

5.3.1 Basic characteristics of health visitors in different locations

Post type
Among the 340 health visitors 247 were working full time (defined as working more than 18 hours per week) and 93 part time (18 hours or less per week). No significant divergence was found ($\chi^2 = 0.80, P > 0.25$) in the frequency of post type between the two regions (Table 5.2).

<table>
<thead>
<tr>
<th>Type of post</th>
<th>NET</th>
<th>NWT</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Full time</td>
<td>140</td>
<td>74.9</td>
<td>107</td>
</tr>
<tr>
<td>Part time</td>
<td>47</td>
<td>25.1</td>
<td>46</td>
</tr>
<tr>
<td>All</td>
<td>187</td>
<td>100.0</td>
<td>153</td>
</tr>
</tbody>
</table>

$\chi^2 = 0.80$  df = 1  0.25 < P < 0.5

Years working as a health visitor
Working years were divided into three groups—less than one year, one to two years and three
years or more. (Initially on the questionnaire, working years were categorised as four groups. In the analysis, groups of 3 - 5 years and 6 years or more were merged due to small numbers in the last group.) The distribution of working years was compared between the NET and NWT districts, and it appeared that the observed proportion of health visitors having three years or more experience was smaller in NWT (75.8%) than in NET region (80.7%), but there proved to be no statistical significance ($\chi^2 = 1.2$, $P > 0.5$; Table 5.3).

<table>
<thead>
<tr>
<th>Region</th>
<th>Working years</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;1</td>
<td>1-2</td>
<td>≥3</td>
<td>All</td>
<td></td>
</tr>
<tr>
<td>NET</td>
<td>18 (9.6)$^+$</td>
<td>18</td>
<td>151</td>
<td>187</td>
<td>99.9$^+$</td>
</tr>
<tr>
<td>NWT</td>
<td>19 (12.4)</td>
<td>18</td>
<td>116</td>
<td>153</td>
<td>100.0</td>
</tr>
<tr>
<td>All</td>
<td>37 (10.9)</td>
<td>36</td>
<td>267</td>
<td>340</td>
<td>100.0</td>
</tr>
</tbody>
</table>

$+$: Figures in parentheses show percentages.
$^+$: Due to rounding numbers. $\chi^2 = 1.2$ df = 2 $0.5 < P < 0.75$

5.3.2 Attitudes to the computerised child health system

**Access to the system**

Access to a child health system meant that a health visitor had her own authorised user's name and password to allow her to log into the *child health system* to retrieve and/or input and update child health information via remote data capture facilities, i.e., a computer terminal available in her local clinic. This did not include access to a health visitor's own administrative computer system (whatever it was), running in some districts for administrative or Kömner reporting purposes, which all were, at the time, incompatible with the child health computer system.

No health visitors working in the NWT districts claimed to have access to their child health system, while in the five NET districts a total of 58 out of 187 health visitors (31.0%) stated that they had been authorised to use the RICH S system directly, among whom were 12 from rural/suburban districts (giving an access rate of 10.8%) and 46 from inner cities (access rate being 60.5%). It is obvious that more health visitors in the inner city districts had been provided with access to the computer system compared with those in rural and suburban areas ($\chi^2 = 49.8$, $P < 0.001$). There were two types of access to the system, logging onto the *enquiry* screen where only data retrieval was allowed, and access to both enquiry and *amendment* screens where data editing was possible as well as the retrieval of data; 33 (56.9%) of the 58 accessing health visitors were authorised for only data enquiry and 25 (43.1%) for both.

**Training in using the system**

It was found in the study that among those 58 accessing health visitors in the five NET districts, 19 (32.8%) said that they had *never* been formally trained (by *formally* trained it meant that a special course or time had been arranged for the purpose) in using the computer
system, and 25 were trained for two hours or less, 10 for three to five hours, and 4 for six hours or more. Table 5.4 shows the response of the 39 computer trained health visitors to the question enquiring about their perception of the usefulness of their training in operating the computer system; fourteen of them did not think that the training had been useful (rating point 1 or 2) and 16 stated that the training had been useful or very useful (rating point 4 or 5).

Table 5.4—Health visitors' view to the usefulness of training in using the computer system in the five NET districts

<table>
<thead>
<tr>
<th>Subjective scale</th>
<th>not useful at all</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>very useful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>3</td>
<td>11</td>
<td>9</td>
<td>8</td>
<td>8</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Percentage</td>
<td>7.7</td>
<td>28.2</td>
<td>23.5</td>
<td>20.5</td>
<td>20.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The numbers of health visitors who had access to the computer system and had been trained to use the computer system were too small to allow further analysis on this topic.

**Attitudes to the computer system**

All health visitors in both regions were asked to assess: (1) how *efficiently* the computer assisted child health system had been performing in their localities, specifically, whether and to what extent (a) the system had facilitated their access to child health information, (b) the introduction of computers had reduced their paper work in child health activities, and (c) the operation of the child health system had avoided any duplication in their child health records; and (2) how well the general information held in child health system was *updated* and how *accurate* it was.

Figure 5.1 demonstrates that the proportion of health visitors grading the efficiency of child health computer systems was negatively distributed, shifting towards the low-mark side, indicating that most health visitors were more or less unsatisfied with the efficiency of the child health systems; about 35%, 43% and 55% of them gave the lowest mark of point 1 to the three specific aspects of the efficiency of the systems, i.e., they did *not* think that the running of child health computing systems had facilitated their access to child health information, nor that the operation of the systems had avoided duplication activities in recording child health data, nor that the introduction of the systems had reduced their paper work in child health activities. On the other hand a nearly normal, indeed slightly positive, distribution was noted in the assessment of the quality of the computer data, suggesting that most of the health visitors considered that the general information held in the child health system was reasonably up-to-date and accurate.
Immunisation uptakes
A total of 336 health visitors responded to the question regarding the accuracy of reported immunisation uptake rates in their localities. No health visitors thought that the reported rate in their locality was higher than the "real" rate, i.e., rating point 4 or 5. Surprisingly, less than half (146) of the responding health visitors considered that the reported rates in their localities were the true rates (rating point 3), and the rest 190 (56.5%) believed that the rates were more or less under-estimated (rating point 1 or 2). To identify any variation in the view about computer reported immunisation uptake rates between health visitors working in different locations, i.e., rural, suburban and inner city districts and in NET and NWT regions, rating points were re-grouped into two main categories—rates under-estimated (points 1 and 2) and rates correctly reported (point 3), and logistic regression analysis was used to study the strength of the association between the health visitors' view and their working locations.

It was found that the subjective view of health visitors related to both region ($\chi^2 = 6.90, P < 0.01$) and district location ($\chi^2 = 52.34, P < 0.001$). The odds on the reported rates being under-estimated among the inner city health visitors were greater than among their rural/suburban counterparts by a factor of $e^{1.72} = 5.6$ (95% C.I. 3.4 - 9.0), and the odds among NWT health visitors were 1.9 times (95% C.I. 1.2 - 3.1) that among health visitors in NET, indicating that health visitors working in NWT and in inner city districts were more likely to consider the reported immunisation uptake rates as being under-estimated.

It has been suggested that under-reported immunisation rates are mainly linked to inadequate information exchange between health professionals [Morris et al., 1988]. This hypothesis was investigated by asking the health visitors how much inadequate communication between health professionals contributed to any incorrectly reported immunisation uptake rates. In order to
minimise the possible response bias, communication directly involving health visitors was excluded from the analysis, and the focus was placed on that between general practitioners and the district child health department staff, and between child health departments and child health clinics. Child health departments as the site of child health system were involved, and general practices and child health clinics were included since they were the main locations where children were normally vaccinated and the major sources of immunisation information for the child health computing systems.

Overall, 320 and 321 of the 340 health visitors respectively assessed the first and the second communication channels. Figure 5.2 shows that many more health visitors (58.8%, 188/320) considered “problematic” communication (rating point 1 or 2) between general practitioners and child health departments as an attributing factor to the under-estimation of the immunisation rates, compared with only 17.1% (55 of the 321) health visitors who thought that communication between child health departments and health clinics was problematic.

![Figure 5.2](image)

**Figure 5.2—Subjective view of health visitors about communication between general practitioners (GPs) and child health department staff (CHD), and between child health clinics (CHCs) and child health departments, contributing to incorrect reported immunisation uptake rates**

5.3.3 Attitudes to general child health services

Notification of births

Information flow between health professionals was investigated here by asking health visitors about how soon they were usually notified about a child’s birth. Overall, in NET 9.6% of health visitors said they were not informed about a child until 10 days or more after the child’s birth and only 3.2% indicated that birth information reached them within 48 hours, whereas in NWT, the corresponding proportions were 2.1% and 11.8% respectively. These figures suggest that, generally, it took less time for a health visitor to be notified of a birth in NWT than
in NET.

However, these crude proportions might be confounded by the proportion of health visitors working in different types of area, i.e., rural, suburban or inner city districts. It was found that of the 187 health visitors in the five NET districts, 111 (59.4%) were working in rural and suburban districts, and of the 153 in the five NWT districts only 59 (38.6%) were from rural and suburban areas, the difference in these distributions being significant at the 1% level ($\chi^2 = 10.3$). It is believed and has been confirmed by findings presented in Chapter Four that a mother living in an inner city district is more likely to deliver her baby outside her home district, hence it might take longer for birth information to arrive at the resident child health department for transmission to the health visitor. To assess this possibility, I broke down the numbers of health visitors in each region into those working in rural/suburban areas and those in inner city districts. The fact was that in both regions, rural/suburban health visitors were notified about a birth earlier than were those in inner city districts. Notification times in both rural/suburban and inner city districts seemed more likely to be delayed in NET than in NWT districts (Table 5.5).

### Table 5.5—Notification of birth to health visitors in the two regions, by type of district

<table>
<thead>
<tr>
<th>Region</th>
<th>Type of district</th>
<th>Notification period (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0-2</td>
</tr>
<tr>
<td>NET</td>
<td>R/S</td>
<td>5 (4.5)</td>
</tr>
<tr>
<td></td>
<td>City</td>
<td>1 (1.4)</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>6 (3.3)</td>
</tr>
<tr>
<td>NWT</td>
<td>R/S</td>
<td>13 (22.0)</td>
</tr>
<tr>
<td></td>
<td>City</td>
<td>5 (5.3)</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>18 (11.8)</td>
</tr>
</tbody>
</table>

R/S: Rural and suburban districts; City: Inner city districts.
Figures in parentheses show percentages.

To assess quantitatively the association between notification time and the type of district and region, a logistic regression model was used, where the notification period was re-grouped as less than or equal to five days, and six days or more. The fitted model suggested that the notification time related not only to the district location within a region ($\chi^2 = 18.84$, $P < 0.001$), but also to the region itself ($\chi^2 = 6.97$ and $P < 0.01$); the odds on a baby being notified on or after the sixth day of life to an inner city health visitor was 2.8 (95% C.I. 1.7 to 4.5) times that to her colleague in a rural or a suburban district, and 1.9 (95% C.I. 1.2 to 3.0) times greater to a NET health visitor than that to one in NWT.

When the subjective view of health visitors about the timing of their being notified about a child’s birth was studied, a similar pattern was noted; rural and suburban health visitors seemed more likely to be satisfied than those in inner city areas in both NET and NWT. Among the 340 health visitors who responded to the question, 26% in rural/suburban districts said that they usually received the birth information “in good time”, while in inner city areas less than five percent graded “in good time” (Figure 5.3).
North East Thames

North West Thames

Figure 5.3—Subjective view of health visitors as to the appropriateness of notification of birth in rural/suburban and inner city districts and in NET and NWT regions

In a further analysis using the same statistical modelling methods, the health visitors were re-categorised according to their grading points to the question—those notified in reasonably good time (point 1 or 2) and those notified rather late (point 3, 4 or 5)—to quantify the association between the health visitors' point of view and their working locations. The statistical estimates obtained from the model suggested that the subjective view of health visitors as to the appropriateness of birth notification was strongly associated with district location ($\chi^2 = 34.19$, $P < 0.001$); the odds on being notified about a birth "rather late" for inner city health visitors was nearly 4 (95% C.I. 2.4 to 6.4) times that for their rural/suburban counterparts. But this subjective view was not significantly related to which region they were working in ($\chi^2 = 0.89$, $P > 0.25$). Data in Table 5.5 and the subjective view (Figure 5.3) seemed to suggest that health visitors in NET were less likely to regard birth notification on or after the sixth day of a child's birth as a delay (even though they were more likely to be notified on or after this time), compared with their counterparts in NWT.

**First home visit to a neonate**

There is no officially recommended age range for this first home visit by the health visitor although in most districts health visitors are expected to take over from the community midwife from the tenth day after birth. It was found in this study that 334 (98.2%) of the 340 health visitors stated that they normally made their initial home visits between the 10th and 15th day after birth, this age being uniform across inner city and rural/suburban districts and between NET and NWT.

However, when asked whether and how frequently late home visits to a neonate occurred—whenever they happened—inner city health visitors were more likely than rural/suburban,
to blame late birth notification (Figure 5.4) with no regional variation ($\chi^2 = 1.47, P > 0.1$). The regression model estimated that the odds on attributing late notification of a child’s birth as a cause of late neonatal home visit (rating point 3, 4 or 5) among inner city health visitors was, on average, 5.9 times (95% C.I. 3.6 to 9.8) greater than that among rural/suburban health visitors ($\chi^2 = 53.84, p < 0.001$).

![Figure 5.4](image)

**Figure 5.4—Subjective view of health visitors as to the lateness of birth notification causing delayed home visits to a neonate in NET and NWT districts**

**General training in child health care**

The health visitors were asked about general training in preventive child health care (e.g., about childhood immunisation or/and pre-school health surveillance). The questions asked included (1) whether and how many days they had been provided with training during the past year? (2) how useful was the training they had received in guiding their practical child health activities? (3) how often did they think such training should be provided for them, and (4) had any training actually been arranged for them in the coming six months.

Among the 333 health visitors (representing 97.9% of the total respondents) who presented valid answers to the first question, 72 (21.6%) stated that they had been provided with no training in child health care during the past twelve months, and 55 (16.5%), 167 (50.2%) and 39 (11.7%) reported training for less than one day, one to five days, and 6 to 20 days respectively. There was no regional variation in the quantity of training provided for health visitors ($\chi^2 = 4.2, P < 0.25$; Table 5.6). No significant difference was found in the training time between health visitors with different lengths of work experience, i.e., working less than one year, one to two years and three years or more in both NET and NWT.
Table 5.6—Training time (days) in preventive child health provided for health visitors during the previous 12 months, by region

<table>
<thead>
<tr>
<th>Region</th>
<th>None</th>
<th>&lt;1</th>
<th>1 - 5</th>
<th>6 - 20</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NET</td>
<td>43 (23.8)</td>
<td>24 (13.3)</td>
<td>90 (49.7)</td>
<td>24 (13.3)</td>
<td>181 (100.1)†</td>
</tr>
<tr>
<td>NWT</td>
<td>29 (19.1)</td>
<td>31 (20.4)</td>
<td>77 (50.7)</td>
<td>15 (9.9)</td>
<td>152 (100.1)†</td>
</tr>
<tr>
<td>All</td>
<td>72 (21.6)</td>
<td>55 (16.5)</td>
<td>167 (50.2)</td>
<td>39 (11.7)</td>
<td>333 (100.0)</td>
</tr>
</tbody>
</table>

Figures in parentheses show the percentage. \( \chi^2 = 4.2 \) df = 3 0.10 < \( P < 0.25 \).
†: Due to rounding of numbers.

Question 2 was answered by all 261 health visitors eligible to respond, i.e., those who had received some training during the past year regardless of hours. On a five-point scale from “not useful at all” to “very useful”, most health visitors who attended training rated 4 or 5, suggesting that they were satisfied with the training in guiding their practical child health activities. There appeared no difference in the assessment of the training between health visitors from the two regions \( (\chi^2 = 2.0, P < 0.75; \text{Table 5.7}) \).

Table 5.7—Health visitors’ assessment of training in preventive child health provided during the past year, by region

<table>
<thead>
<tr>
<th>Subjective scale</th>
<th>not useful at all</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>very useful</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NET</strong></td>
<td>3 (2.2)</td>
<td>9 (6.5)</td>
<td>46 (33.3)</td>
<td>43 (31.2)</td>
<td>37 (26.8)</td>
</tr>
<tr>
<td><strong>NWT</strong></td>
<td>1 (0.8)</td>
<td>10 (8.1)</td>
<td>34 (27.6)</td>
<td>41 (33.3)</td>
<td>37 (30.1)</td>
</tr>
<tr>
<td><strong>All</strong></td>
<td>4 (1.5)</td>
<td>19 (7.3)</td>
<td>80 (30.7)</td>
<td>84 (32.2)</td>
<td>74 (28.4)</td>
</tr>
</tbody>
</table>

Figures in parentheses show the percentages. \( \chi^2 = 2.0 \) df = 4 0.50 < \( P < 0.75 \).

Question 3 sought information about whether and how often the health visitors themselves considered general training in preventive child health care should be provided for them. These views were analyzed with stratification by years of working experience, since it was considered that the desire for training might vary depending on experience. It was found that all 338 (two missing data) health visitors, except three who had worked for more than six years, thought that training in preventive child health care was necessary for them and that it should be provided regularly and more or less frequently. It was found that 40.7%, 43.6% and 37.6% health visitors, with experience of less than one year, one to two years and three years or more, thought that training should be provided every three months (quarterly). There seemed no tendency for less experienced health visitors to desire more frequent training in child health care than those with more experience, or vice versa \( (\chi^2 = 3.9, P > 0.50; \text{Table 5.8}) \).
When studying the response to the fourth question an apparent trend appeared that the less experienced health visitors were more likely to have training sessions arranged in the coming six months ($\chi^2_{\text{trend}} = 12.4, P < 0.01$; Table 5.9). The overall $\chi^2$ statistic was 12.7 and the test for departures from linear thus gave $\chi^2_{\text{departures}} = \chi^2_{\text{overall}} - \chi^2_{\text{trend}} = 12.7 - 12.4 = 0.3$, which is clearly non-significant on 1 degree of freedom [Armitage and Berry, 1987]. There was thus a definite linear trend for the proportion of health visitors arranged to attend for training sessions in child health care to decrease at an approximately equal rate as working experience increased from less than one year, one to two years, to three years or more (Table 5.9). From Tables 5.8 and 5.9 the conclusion might be drawn that the less experienced health visitors had been provided with more chance to receive further training, although their personal perceptions of the need for training were no stronger than that of their more experienced colleagues. Alternatively, experienced health visitors' requirements for further training were not being met.

### Table 5.9—Proportion of health visitors with training in preventive child health arranged for the coming six months, by work experience

<table>
<thead>
<tr>
<th>Working years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td>119 (35.0)</td>
</tr>
<tr>
<td>1 - 2</td>
<td>81 (30.3)</td>
</tr>
<tr>
<td>≥ 3</td>
<td>16 (56.8)</td>
</tr>
</tbody>
</table>

+ Figures in parentheses show percentages.

$$\chi^2_{\text{overall}} = 12.7 \quad df = 2 \quad 0.001 < P < 0.01$$

$$\chi^2_{\text{trend}} = 12.4 \quad df = 1 \quad P < 0.001$$

$$\chi^2_{\text{departure from linear}} = 0.3 \quad df = 1 \quad 0.5 < P < 0.75$$

### 5.3.4 Free comments made by the health visitors

At the end of the questionnaire health visitors were provided with an opportunity to make addi-
tional comments on relevant aspects that they thought the questionnaire did not cover or which they thought needed to be reinforced. Sixty-four of the 340 health visitors made comments which covered a wide range of topics in respect of child health computer systems and general child health services in their localities. Some comments were enthusiastic, but most were critical, together with generally constructive suggestions. I studied all these comments with great interest. For this presentation the comments have been categorised under the following headings relevant to this study.

**Direct access to the computer system**

This was the most frequent request/demand by the health visitors with almost half (29) of those commenting including it in their remarks. Some just mentioned its necessity, some presented reasons why direct access should be made available, and some described possible negative outcomes if direct access was not made available for health visitors. Here are some of the comments quoted from the health visitors.

— "Too much time is spent completing forms for the computer system for someone else to enter. It would be quicker and more accurate to have direct access to the system to enter one’s work personally. This would also speed the flow of information."

— "Anything that relieves the HVs (health visitors) from manual activities such as writing
records, ... and telephoning to make appointments for checks and visits would allow the HVs to have more time for regular home visits which I consider essential to perform health promotion in the area in which it is needed more."

— "It would be very beneficial to have direct access to the information held—thus saving numerous phone calls, ... and this would enable easy updating of case load and identification of areas of need."

— "... The current system involves a lot of duplication in paperwork.... The main reason for duplication is because we do not have direct access to the computer and so record information manually AND have to inform the computer in the child health department. Being able to tap straight into computer to add/update/amend/extract information would reduce the amount of work currently necessary."

— "... I can see the benefits of a (computer) system where I could quickly access for myself the immunisation and developmental assessment status of children on my case load—freeing me of much repetitive paperwork, enabling me to set aims and objectives for visits, etc. ... This is my opinion—but I think many of my colleagues hold similar views."

**Communication between professionals**

In the free comments there were 15 health visitors who reiterated the importance of communication between health professionals. Some health visitors pointed out that the child health computer systems should be made compatible with other systems, e.g., the health visitors’ own system, the general practitioners’ systems, or any systems which were in use in other health authorities, to facilitate more efficient exchange of information, to reduce duplicated paperwork, and to make statistics more accurate. This seems particular important in those areas where mobility of the population is common. They stated that:

— "... There should be some enforcement compelling GPs to communicate with clinics/health visitors."
"... Until there is a legal obligation for all doctors (especially private doctors) to register immunisations given the rates obtained will not be accurate."

"There appears to be a major problem in communication between local health authorities,... so a computer system needs to be able to cope with a high mobility rate, if it is to be of any use in this district."

"If the FHSA computer systems had exchange systems regarding certain aspects of information, i.e., immunisation, with any health authority's computer in use, problems in recording information would be less."

"There needs to be some sort of 'official' system to gather information—whereby we know what the children, who attend child health clinics or GPs in other districts, have done, and... that they do not repeatedly get sent reminders to attend clinics here."

"... Communication between GPs and child health department seems very poor, and information about immunisations given at GP practice takes too long to be entered into the computer."

"The problem of late notification of new births from... hospital has been going on for a long time. This is a great nonsense... I have brought it to the attention of various managers at various times."

**Training to “computer staff”**

Twelve health visitors pointed out in their additional comments that some of the “computer staff” had not been properly trained; some of the health visitors thought that the lack of training for computer staff would be the main source of data error. Here are some of their comments.

"The reason the immunisation uptake rates are underestimated is, I believe, due to our correct details on the scheduled and unscheduled forms being input into the computer wrongly by temporary untrained staff."

"The biggest problem with monitoring immunisation uptake data is the incorrect and delayed input by temporary and bored VDU operators into the health care system. It doesn't matter which one is used, the human element is the main factor for false data."

"There is a paramount need for full and adequate training in the basic understanding and use of computers, and the need for accurate recording of information if the system is to work; regular up-dating of this training and the employment of highly qualified staff to manage information systems are crucial. ... Too often the 'computer staff' cannot cope because they are not properly trained."

"It seems that the whole computer system was brought in, in a very haphazard fashion. The computer operators seem to be poorly trained which may be the reason for the many errors and queries, time and time again!!"

**CHILD HEALTH STAFF**

Child health staff were restricted, in this study, to those who were working at the district central office of a child health department, and who were dealing with child health system data, i.e., the system data operating staff. Sixty-eight such staff in the ten districts were eligible for inclusion and all of them participated in the study and responded to the questionnaire. Data on their views about the child health systems were analyzed in the following aspects.
5.3.5 General views about the systems

The child health systems or the programmes in the systems were assessed by their operators or users as to whether and how the system they were operating was user friendly, i.e., how simple and easy was it to handle? In this aspect four operating staff in a NWT district were excluded in the analysis because they did not have computer terminals available in their office and their assessment might not be comparable with that of staff who were dealing with the data directly on computer terminals.

Data from the 64 staff in the nine districts were analyzed. Figure 5.5 shows the comparison of the views between NET staff who were using RICHS and NWT staff who were operating on NCHS. From the figure it appeared that RICHS was more likely to be considered by its operating staff in NET as a system that was user friendly compared with NCHS operated by staff in NWT. It was considered that the attitudes to the systems or programmes in the systems might be affected by the working experience of staff, i.e., the length of time that staff had been working with the system. So I re-analyzed these data using a logistic regression modelling technique in which the factors of region and of the operating experience (represented by the length of working years with the systems) were considered simultaneously. When modelling, the subjective scales were re-grouped into a binomial variable, i.e., the “positive” answers (points 4 and 5) and “negative” (points 1, 2 and 3), and the working experience of the staff was categorised as less than one year and one year or more.

![Subjective view of child health staff about the user-friendliness of the systems](image)

Figure 5.5—Subjective view of child health staff about the user-friendliness of the systems

A well fitted model suggested that the attitudes to the systems related strongly to the region in which the staff were working ($\chi^2 = 8.2, P < 0.01$) and also, marginally, to the length of operating experience of the staff ($\chi^2 = 5.2, P = 0.025$); the estimated odds ratio of “negative”
response among the NWT staff was 5.2 (95% C.I. 1.5 - 18.0) to 1.0 among NET colleagues, and the odds on negative response among the staff with less than one year’s operating experience was 3.8 (95% C.I. 1.1 - 13.2) greater than among those who had worked longer. This analysis confirmed that RICHS was more likely to be considered by operating staff as a user friendly system, compared with the national system, allowing for the staff’s working experience in operating the systems. The model also indicated that the longer the operators had worked with a computer system, the more likely they would be to appreciate its user friendliness.

5.3.6 Views about general quality of computer data

General quality of the computer data was assessed by all 68 operating staff in two aspects, i.e., how up-to-date and how accurate the computer data was thought to be. These 68 operating staff working with the two different types of computer system were asked to assess these two areas by grading a point on a five-point scale from “not at all” (point 1) to “very much” (point 5). Figure 5.6 reveals that the general quality of both computer systems was thought by their operators to be reasonably high, particularly in terms of data accuracy. The curves in each graph, representing the two regions, appear to vary slightly, which might indicate that the NET staff were happier with the general quality of data stored in their RICHS system, compared with the NWT staff with that in the national system. However, no significant variations in either aspect between the two regions were statistically identified by chi-square test or by modelling analysis allowing for the working experience of operating staff.

![Figure 5.6](image)

Figure 5.6—Subjective view of the staff about the general quality of data in terms of updating and accuracy

The operating staff were asked to indicate possible reasons listed on the questionnaire responsible for any non-updating of the computer data. Possible reasons listed were poor
communication with relevant staff, lack of time to up-date, and others (for the staff to state any other reasons). When analyzing the responses I noted that the "lack of time to up-date" was not considered a major problem; almost all staff in both regions rated points 1 or 2, meaning that this had never or seldom happened to them. However, it was found that 36 staff (52.9% of the total) considered inadequate communication (point 1 or 2 on the scale) as being responsible for non-updating of system data, as shown in Figure 5.7. This means that poor or inadequate communication between the computer operating staff (i.e., in the district child health department) and other health professionals providing the computer staff with relevant information required for updating, was considered by more than half of the computer staff as the chief or at least one of the chief reasons responsible for non-updating of child health computer system data. No significant regional variation was identified on this ($\chi^2 = 3.50$ on 4 degrees of freedom, $P > 0.25$) although the observed proportion of staff who considered that communication between relevant health workers was problematic was greater in NWT than in NET.

![Subjective view of the staff about the contribution of communication between relevant health workers to the non-updating of computer data](image)

Figure 5.7—Subjective view of the staff about the contribution of communication between relevant health workers to the non-updating of computer data

Other possible reasons were given by the computer operators, including "need to refer back to sender due to incomplete or incorrect information", "lack of awareness of the need to update on a regular basis", "lack of compulsory data updating imposed at all levels", and "doctors' surgeries not completing forms correctly". These reasons were given by only a small number of staff and therefore could not be statistically analyzed, although they may provide a basis for improving system data, and probably they are more important in some districts than in the others.

Possible reasons for the inaccuracy of computer data were also investigated by asking the operating staff to grade a point on a five-point scale for various factors listed on the question-
naire. These factors included change of child's address, change of child's name, input errors made by operating staff, recording errors in the original documents (i.e., Notification of Birth, Neonatal Discharge Form, Movement-in Form, Immunisation Return, and any other documents on which the computer data were based), and poor standardisation of record codings used in the systems.

Figure 5.8 illustrates the response of the 68 staff. The contribution of each factor to the inaccuracy of computer data varied, according to the staff, and there was no significant variation by chi-square in the contribution of each factor between NET and NWT staff. From the figure an apparent pattern can be noted, that the distribution of ratings given to the factors of changes of address (Graph a) and of name (Graph b) swerved towards "problematic", indicating that these two factors were considered important reasons for inaccurate data. The distribution of "staff input errors" was left-shifted (Graph c), which suggests that staff did not think their input errors contributed much to inaccurate computer data. Regarding possible errors in the original documents and poor standardisation of record codings, most staff rated a middle point with few extremes (Graphs d and e), suggesting that staff considered these two factors as real but not big problems affecting the accuracy of computer data.

Figure 5.8—Subjective view of the operating staff about the contribution of various factors to the inaccuracy of computer data
(a) Change of address
(b) Change of names
(c) Staff input errors
(d) Errors in original document
(e) Poor standardisation of record codings
5.3.7 Training

Of the 68 operating staff, only 40 (58.8%) stated that they had ever been formally trained to operate the present computer system. (Formal training meant that a special course or special time had been arranged for the purpose.) There existed a marginally significant variation ($\chi^2 = 4.5, 0.025 < P < 0.05$) in the proportion of staff having been formally trained between the two regions; in NET 17 out of 37 staff (45.9%) compared with 23 of 31 in NWT (74.2%). Among the 40 staff in the two regions who had been formally trained, 12 (30.0%), 21 (52.5%) and 7 (17.5%) said they were trained for less than 2 hours, 3 to 5 hours and 6 up to 10 hours respectively. There was no difference in training hours provided for the staff between the two regions ($\chi^2 = 2.4, P > 0.1$). It was noted that 16 of the 17 trained staff in NET were trained in the child health department where they were working, while in NWT training courses were provided at regional level for 15 of the 23 trained staff; the remaining 8 in their own department. Overall, 72.5% (29 out of 40) said they were more or less satisfied with the training courses, and the satisfaction rate was similar regardless of where the training courses were given, 70.8% in child health departments against 75.0% at region ($\chi^2 = 0.00013$). The desire of staff to receive training was investigated. It was found overall, that desire for training was not strong for 20 staff, who gave their rating point 3, and that more staff in NET wanted training; 8 (26%) and 11 (35%) of the NET staff thought training was “necessary” or “very necessary”, compared with 6 (16%) and 3 (8%) in NWT. In a logistic regression model, where the work experience (less than one year and one year or more), whether staff had been previously trained (yes/no), and the region (NET/NWT) were taken into account simultaneously, with the desire for training re-grouped into two categories—strong (points 4 and 5) and weak (points 1, 2 and 3), it was found that staff’s desire for training did not relate to work experience ($\chi^2 = 2.0, P > 0.1$), nor to region ($\chi^2 = 2.9, P > 0.05$), but to whether they had previously been trained in using the present computer systems ($\chi^2 = 5.2, P < 0.025$). The fitted model suggested that the odds on strong desire for training among those who had not been trained before was greater than among those who had been previously trained by a factor of $e^{0.95} = 2.6$ (95% C.I. 1.2 - 5.5).

**CHILD HEALTH MANAGERS**

All ten child health managers in the ten study districts responded to the questionnaire. The main purpose was to assess general views of these managers regarding the performance of child health activities including computing systems in their districts. The results are presented under the following headings.

5.3.8 The computer systems

By the time the study was undertaken nine of the ten districts had been provided with computer terminals in the district child health department offices. In one, microfiches were still being used as tools for the staff to retrieve, amend and update child health information. The response from the manager in that district was excluded from this analysis. First of all, when asked...
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whether and how much the district had generally benefited since starting using the present system with terminals available in the district office, grading their assessment on a five-point scale (point 1 for "not at all" and point 5 for "a lot"), five of the nine managers rated point 5, one rated 4 and three point 3. Their ratings indicate that the present child health systems with available terminals were very much appreciated by the child health managers.

The benefits were further studied in more concrete categories, including whether and how (much) the present system (a) speeded up the daily work, (b) was user friendly, (c) reduced the manual work, and (d) avoided administrative duplication work. Table 5.10 demonstrates the average assessments which indicated that the present systems were considered efficient and effective for local child health activities.

Table 5.10—Average scale point\(^t\) of the assessment given by child health managers, to the presently used child health computer systems in the nine districts

<table>
<thead>
<tr>
<th>Category</th>
<th>Mean scale</th>
<th>Median scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speeded up daily work</td>
<td>4.1</td>
<td>4.0</td>
</tr>
<tr>
<td>User friendly</td>
<td>3.9</td>
<td>4.0</td>
</tr>
<tr>
<td>Reduced manual work</td>
<td>3.7</td>
<td>4.0</td>
</tr>
<tr>
<td>Avoided duplication work</td>
<td>3.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

\(^t\): Five-point scale from point 1 (not at all) to point 5 (very much).

5.3.9 Training

All nine child health managers (NWH was excluded) stated that they had received formal training to manage and use the present computer system. Training hours ranged from 5 to 72 hours, with a median value of 20 hours. Seven of the nine managers also thought they would need refresher or update training, either every quarter (4 managers), or every six months (3 managers). Two considered refresher training unnecessary for them.

Refresher or update training for their computer system operating staff were considered essential by all nine managers; two said training should be provided monthly, two said quarterly, three every six months and two irregularly. However, only five managers said that training had already been arranged within the next six months for their computer operating staff.

5.3.10 Child health services

Managerial aspects

The following information relevant to child health services in the ten districts was obtained from the child health managers; (a) the number of district community health clinics operating, and (b) the total number of pre-school child health clinic sessions held in these clinics in one year.

The original aims in collecting these data were to understand: (1) how many pre-school health care clinic sessions were carried out in relation to the pre-school population, and (2) whether there existed significant variation in the numbers of clinic sessions in relation to the pre-school
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population among these ten districts.

Based on information obtained from the child health managers and population data (1988 mid-year estimated population, OPCS), some statistics were derived as shown in Table 5.11, which lists the number of community child health clinics in each district, the total number of child health clinic sessions held in one year (1989) at these clinics, and, in order to provide comparisons between districts, the total pre-school population. The table also lists the ratio between the proportions of children registered for immunisations at general practices (GP) and those at community child health clinics (HC).

Table 5.11—Comparative data on some indicators of child health services among the ten study districts

<table>
<thead>
<tr>
<th>District</th>
<th>No. of clinics</th>
<th>Sessions run/year</th>
<th>Population/clinic (000s)</th>
<th>Clinic session/100 population</th>
<th>GP children/HC children</th>
</tr>
</thead>
<tbody>
<tr>
<td>BHB†</td>
<td>21</td>
<td>1300</td>
<td>1.4</td>
<td>4.6</td>
<td>11.8</td>
</tr>
<tr>
<td>HAR†</td>
<td>14</td>
<td>936</td>
<td>1.0</td>
<td>7.0</td>
<td>2.4</td>
</tr>
<tr>
<td>NWH†</td>
<td>35</td>
<td>1364</td>
<td>0.5</td>
<td>8.1</td>
<td>3.2</td>
</tr>
<tr>
<td>WEX†</td>
<td>18</td>
<td>1130</td>
<td>0.9</td>
<td>7.0</td>
<td>23.0</td>
</tr>
<tr>
<td>BRT</td>
<td>13</td>
<td>3672</td>
<td>1.0</td>
<td>19.6</td>
<td>1.0</td>
</tr>
<tr>
<td>CHK</td>
<td>15</td>
<td>2496</td>
<td>1.1</td>
<td>15.9</td>
<td>1.2</td>
</tr>
<tr>
<td>HAM</td>
<td>6</td>
<td>520</td>
<td>1.0</td>
<td>8.5</td>
<td>0.8</td>
</tr>
<tr>
<td>ISL</td>
<td>8</td>
<td>1820</td>
<td>1.5</td>
<td>15.3</td>
<td>0.3</td>
</tr>
<tr>
<td>PNK</td>
<td>8</td>
<td>1901</td>
<td>1.0</td>
<td>23.3</td>
<td>0.3</td>
</tr>
<tr>
<td>RIV</td>
<td>19</td>
<td>2173</td>
<td>0.8</td>
<td>13.9</td>
<td>0.7</td>
</tr>
</tbody>
</table>

†: Rural and suburban districts.

It can be seen that the number of health clinic sessions per hundred pre-school population (0-4 years) and the ratio of GP children to HC children varied greatly among the ten districts. An apparent pattern appeared that rural and suburban districts were running fewer clinic sessions in relation to pre-school populations, compared with inner city districts, and the ratio of children registered at general practices to those attending child health clinics was greater for the former type of districts than for the latter type.

Immunisation performance

In these ten districts, immunisation appointments were forwarded to the clients some one to two weeks in advance. The interval to appointment seemed shorter in the six inner city districts compared with that in the four rural and suburban districts, being 12.5 days on average (10, 12, 14 and 14) in the latter districts and 9.0 days (6, 7, 9, 10, 10, and 12) in the former. Some inner city district child health managers remarked in the free comment section in the questionnaire that the appointment interval might be a key factor "causing" so many children not to attend scheduled appointments but to attend opportunistically. As will be presented and discussed in Chapter Six, inner city children were more likely not to attend for scheduled immunisation than those in rural and suburban districts, and unscheduled immunisations were likely to be done later than the recommended ages. Did higher acceptance rates for scheduled immunisation and longer appointment intervals in the rural and suburban areas occur by coincidence, or did shorter appointment intervals directly contribute to the poor acceptance of
invitations to immunisation?

To answer these two questions I studied the response from the ten child health managers regarding immunisation appointment interval and the average proportion of appointments not kept by clients, in order to examine whether there existed any correlation between these two factors. Figure 5.9 shows a significant correlation, with a higher proportion of unaccepted immunisation appointments correlated with shorter appointment interval ($r = -0.90, P < 0.001$), i.e., a longer interval apparently "resulted" in a higher acceptance rate of immunisation appointments. This tendency held when inner city and rural/suburban districts were considered separately.

![Graph showing correlation between immunisation appointment interval and proportion of appointments not kept.](image)

**Figure 5.9—Correlation between immunisation appointment interval (in days) and the proportion of the immunisation appointments NOT kept by the clients in the ten districts**

Some other possible factors were also evaluated as why so many immunisation appointments were not kept, especially in inner city areas. The factors included appointments not received by the parents, immunisation session time and/or venue not convenient for the clients, incorrect appointments (e.g., change of address or movement out of the district), immunisations refused by the parents, and a shortage of immunisation staff. All these factors were assessed by the managers by rating a point on a five-point scale from "never happens" (point 1) to "always happens" (point 5).

According to the ten managers, the inconvenience of immunisation sessions (time or/and venue) was the main possible reason for non-attendance at immunisation appointments, with the mean and median ratings being 3.1 and 3.0 respectively. It seemed least likely that immunisation appointments were not kept because the parents refused immunisations (mean and median ratings being 2.0). The possibility of other factors "causing" non-attendance at appointments lay in between (Table 5.12).
Table 5.12—Assessment by the ten child health managers regarding factors possibly contributing to non-attendance at immunisation appointments

<table>
<thead>
<tr>
<th>Factor</th>
<th>Mean scale point</th>
<th>Median scale point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immunisation session not convenient</td>
<td>3.1</td>
<td>3.0</td>
</tr>
<tr>
<td>Incorrect appointment</td>
<td>2.8</td>
<td>2.5</td>
</tr>
<tr>
<td>Appointment not received by parents</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Shortage of immunisation staff</td>
<td>2.4</td>
<td>2.0</td>
</tr>
<tr>
<td>Immunisation refused by parents</td>
<td>2.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

The managers were also asked to scale the accuracy of reported immunisation uptake rates in their districts. The results revealed a very similar pattern to that demonstrated by health visitors; no managers believed that the reported uptake rates were over-estimated, and only two managers considered rates as being correctly reported (BHB and CHK), four rated point 1 and four point 2. No discernable pattern was noted between rural/suburban and inner city managers.

Similarly, the attitudes of the ten managers to communication between the district child health departments and general practices, and between the departments and health clinics and its contribution to incorrectly reported immunisation rates in their districts were investigated using a five-point assessment scale from “problematic” (point 1) to “no problem” (point 5). The tendency was very clear for child health department/general practice communication: managers in the four rural and suburban districts rated points 3, 3, 3 and 2, while in the six inner city districts four managers rated point 1 and, two point 2. For child health department/clinic communication, the grading varied from 2 to 5, with the mean and median scale points being 3.0 and 3.0 respectively, and no obvious trends. These results from the child health managers, together with those from health visitors, provided further evidence that communication between general practices and community child health departments is likely to be a key element affecting incorrect reporting of immunisation rates, especially in inner city areas.

5.4 DISCUSSION

5.4.1 Child health computer systems

It is useful when evaluating a child health computer system to examine what facilities the system can provide, how much information it can generate and how accurate the generated information is, i.e., the outputs of the system in relation to its inputs. A computer system, however, is operated by people and it seemed equally important to assess what the users thought about the system, its ease of handling and its user orientation.

In the present questionnaire study, subjective assessment of two computer systems included the views of system operating staff, child health managers and health visitors. There was wide
variation in views about the systems with a considerable proportion of interviewees not satisfied with the systems in one or more areas.

Among the system operating staff, the most direct users of the systems, RICHS was considered a more user friendly system than NCHS; the odds on the latter (NCHS) staff regarding the system as less user friendly were 5.2 times greater than for the former. Immunisation rates generated by RICHS in the NET districts were also more likely to be considered as the real statistics by the health visitors compared with those produced by NCHS. These differences might be associated with the fact that RICHS is a relatively recently designed system, taking into account the problems, shortcomings and limitations of older systems. NCHS was originally designed as a “batch” processing rather than an “on-line” editing system, with data mainly processed centrally—in the regional computer centre. The system operating staff at district level had minimal access to the system data. During the past three years or so, a new more interactive version of the national system has been introduced with data entry facilities available in the districts [Ross and Begg, 1991]. However, the new version may not have gone far enough to allow a completely free and flexible access to system data by users at district level. For instance, the districts can not generate all aspects of the statistics on demography and child health services, instead they still have to rely on the regional computer centre to get such pieces of information, and this exchange mechanism might be less efficient. On the contrary, districts running RICHS can get every single piece of information, from demographic data to child health statistics, directly from their own machines, with less dependence upon the regional centre [CHCC, 1987; Horne and Roy, 1988]. The availability of complete facilities at district child health offices may ensure more efficient exchange of child health information between the relevant health staff at different service levels.

According to the child health managers in the nine districts that had data entry facilities in their district offices, both types of system as presently used in the two regions had produced considerable benefits, particularly in terms of speeding up the daily work, and reducing manual preparation of child health records. However, the health visitors in the districts had different views—up to 55% of them complained that the running of the computer systems in their districts had not sped up their daily work at all, nor reduced paper work or avoided duplicative tasks. Many of them even said the systems had increased their paper and duplication work loads. These different views between child health managers and health visitors towards the benefit of computer systems may be associated with the limited access of health visitors to system data. Health visitors have to maintain their own records and duplicate the same information to send to the district office for computerisation. Therefore, as one HV commented, “having a centralised computer system with manual application at the point of delivery of service leads to duplication and a lot of time wasted”. This may be the reason why so many health visitors expressed a wish for direct access to the child health systems and stated the necessity of establishing efficient data exchange mechanisms between health professionals.

5.4.2 Communication between health professionals

Efficient functioning of a child health computer system relies, among other factors, on high quality data, i.e., complete, accurate data optimally updated. Data accuracy and updating are
largely determined by the effectiveness of communication between health professionals. Almost all health care providers are involved in exchanging child health information [Morris et al., 1988], e.g., birth attendants, health visitors, other community nurses, general practitioners, hospital medical staff, private doctors, child health department administrative staff, and other relevant staff in FHSA and in local Registrars offices. Child health data may also need to be exchanged between adjacent districts or across the country when a family moves. There is no doubt that any hold-ups in data exchange could result in malfunction of a computer system, adversely affecting the quality of child health data, and perhaps, important aspects of population child health care. The importance of efficient exchange of data between health professionals is fundamental to effective information and health care systems.

This topic was discussed in Chapter Four, where the focus was placed on child health department staff/birth attendant communication in the exchange of birth data. It was demonstrated in that chapter that birth data did not always arrive at the responsible child health department as early as it could and should, indicating that the communication between birth attendants and child health department staff was less efficient in some localities, especially in inner city areas.

In this chapter the questionnaire data has again suggested poor communication between health professionals in some localities (especially, again, in inner city districts) where health visitors were more likely to be notified late about a birth, where more health visitors delayed their initial home visits to a neonate because of late notification of births, and where the reported immunisation uptake rates were more likely to be considered as being under-estimated, and the underestimate was more likely to be attributed to poor communication between general practices and child health departments. The outcomes of this latter communication problem, if confirmed by objective assessment, are likely to be serious if measures are not to be taken, as general practitioners are undertaking more preventive child health activities.

Generally in these ten districts, more child health clinic sessions in proportion to the pre-school population were held in inner city districts, but no improved proportional increased outcomes were obvious (Table 5.11 and Figure 5.10 in section 5.4.3). This finding provided little support for continuing the present high level of clinics in inner cities although there were other adverse social and environmental factors which would have to be taken into account [Jarman et al., 1988]. Poor communication between health professionals seems a likely important factor which is not often considered. Optimal communication seems particularly important in inner city areas where the population is far less stable than in rural and suburban districts. Powerful and effective systems of information exchange between health professionals, between departments, and between localities are required when children move, to ensure that complete information is available on the child health system of the new district of residence.

Some children not recorded in the local system may participate opportunistically in health services. Information about these children may not be fed back to the system because of inadequate communication between service providers and the child health system operators. Such deficiencies may distort the quality of child health system data and the accuracy of local and probably national statistics on child health services; such adverse influence has been well
Many health visitors recognise the urgency for improving communication between health professionals. Recommendations made include establishing direct access by all field health workers to computerised child health system data, compatibility of child health computer systems with health visitor information systems and with other health systems (e.g., FHSA's and the systems used in other districts), and the development of an "official" standard system to gather and exchange child health information, which would "speed the flow of information" between field workers and child health department so ensuring high quality health services for the child population.

To improve communication between health professionals and to ensure high quality of child health data some strategies are being piloted or have been launched in some areas, e.g., the development of a new version of NCHS, which "moves away from centralised batch processing to an on-line system based in districts" and "allows direct data entry" [Ross and Begg, 1991], connecting a child health system with the FHSA system [Home, 1990; Mahony, personal communication, 1991], with health visitors' [Ross and Begg, 1991], and with hospital's administrative systems [Caulfield, personal communication, 1990]. If these strategies were successfully presented nationwide, with legislative back-up (e.g., mandatory data exchange between health professionals, especially from general practitioners and private doctors), the quality of child health data and the standard of child health services would be greatly improved [Nicoll et al., 1988].

5.4.3 Number of health clinic sessions in relation to local child population

Having analyzed the response from the child health managers, data derived from the computer systems and the 1988 OPCS population data in the ten districts, I found that in general more child health clinic sessions were held in inner city child health clinics compared with rural and suburban clinics (Table 5.11). By and large, the populations, especially the pre-school population, in these underprivileged inner city districts seem likely to need more health resources allocated in order to meet general targets than would the less deprived rural and suburban districts [Jarman, 1984; Jarman et al., 1988]. The present results suggest that, to some extent, the policy of "more needy populations need more resources" (here through running more health clinic sessions) has been realised, at least in these ten districts. However, there is also the principle that "more resources should result in better health outcomes". An important outcome in the assessment of pre-school health is uptake of immunisations. There is no evidence from the present results to show, for example, that BHB, which on average ran five health clinic sessions per hundred pre-school population a year, had a poorer immunisation uptake than PNK, where 23 sessions were held in relation to one hundred pre-school population—nearly 5 times more, indeed rather the reverse.

Obviously, there are marked differences in the two populations and further research is needed. However, running more health clinic sessions did not appear to "produce" higher immunisation uptakes. Figure 5.10 illustrates the relationship between the number of clinic sessions per
hundred pre-school population run in the community child health clinics in the ten study districts and uptake. The data appeared to indicate a negative association between these two variables \((r_{P3} = -0.86, P < 0.001; r_{MMR} = -0.77, P < 0.001)\), suggesting that immunisation outcomes became less satisfactory as the number of health clinic sessions increased.

It is unlikely that running more health clinic sessions for pre-school children directly resulted in poorer outcomes. The correlation results indicate, however, that running more clinic sessions alone does not seem to be an efficient strategy to increase the uptake of immunisation and possibly surveillance. Other factors may be crucial, such as immunisation location, maternal age, family size, one-parent family status and resident location as will be presented in next chapter, among which immunisation location was identified as an important factor associated with childhood immunisation uptake (see Chapter Six). To improve immunisation uptakes child health clinics may need to provide more convenient sessions, e.g., evening or Saturday morning clinics. There may be benefits from extended crèche facilities for siblings and from domiciliary immunisation services provided, particularly for "problem" families.

### 5.4.4 Training programmes

Almost all health visitors in these ten districts considered general training in preventive child health care necessary, and most of them thought that training should be provided for them every three to six months. The desire for training in this field was similar among health visitors with different years of working experience. However, only 35% of the health visitors had training sessions in preventive child health care arranged in the coming six months. Districts seemed to
grant higher priority to training less experienced health visitors. This priority seems common sense, but the fact was that more experienced health visitors expressed a similar desire for training as their colleagues with shorter working experience (Table 5.9).

Proper training of health visitors in preventive child health care, notably on immunisation programmes, is very important. Previous studies have demonstrated that many health professionals, including health visitors, did not fully appreciate the association between immunisations and the diseases being prevented [Nicoll and Ross, 1985; Peckham et al., 1989]. An appreciable proportion of children with certain medical conditions but eligible for the immunisations [DH, 1992] might have been advised not to be vaccinated with certain types of vaccine because the health staff thought wrongly that these medical conditions were contraindications to immunisation. This is thought to have led to a considerable proportion of eligible children missing immunisations that would have otherwise been given [Harding and O’Looney, 1984; Kemple, 1985; Nicoll, 1985; Nicoll and Ross, 1985; Moules, 1987].

Some health visitors believed that inaccuracies in the computer data resulted, more or less, because system operating staff had not been properly trained. This belief was justified. Among 68 system operators only 58.8% said that they had ever been formally trained to operate the present computer system; the proportion of trained staff was lower in NET districts (45.9%). The overall low proportion of trained staff was not because staff did not see the need for training, but because they had not been provided with the opportunities; the odds on training being wanted by staff who had received no training were 2.6 times greater than among those who had received some. Therefore, districts should provide all operating staff with sufficient training before they begin to use the computer system, followed by refresher or update training. As a strategy to obtain as high quality data as possible, operating staff training seems especially important. According to the trained staff, training given at district level produces outcomes at least as good as training provided at Region.

Poor training in operating the system was also demonstrated among the 58 health visitors in the five NET districts who had been authorised access to the child health computer system. Only 39 (67.2%) said they had ever been formally trained to use the system, among whom only 41.0% (16 rating point 4 or 5) were satisfied with the training and three said the training had been “not useful at all” (Table 5.4). Extrapolating from these proportions it can be estimated that if all health visitors were authorised to use child health systems (67.2% of them trained, but only 41.0% of these satisfied with the training), then fewer than 30% of total health visitors would be able to use the computer systems properly. If the percentages were to remain so low, there would be little sense in decentralising a system down to clinics with so many untrained or not properly trained health visitors and other field health staff having access to the system. This would seem very likely to reduce the quality of the computer data, particularly if data editing was authorised.

In summary, large amounts of money have been spent on the computer systems. Adequate training does not appear to have been provided. There appear to be other problems with the systems, especially from a field worker view point. Nevertheless benefits of the systems have been considerable. Recorded immunisation rates have risen considerably since computer
systems have been introduced, almost certainly due to computers enabling both more accurate recording of procedures (the numerator) and a more accurate population register (the denominator). Child health computing systems now also provide an opportunity to assess, on a total population basis, surveillance uptake, the usefulness (or otherwise) of various procedures and a facility to "target" specific groups in need of enhanced health care provision or individuals with "special needs".
6.0 PREVIEW

Immunisations have contributed powerfully to the control of certain infectious diseases both in individuals and in populations. Vaccines, however, differ from most other medicines in two important respects. First, they are offered to individuals who in most cases are currently in good health and, secondly, they are promoted not only to benefit the recipient by giving personal protection but also the rest of the population by reducing the spread of infection. The fact that vaccinating children is an effective primary preventive procedure has been well recognised by the majority of parents as well as health professionals, yet immunisation coverage rates in Britain have until very recently fallen far short of ideal [Lancet, 1983; Jarman et al., 1988], lagging behind those in most industrialised nations and even some developing countries [Nicoll et al., 1988]. To improve the situation various strategies to increase uptake of immunisations have been launched, including special information campaigns, computer controlled immunisation systems, the running of child health clinics at times suitable for parents, the increased availability of expert opinions on immunisation, and the re-education of those responsible for education about immunisation [Nicoll et al., 1988]. Some of these methods have resulted in great improvement in outcome in certain groups of children, but they have failed to reach other groups of children in some areas, notably in underprivileged inner city areas [Baker et al., 1984; Peckham et al., 1989; Li and Taylor, 1991]. Recently, there has been a renewed interest in the identification of factors influencing childhood immunisation uptake, in part to improve the relatively poor coverage in British children and to meet the goal of vaccinating at least 90% of the target population, set by the WHO and including European countries [Begg and Noah, 1985].

The aim of this chapter is to demonstrate the status of immunisations against diphtheria, pertussis, tetanus, poliomyelitis and measles, mumps and rubella. Various aspects were studied, including overall coverage rates, age at immunisations, the proportion of children attending different immunisation locations, and factors associated with variation in uptake of immunisations between different groups of children.

6.1 METHODS

6.1.1 Immunisation versus vaccination/vaccine

The substantial basis of an immunisation service seems clear, i.e., to protect individual children from infectious diseases by giving them specific antigens called "vaccines". However, there has
been a debate on the terminology used to describe the immunisation process. In recent literature "immunise/vaccinate" and "immunisation/vaccination" have been used almost interchangeably [Cooke, 1992]. There is no authoritative guide to define in what circumstances which term should be used. In this thesis the terminology used has been based on the following principles. (1) When describing the service to administrate vaccines to target populations "immunisation" has been used, e.g., coverage or uptake of immunisation which implies the proportion of children having received the service (vaccine). The term "vaccination" has been avoided as mainly applying to small-pox immunisation. (2) It was considered that to "vaccinate" a child was more appropriate than to "immunise" a child in describing the procedure of giving vaccine to the child when no serological evidence was available that the child had immunologically responded to the vaccine (e.g., produced antibodies). A child who received a vaccine may not respond immunologically to the vaccine; in this case the child has been vaccinated but not immunised [Waterston, 1992].

6.1.2 Immunisation status

The status of immunisations against diphtheria (D), pertussis (P), tetanus (T), poliomyelitis (Polio) and measles, mumps and rubella (MMR) was examined in terms of coverage, age at administration and other characteristics of the procedures. The immunisation schedule recommended by the Joint Committee on Immunisation and Vaccination [DH, 1990], from May 1st 1990 and current during the study period, has been 2, 3 and 4 months for the first, second and third doses of primary immunisation course (D(P)T and Polio vaccines) and 12 to 18 (usually 15) months for the multi-antigens of MMR (see Table 2.1). Therefore, all children (except for the few with definite contraindications to certain immunisations [DH, 1990]) should have received all these immunisations when the study was undertaken, i.e., when the children were 19 to 21 months of age.

6.1.3 Definition of variables in this study

Initially registered immunisation location
The registered immunisation location referred to the premise which a child was initially registered to attend for his/her due immunisation procedures. In this study, immunisation location chosen by the parents for their child’s immunisation procedures were categorised as (1) a general practice surgery; (2) a community child health clinic; and (3) others, which included a premise outside the child’s district of residence, a private doctor/clinic, a hospital, or an “unknown” location (in this case the information was not recorded in the child health computer system).

Actually attended immunisation location
This denoted the place where a child had actually received his/her immunisations. The categorisation of this location was the same as that of the initially registered immunisation location.

Immunisation scheduling arrangements
As has been discussed in Chapter Two, when a child attends a session for immunisation as a
result of receiving an appointment sent by the computerised call and recall immunisation module, the procedure received by this child will be recorded in the system as a scheduled procedure. If a child attends a clinic uninvited, or for other medical reasons and the doctor vaccinates this child the procedure will be recorded as an unscheduled (or opportunistic) procedure. There are a few other immunisation procedures notified to the computer system by parents, health visitors, private doctors or FHSAs; this group of immunisation procedures were defined as others in this study.

**The “old” and “new” immunisation schedules**

The “old” immunisation schedule for primary immunisation procedures, valid until April the 30th 1990, [DHSS, 1988], was 3, 5 and 8.5 months for the first, second and third doses of D(P)T and Polio vaccines. The “new” schedule is 2, 3 and 4 months for the three doses of primary immunisations [DH, 1990]. The recommendation for MMR vaccine was unchanged at 15 months (see Table 2.1).

**“Stable” and “mobile” child population**

The “mobile” child population was defined, in this study, as those children who used to live in an outside district and who subsequently moved into the current residence district, with “stable” population referring to those children who had been living in the current resident district since birth. Because the computer systems would not change the residence status of a child who moved within a resident district [CHCC, 1983; Horne and Roy, 1988], “mobile” population referred only to those children who moved between districts, and those who changed their addresses within a district would still be considered as “stable”.

### 6.1.4 Data analysis

Three steps were involved in data analysis. Firstly, a descriptive presentation of immunisation status, including overall immunisation uptake rate for all the procedures, the age at immunisations, immunisation locations where children were registered for due procedures and where they actually received the vaccines, and variations in the uptake rates between groups of children. Secondly, uni-variate analysis procedures (e.g., chi-square test, chi-square test for trend and non-parametric test) were used to investigate possible associations of uptake rate and immunisation age with certain demographic, familial and service factors. In this aspect of the analysis, only the status of immunisations against diphtheria, pertussis and against MMR was studied. This choice was based on the ground that (a) diphtheria, tetanus and polio vaccines were usually given at the same attendance and shared very similar (often identical) uptake rates [Jarman et al, 1988; DH, 1990], and (b) uptake of the immunisations against pertussis and MMR has been usually less satisfactory than that of other immunisations of the primary course with children facing more difficulties in getting these immunisations in this country. Thirdly, multivariate analyses, e.g., logistic regression modelling technique and modelling for survival time data, were employed to study the direction and strength of the association of uptake or immunisation age with a specific factor, allowing for other related factors, i.e., in epidemiological terms, to control for possible confounding effects of other factors on a specifically studied association [Kleinbaum et al, 1982].
In the logistic regression analyses the response variable was whether (1) or not (0) a child had been vaccinated. Effects of other variables (predictors of the response) on the response variable were evaluated by fitting a logistic regression model; if the effect of a variable significantly contributed to the variation of immunisation uptake, the variable would be included in the model, otherwise excluded. In this study the criterion for including a predictor variable in the final model was set to be that the inclusion of this predictor variable would increase the predictive power of the model at the $\alpha = 0.05$ level, i.e., in modelling terms, the change of the deviance due to including or excluding the variable was significant at the set level (0.05). The direction and strength of the predictor variable would depend on the sign and value of the estimated coefficient of the variable in the model [Kleinbaum et al., 1982; Aitkin et al., 1990].

Due to highly skewed, i.e., far from normal, distributions of immunisation age data and an inability to normalise the distribution by data transformation, it was inappropriate to use ordinary linear regression to study the factor-immunisation age association. Therefore, analysis of survival time data theory was used to study the effect of a specific factor (often called the prognostic factor in survival data analysis) on survival times (response variable) with other factors controlled. In this study, the "survival times" referred to the time from the start (birth) to the occurrence of the event (receiving the vaccine). The Cox's proportional hazards model was fitted, where immunisation age was the response variable. From the fitted model a prognostic factor was evaluated in terms of its effect on immunisation age by checking the sign and value of coefficient of the factor [Everitt, 1989; Armitage and Berry, 1990; SAS Inc., 1991].

Detailed discussion on statistical studies, particularly on logistic regression and Cox's proportional hazards model for survival data, will be presented in Chapter Eight.

6.2 RESULTS

6.2.1 Descriptive data

Where were children initially registered for due immunisations?
There were 7,841 children in the three month birth cohort and resident in the ten study districts at the end of October 1991. Of these children 4,549 (58.0%) of their parents had selected a general practitioner surgery as the premise for their child's due immunisation procedures, and 2,925 (37.3%) had chosen a community child health clinic, with the remaining 4.9% (387) children being registered either at a premise outside their resident district, a private doctor/clinic, a hospital, or at an "unknown" premise (information was not available).

There was a wide variation in the proportion of children initially registered at these immunisation locations (notably general practice versus child health clinic) between low deprived rural/suburban districts and high deprived inner city districts. Figure 6.1 illustrates that in the four rural and suburban districts 80.2% of children were "allocated" to general practitioner surgeries for their immunisation procedures, with 14.1% attending child health clinics, compared with 38.7% and 57.1% for the six inner city children.
Figure 6.1—Proportion of children initially registered at different immunisation locations, by type of district

Where did children actually get vaccinated?
A total of 48,319 procedures of primary immunisations (D(P)T, Polio and MMR) had been received by a total number of 7,385 children in the ten study districts by the time the children were 19 to 21 months of age, when the analyses were undertaken. Overall, some 32% of the procedures were carried out in community child health clinics and 60.9% in general practitioner surgeries, with the remaining of 7.4% given at other premises.

Wide variations were identified between rural/suburban and inner city districts. As illustrated in Figure 6.2, children resident in inner city districts were more likely to have their immunisations at community child health clinics, with most children in rural and suburban districts being vaccinated at general practitioner surgeries; in the former type of districts 52.3% of the procedures were done in child health clinics, compared with 14.2% in the latter, and 81.5% of the procedures given to rural/suburban children were carried out in general practices compared with 41.2% to their inner city peers. A slightly higher proportion of inner city children (6.5%) fell into the category of others compared with 4.3% of their rural and suburban counterparts.

Did children attend the registered location to receive immunisations?
It can be seen from figures 6.1 and 6.2, that some children did not apparently attend the immunisation location to which they were initially “allocated”. In order to determine how many children, an investigation was undertaken to compare, on an individual child basis, the proportions of children who did or did not attend their initially registered immunisation location for their third dose of pertussis immunisation.
Data on 6,503 children were available for this investigation. It was found that overall, 93.9% of them attended their initially registered location for immunisations, with 6.1% attending another premise. Again, a considerable difference was noted between rural/suburban districts and inner cities ($\chi^2 = 89.4$, $P < 0.001$). Table 6.1 shows that 96.8% (95.7% to 97.9%, 95% C.I.) of rural and suburban children attended the initially registered immunisation location for the third dose of pertussis, whereas in inner city districts the proportion was 91.2% (90.2% to 92.2%, 95% C.I.). The greater change in inner city districts was mainly a reduction in children attending child health clinics, and probably reflects the increasing trend for immunisation to be done at general practitioner surgeries resulting from the new GP contract introduced from the 1st April 1990 [NHS, 1990].

Table 6.1—Number of children who attended or did not attend the initially allocated immunisation location for the third dose of pertussis immunisation, by type of district

<table>
<thead>
<tr>
<th>District</th>
<th>Attended initially registered location?</th>
<th>Total†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes (%)</td>
<td>No (%)</td>
</tr>
<tr>
<td>Rural and suburban</td>
<td>3091 (96.8)</td>
<td>102 (3.2)</td>
</tr>
<tr>
<td>Inner city</td>
<td>3018 (91.2)</td>
<td>292 (8.8)</td>
</tr>
<tr>
<td>Total</td>
<td>6109 (93.9)</td>
<td>394 (6.1)</td>
</tr>
</tbody>
</table>

†: Data of 124 children were not available.

For the analyses of the associations between immunisation uptake and immunisation location, initially registered location was used since the actual place of immunisation was available only for those children who had been vaccinated.
**How had immunisation procedures been arranged?**
The proportions of scheduled and unscheduled immunisation procedures and those from other sources were examined. These data were only available from the five NET districts.

It was found that a total of 26,787 primary and MMR vaccines had been received by 4,002 children in these five NET districts. Overall, 15,589 of the immunisations (58.2%) were given opportunistically, i.e., unscheduled, and some 36% (9,691) were given on schedule, with 5.6% (1,507) from other sources. A significant difference was noted between districts; for rural and suburban children, 52.2% of immunisations were done by scheduled appointments and 42.9% given opportunistically (unscheduled procedures), with about 5% others, compared with 17.7% scheduled, 75.8% unscheduled and 6.5% others for inner city children (Figure 6.3). These results suggested that immunisation appointments produced and forwarded by the computer system were more likely to be kept by rural/suburban clients, and children in inner city areas were far more likely to receive their immunisation procedures opportunistically.

![Figure 6.3](image)

*Figure 6.3—Proportion of immunisation procedures carried out according to their scheduling arrangements in the five NET districts, by district location*

It may be argued that it is of no fundamental importance whether a child attends a scheduled or unscheduled immunisation session as long as he or she gets vaccinated. However, I compared the *age* at scheduled and unscheduled immunisation sessions for the third diphtheria and found a considerable delay for children vaccinated at unscheduled sessions compared with those vaccinated at a scheduled appointment; as Figure 6.4 indicates, the median ages were almost 30 days different—171 versus 197 for the third dose of diphtheria ($\chi^2 = 7.8$, $P < 0.01$ (Kruskal-Wallis one-way analysis of variance)).
Figure 6.4—Cumulative proportion of children vaccinated with third dose of diphtheria, by age

Overall uptake rates
Table 6.2 shows the 19 - 21 month uptake rates of the immunisations against diphtheria, pertussis, tetanus, poliomyelitis and MMR for the study cohort.

Table 6.2—Immunisation uptake rates (numbers and percentages) for children aged 19 to 21 months resident in the ten NET and NWT districts

<table>
<thead>
<tr>
<th>Immunisation against</th>
<th>No. vaccinated</th>
<th>Uptake rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diphtheria</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st dose</td>
<td>7175</td>
<td>91.5</td>
</tr>
<tr>
<td>2nd dose</td>
<td>7083</td>
<td>90.3</td>
</tr>
<tr>
<td>3rd dose</td>
<td>6935</td>
<td>88.4</td>
</tr>
<tr>
<td><strong>Pertussis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st dose</td>
<td>6897</td>
<td>88.0</td>
</tr>
<tr>
<td>2nd dose</td>
<td>6789</td>
<td>86.6</td>
</tr>
<tr>
<td>3rd dose</td>
<td>6627</td>
<td>84.5</td>
</tr>
<tr>
<td><strong>Tetanus</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st dose</td>
<td>6175</td>
<td>91.5</td>
</tr>
<tr>
<td>2nd dose</td>
<td>7083</td>
<td>90.3</td>
</tr>
<tr>
<td>3rd dose</td>
<td>6935</td>
<td>88.4</td>
</tr>
<tr>
<td><strong>Poliomyelitis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st dose</td>
<td>7167</td>
<td>91.4</td>
</tr>
<tr>
<td>2nd dose</td>
<td>7073</td>
<td>90.2</td>
</tr>
<tr>
<td>3rd dose</td>
<td>6924</td>
<td>88.3</td>
</tr>
<tr>
<td><strong>MMR</strong></td>
<td>6415</td>
<td>81.8</td>
</tr>
</tbody>
</table>

†: Population denominators = 7,841.

Four general patterns seemed to be clear from the table: (1) uptake rates were almost identical for diphtheria, tetanus and poliomyelitis, reflecting the fact that these three immunisations were usually given to a child at the same attendance; (2) the differences in uptake rates between the second and the first and between the third and the second doses of the primary immunisations (D(P)T and Polio) were about two per cent, indicating that some children were only “partly”
vaccinated with one or two doses missing; (3) the target of 90% for immunisation had not been met for this cohort of children by the age of 19 to 21 months; and (4) the rates for pertussis (84.5%) and MMR (81.8%) immunisations were notably low.

Age at immunisations
The triple (DPT) components of primary immunisations together with poliomyelitis immunisation are usually given at the same attendance [Jarman et al., 1988; DH, 1990]. Some children have pertussis omitted (for good or bad reasons) but receive the other three vaccines. Therefore, it was decided to use the age at diphtheria to represent the primary immunisation course. The age at MMR immunisation was also investigated. Table 6.3 demonstrates the age, in weeks, at which primary diphtheria immunisation and MMR vaccine were received by the children resident in the ten districts. The results were derived from those children whose immunisation age was available.

Table 6.3—Age (in weeks) at which the three doses of diphtheria and MMR immunisation were given

<table>
<thead>
<tr>
<th></th>
<th>Number vaccinated</th>
<th>Median</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>90th centile</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st dose</td>
<td>7160(15)†</td>
<td>13.0</td>
<td>13.5</td>
<td>5.4</td>
<td>17.0</td>
</tr>
<tr>
<td>2nd dose</td>
<td>7080(3)</td>
<td>19.0</td>
<td>20.8</td>
<td>8.0</td>
<td>27.0</td>
</tr>
<tr>
<td>3rd dose</td>
<td>6921(14)</td>
<td>26.0</td>
<td>28.8</td>
<td>10.7</td>
<td>40.0</td>
</tr>
<tr>
<td>MMR</td>
<td>6406(9)</td>
<td>58.0</td>
<td>60.0</td>
<td>8.3</td>
<td>70.0</td>
</tr>
</tbody>
</table>

†: Figures in parentheses are numbers of children with missing data on immunisation age.

The data revealed that the distribution of immunisation ages were negatively skewed for all three doses of primary and the MMR immunisation, as suggested by higher means compared with medians. The results showed that 50% of the vaccinated children had been or were vaccinated before or on the 13th, 19th, 26th and 58th week for the three doses of diphtheria and the MMR, respectively, and the corresponding 90th centile (i.e., the age point by which 90% of the children had been vaccinated) were 17, 27, 40 and 70 weeks, indicating that an appreciable proportion of children had not been vaccinated by the recommended times [DHSS, 1988; DH, 1990]. The data also suggested that the range of immunisation ages was wider for later immunisation compared with earlier, reflected by the larger standard deviations and the larger difference between the 50th and 90th centiles for the later doses.

It was perhaps unfortunate that the new immunisation schedule became operational in May 1990—a crucial time for immunisation procedures for this cohort of children—which meant that it was very difficult to evaluate the mean (or median) age for the three doses of primary immunisation because of the change of immunisation schedule. However, there was no change for MMR immunisation [DHSS, 1988; DH, 1990].

The 50th and 90th centiles of the age at MMR immunisation were found to be 58 and 70 weeks (about 13.5 and 16.5 months), suggesting that at least 90% of the vaccinated children had received the MMR immunisation within the recommended maximal age (18 months). The data
in Table 6.4 suggest that most (67.4%) children received their MMR between 52 and 65 weeks (between about 12 and 15 months), with about one fourth between 66 and 78 weeks (between about 16 and 18 months). However, some children were vaccinated outside the recommended maximal age; about 4% of children received the MMR later than 78 weeks (18 months).

<table>
<thead>
<tr>
<th>Immunisation age (weeks)</th>
<th>Number</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;52</td>
<td>285</td>
<td>4.4</td>
</tr>
<tr>
<td>52-65</td>
<td>4318</td>
<td>67.4</td>
</tr>
<tr>
<td>66-78</td>
<td>1570</td>
<td>24.5</td>
</tr>
<tr>
<td>&gt;78</td>
<td>233</td>
<td>3.6</td>
</tr>
</tbody>
</table>

When examining immunisation age at diphtheria I compared the age with the “old” immunisation schedule, i.e., 3, 5 and 8.5 months for the three doses [DHSS, 1988]. The criteria for defining appropriateness of immunisation age are listed in Table 6.5. The proportions of children in the three categories were calculated according to these criteria. It was found that even with the “old” schedule, although most immunisation procedures were given within the recommended times, a considerable proportion of children had delays; between 10% and 59% of the vaccinated children were delayed for up to 8 weeks, and 4% to 8% more than 8 weeks (Figure 6.5). The results were derived from comparing actual immunisation age with the “old” immunisation schedule. It can be assumed that if the “new” schedule, which is earlier than the “old” one, had been used the proportion of children with delayed immunisations would have been even greater. All the proportions presented were based on children who had been vaccinated by the age of 19 to 21 months.

![Figure 6.5 — Age at immunisations in relation to the “old” immunisation schedule](image-url)
### 6.2.2 Variation in immunisation status

In this section, results of the association between immunisation status and various factors will be presented. Immunisation status included two aspects; uptake rate and age at immunisation. Tables 6.6 and 6.7 summarise the associations between various factors and immunisation status of three doses of diphtheria and pertussis, and the MMR vaccine.

#### Table 6.6—Association* between immunisation uptake and various factors

<table>
<thead>
<tr>
<th>Factor</th>
<th>D1 (n%)</th>
<th>D2 (n%)</th>
<th>D3 (n%)</th>
<th>P1 (n%)</th>
<th>P2 (n%)</th>
<th>P3 (n%)</th>
<th>MMR (n%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Birth weight (grams)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;2500</td>
<td>487(93.5)</td>
<td>482(92.5)</td>
<td>465(89.3)</td>
<td>467(89.6)</td>
<td>464(89.1)</td>
<td>450(86.4)</td>
<td>432(82.9)</td>
</tr>
<tr>
<td>≥2500</td>
<td>6207(93.9)</td>
<td>6119(92.5)</td>
<td>5982(90.5)</td>
<td>5960(90.1)</td>
<td>5852(88.5)</td>
<td>5699(86.2)</td>
<td>5523(83.5)</td>
</tr>
<tr>
<td>p value</td>
<td>NS(0.8)</td>
<td>NS(1.0)</td>
<td>NS(0.4)</td>
<td>NS(0.8)</td>
<td>NS(0.8)</td>
<td>NS(1.0)</td>
<td>NS(0.8)</td>
</tr>
<tr>
<td><strong>Child sex</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>3644(91.5)</td>
<td>3593(90.2)</td>
<td>3511(88.2)</td>
<td>3514(88.3)</td>
<td>3441(86.4)</td>
<td>3353(84.2)</td>
<td>3243(81.4)</td>
</tr>
<tr>
<td>Female</td>
<td>3530(91.5)</td>
<td>3489(90.4)</td>
<td>3423(88.7)</td>
<td>3382(87.7)</td>
<td>3347(86.8)</td>
<td>3273(84.8)</td>
<td>3171(82.2)</td>
</tr>
<tr>
<td>p value</td>
<td>NS(1.0)</td>
<td>NS(0.8)</td>
<td>NS(0.5)</td>
<td>NS(0.5)</td>
<td>NS(0.7)</td>
<td>NS(0.5)</td>
<td>NS(0.4)</td>
</tr>
<tr>
<td><strong>Immunisation site</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GP surgery</td>
<td>4345(95.9)</td>
<td>4320(95.3)</td>
<td>4265(94.1)</td>
<td>4177(92.2)</td>
<td>4135(91.3)</td>
<td>4061(89.6)</td>
<td>3995(88.2)</td>
</tr>
<tr>
<td>Health clinic</td>
<td>2378(88.6)</td>
<td>2324(86.6)</td>
<td>2245(83.7)</td>
<td>2283(85.1)</td>
<td>2234(83.3)</td>
<td>2162(80.6)</td>
<td>2052(76.5)</td>
</tr>
<tr>
<td>Other</td>
<td>452(72.1)</td>
<td>439(70.0)</td>
<td>425(67.8)</td>
<td>437(69.7)</td>
<td>420(67.0)</td>
<td>404(64.4)</td>
<td>368(58.7)</td>
</tr>
<tr>
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<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Maternal age (years)</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;20</td>
<td>345(95.3)</td>
<td>335(92.5)</td>
<td>326(90.1)</td>
<td>327(90.3)</td>
<td>318(87.9)</td>
<td>304(84.0)</td>
<td>287(79.3)</td>
</tr>
<tr>
<td>20-29</td>
<td>3641(93.9)</td>
<td>3565(92.6)</td>
<td>3484(90.5)</td>
<td>3475(90.3)</td>
<td>3413(88.7)</td>
<td>3327(86.4)</td>
<td>3204(83.2)</td>
</tr>
<tr>
<td>30-39</td>
<td>2466(93.5)</td>
<td>2442(92.6)</td>
<td>2380(90.2)</td>
<td>2372(89.9)</td>
<td>2340(88.7)</td>
<td>2277(86.3)</td>
<td>2202(84.2)</td>
</tr>
<tr>
<td>p value</td>
<td>=0.05</td>
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<td>&lt;0.001</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
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<tr>
<td><strong>No. of children in family</strong></td>
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<tr>
<td>One</td>
<td>2841(94.3)</td>
<td>2815(93.5)</td>
<td>2782(92.4)</td>
<td>2764(91.8)</td>
<td>2727(90.5)</td>
<td>2690(89.3)</td>
<td>2602(86.4)</td>
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<tr>
<td>Two</td>
<td>2129(94.5)</td>
<td>2097(93.1)</td>
<td>2061(91.5)</td>
<td>2061(91.5)</td>
<td>2018(89.6)</td>
<td>1974(87.6)</td>
<td>1938(86.0)</td>
</tr>
<tr>
<td>Three</td>
<td>976(94.1)</td>
<td>956(92.2)</td>
<td>917(88.8)</td>
<td>912(88.0)</td>
<td>892(86.0)</td>
<td>856(82.6)</td>
<td>814(78.5)</td>
</tr>
<tr>
<td>Four</td>
<td>361(91.6)</td>
<td>354(89.9)</td>
<td>334(84.8)</td>
<td>334(84.8)</td>
<td>329(83.5)</td>
<td>305(77.4)</td>
<td>299(75.9)</td>
</tr>
<tr>
<td>Five +</td>
<td>251(88.4)</td>
<td>243(86.6)</td>
<td>219(77.1)</td>
<td>224(76.9)</td>
<td>217(76.4)</td>
<td>195(68.7)</td>
<td>187(65.9)</td>
</tr>
<tr>
<td>p value</td>
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<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
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<tr>
<td>No</td>
<td>5428(94.1)</td>
<td>5359(92.9)</td>
<td>526(90.7)</td>
<td>5218(90.4)</td>
<td>5127(88.8)</td>
<td>4994(86.5)</td>
<td>4869(84.4)</td>
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<tr>
<td>Yes</td>
<td>893(92.6)</td>
<td>873(90.6)</td>
<td>856(88.8)</td>
<td>852(88.4)</td>
<td>834(86.5)</td>
<td>814(84.4)</td>
<td>775(82.0)</td>
</tr>
<tr>
<td>p value</td>
<td>NS(0.1)</td>
<td>&lt;0.05</td>
<td>NS(0.07)</td>
<td>NS(0.06)</td>
<td>&lt;0.05</td>
<td>NS(0.1)</td>
<td>&lt;0.01</td>
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<td><strong>Served by</strong></td>
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<td>RICHS</td>
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<td>3899(92.4)</td>
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<td>3746(88.8)</td>
<td>3669(87.0)</td>
<td>3557(84.3)</td>
<td>3401(80.6)</td>
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<td>NCHS</td>
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<td>3184(87.9)</td>
<td>3145(86.8)</td>
<td>3151(87.0)</td>
<td>3120(86.1)</td>
<td>3070(84.8)</td>
<td>3014(83.2)</td>
</tr>
<tr>
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<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.05</td>
<td>NS(0.3)</td>
<td>NS(0.6)</td>
<td>&lt;0.01</td>
</tr>
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<td><strong>Type of district</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural/suburban</td>
<td>3474(95.2)</td>
<td>3450(94.4)</td>
<td>3412(93.3)</td>
<td>3319(90.8)</td>
<td>3285(89.9)</td>
<td>3228(88.3)</td>
<td>3223(88.2)</td>
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<tr>
<td>Inner city</td>
<td>3701(88.4)</td>
<td>3633(86.8)</td>
<td>3523(84.2)</td>
<td>3578(85.5)</td>
<td>3504(83.7)</td>
<td>3399(81.2)</td>
<td>3192(76.3)</td>
</tr>
<tr>
<td>p value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Type of resident</strong></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>6345(94.3)</td>
<td>6262(93.1)</td>
<td>6115(90.9)</td>
<td>6090(90.5)</td>
<td>5984(88.9)</td>
<td>5829(86.6)</td>
<td>5660(84.1)</td>
</tr>
<tr>
<td>Movement-in</td>
<td>8307(94.6)</td>
<td>821(73.8)</td>
<td>820(73.7)</td>
<td>807(72.5)</td>
<td>805(72.3)</td>
<td>798(71.7)</td>
<td>755(67.8)</td>
</tr>
<tr>
<td>p value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

* : Statistical associations were determined by chi-square test.
† : Chi-square test for trend. § : NS = non-significant.
### Table 6.7—Association between immunisation age (in weeks) and various factors

<table>
<thead>
<tr>
<th>Factor</th>
<th>First primary</th>
<th>Second primary</th>
<th>Third primary</th>
<th>MMR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M + score†</td>
<td>M score</td>
<td>M score</td>
<td>M score</td>
</tr>
<tr>
<td>Birth weight (grams)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 2500</td>
<td>14.3</td>
<td>3673.7</td>
<td>21.7</td>
<td>3607.0</td>
</tr>
<tr>
<td>≥ 2500</td>
<td>13.3</td>
<td>3317.0</td>
<td>20.6</td>
<td>3278.5</td>
</tr>
<tr>
<td>p value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.01</td>
<td>NS(0.95)</td>
</tr>
<tr>
<td>Child’s sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>13.6</td>
<td>3600.7</td>
<td>20.9</td>
<td>3582.7</td>
</tr>
<tr>
<td>Female</td>
<td>13.3</td>
<td>3559.6</td>
<td>20.6</td>
<td>3497.0</td>
</tr>
<tr>
<td>p value</td>
<td>NS(0.4)</td>
<td>NS(0.08)</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Immunisation site</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GP surgery</td>
<td>13.2</td>
<td>3482.4</td>
<td>20.3</td>
<td>3387.6</td>
</tr>
<tr>
<td>Health clinic</td>
<td>14.1</td>
<td>3850.1</td>
<td>21.8</td>
<td>3902.0</td>
</tr>
<tr>
<td>Other</td>
<td>13.2</td>
<td>3110.4</td>
<td>20.2</td>
<td>3136.0</td>
</tr>
<tr>
<td>p value</td>
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<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Maternal age (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 20</td>
<td>13.9</td>
<td>3482.0</td>
<td>21.8</td>
<td>3538.0</td>
</tr>
<tr>
<td>20-29</td>
<td>13.5</td>
<td>3310.9</td>
<td>20.7</td>
<td>3255.6</td>
</tr>
<tr>
<td>30-39</td>
<td>13.1</td>
<td>3237.8</td>
<td>20.2</td>
<td>3203.3</td>
</tr>
<tr>
<td>≥ 40</td>
<td>13.0</td>
<td>3082.0</td>
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<td>3102.8</td>
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<tr>
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<td>&lt;0.01</td>
<td>NS(0.07)</td>
</tr>
<tr>
<td>No. of children in family</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One</td>
<td>12.7</td>
<td>2967.3</td>
<td>19.2</td>
<td>2843.1</td>
</tr>
<tr>
<td>Two</td>
<td>13.4</td>
<td>3351.6</td>
<td>20.6</td>
<td>3319.7</td>
</tr>
<tr>
<td>Three</td>
<td>14.4</td>
<td>3596.1</td>
<td>22.5</td>
<td>3671.8</td>
</tr>
<tr>
<td>Four</td>
<td>14.7</td>
<td>3813.5</td>
<td>23.6</td>
<td>3929.3</td>
</tr>
<tr>
<td>Five+</td>
<td>15.9</td>
<td>4059.0</td>
<td>26.6</td>
<td>4298.0</td>
</tr>
<tr>
<td>p value</td>
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<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>One-parent family</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>13.2</td>
<td>3126.9</td>
<td>20.5</td>
<td>3086.6</td>
</tr>
<tr>
<td>Yes</td>
<td>14.1</td>
<td>3336.3</td>
<td>21.4</td>
<td>3314.1</td>
</tr>
<tr>
<td>p value</td>
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<td>&lt;0.001</td>
<td>&lt;0.001</td>
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</tr>
<tr>
<td>Served by</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RICHS</td>
<td>13.4</td>
<td>3535.9</td>
<td>20.8</td>
<td>3500.6</td>
</tr>
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<td>NCHS</td>
<td>13.6</td>
<td>3635.0</td>
<td>20.8</td>
<td>3589.3</td>
</tr>
<tr>
<td>p value</td>
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<td>NS(0.07)</td>
<td>&lt;0.01</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Type of district</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural/suburban</td>
<td>13.2</td>
<td>3551.4</td>
<td>19.8</td>
<td>3279.8</td>
</tr>
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<td>Inner city</td>
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<td>3607.8</td>
<td>21.6</td>
<td>3788.3</td>
</tr>
<tr>
<td>p value</td>
<td>NS(0.2)</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>NS(0.3)</td>
</tr>
<tr>
<td>Type of resident</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>13.4</td>
<td>3591.6</td>
<td>20.6</td>
<td>3532.2</td>
</tr>
<tr>
<td>Movement-in</td>
<td>14.4</td>
<td>3494.9</td>
<td>21.9</td>
<td>3604.8</td>
</tr>
<tr>
<td>p value</td>
<td>NS(0.2)</td>
<td>NS(0.07)</td>
<td>&lt;0.01</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

†: M = Mean age; ‡: Score = Wilcoxon (sum of rank) mean score. §: Statistical association was tested using Kruskal-Wallis one-way analysis of variance. ¶: NS = non-significant.

**District variation**

Wide variations were found among the ten individual districts, ranging from 70.0% to 95.2%. This study focused on variation in rates between types of district rather than among individual districts. A clear trend could be inferred from the data; the rates for rural and suburban districts were always greater than for inner city districts for all immunisations (Table 6.6).
In addition to overall poorer immunisation uptake, inner city children were also found less likely to be fully vaccinated for the primary course. As shown in Table 6.6 a greater proportion of inner city children who had received the first or the first two doses of vaccines missed their second and/or third dose(s), demonstrated by the larger differences in uptake rates between doses, compared with that of their rural and suburban counterparts. For example, for rural and suburban children the rate differences were 0.8% (95.2-94.4) between the second and first doses and 1.1% (94.4-93.3) between the third and second. Compared with these figures, inner city children were more likely to be partly vaccinated with diphtheria; the corresponding differences were 1.6% (88.4-86.8) and 2.6% (86.8-84.2), twice as large as those for rural and suburban children. A similar trend existed for pertussis immunisation rates.

Compared with their rural and suburban peers, children resident in inner city districts not only were less likely to be fully vaccinated, but also had received their immunisation procedures at a later time. The values of mean age at the immunisations were more or less greater for inner city children than those for children living in rural and suburban areas, confirmed by a larger Wilcoxon mean rank score [Armitage and Berry, 1987]. However, the non-parametric-test-associated \( p \) values suggest a later age only for MMR and at the second and third doses of primary immunisation but not the first dose for inner city children, compared with their rural and suburban counterparts (Table 6.7).

**Variation associated with immunisation location**

Data in Table 6.6 indicate that nearly 90% of children attending general practices had been fully vaccinated for diphtheria, pertussis and MMR, and children who were registered at community child health clinics had lower rates of the immunisations. The worst rates were observed for children registered at a premise other than either a general practice or a child health clinic, i.e., a location outside the home district, at a hospital, at a private doctor/clinic, or at an ‘unknown’ premise.

The data seemed also to suggest that “GP” children were more likely to be fully vaccinated, i.e., to have received all three doses of diphtheria and pertussis, compared with health clinic children, suggested by larger difference in the rates between first and third doses, for instance, 2.6% (92.2-89.6%) of pertussis for “GP” children against 4.5% (85.1-80.6%) for health clinic children. Again the “other” group of children were the least likely to complete a full course of primary immunisations with the corresponding difference in the rate of 5.3% (69.7-64.4).

The association between uptake rates of immunisation and immunisation location was further investigated by examining the correlation between coverage of MMR and the ratio of children registered at general practices to those attending child health clinics in the ten study districts. Figure 6.6 appears to suggest a significant positive correlation (\( r = 0.75, p < 0.02 \)); the higher the proportion of children registered at general practices for immunisation procedures, the greater a district’s uptake rate of MMR vaccine appeared be.
As to immunisation age, a rather surprising trend appeared; the mean age and the Wilcoxon mean rank score suggested that children attending "other" locations received their primary immunisations at the earliest time and those registered at child health clinics the latest, with GP children in the middle. However for MMR, GP and health clinic children received the vaccine at a rather similar age, with those attending "other" locations being vaccinated considerably later. The age at all these immunisations were significantly different among (or between) the groups of children.

Variation related to mobility of the child population
Overall, 1,113 children (14.2% of the total in the ten districts) were recorded in the computer systems as having moved from an outside district into the current residence district, among whom were 778 (18.6%) in inner city and 335 (9.2%) in rural or suburban districts, indicating that the inner city child population was more unstable than the rural and suburban population ($\chi^2 = 141.6$, $P < 0.001$, also see Chapter Four).

It was found that mobile children were less likely to be fully vaccinated compared with their stable counterparts (Table 6.6). In addition to lower uptake rates, the mobile child population was also found to have completed the primary immunisations (except for the first dose) and MMR at a later age than the stable children (Table 6.7).

Variation related to the number of children in the family (family size)
The study subjects were divided into five groups by the number of children in their families: those from single child families, those from two children families, those from three, from four and from five or more children families, to investigate the association between immunisation status and family size. It appeared that the more siblings a child had in the family, the less likely he/she would be to receive immunisations; this was the case for all three doses of diphtheria and pertussis, and MMR (Table 6.6). For example, the uptake rate of the third pertussis immunisation...
tion was 89.3% for children from single-child families, and this rate went down steadily to only 68.7% for those from families with five or more children—a more than 20% difference.

It appeared that, in general, children from larger families tended to be vaccinated at a later time compared with those from relatively smaller ones; this was true for all three doses of diphtheria and for MMR (Table 6.7).

**Variation associated with family status**

Among 6,735 children where information on family status was available in the computer systems, 964 (14.3%) were recorded as living in a one-parent family. Their immunisation status seemed to be less satisfactory compared with that for children from two-parent families. Table 6.6 includes the data of the uptake rates of immunisation for children from one-parent and two-parent families; the rates always appeared greater for the latter group by about two per cent.

Pearson chi-square statistics, however, confirmed a significant association between the uptake rates and family status only for the second dose of diphtheria ($p < 0.05$) and pertussis vaccines ($p < 0.05$), and for MMR ($p < 0.01$), but not for the first and third doses of diphtheria or pertussis immunisations.

Data in Table 6.7 indicated that children from one-parent families were more likely to receive their primary immunisations later (all three doses), but there was no significant difference in the age at MMR immunisation between the two groups of children.

**Variation related to maternal age**

According to the age of the mothers when the study children were born, children were divided into four groups: those born to teen-aged mothers (< 20 years); those born to mothers between 20 and 29 years, those to mothers between 30 to 39 years, and those to mothers of 40 years or over. Similar uptake rates were found among the first three groups of children, with apparently lower rates for children in the fourth maternal age group; this was the case especially for the first and third doses of diphtheria and pertussis. There appeared to be little difference in coverage of MMR among the four groups with the chi-square associated $p$ value being 0.12.

On the other hand, children in the fourth maternal age group ($\geq 40$ years) appeared to have received what immunisations they did, at the earliest time, and as maternal age became younger, children were more likely to be vaccinated later. This relationship between time of immunisation and maternal age held for all immunisation procedures (Table 6.7).

**Variation between children of different birth weight**

Children were divided into two groups according to their birth weight: 2,500 grams or more and less than 2,500 grams, to see whether these groups showed any difference in immunisation status.

Firstly, the 19-21 month uptake rates for diphtheria and pertussis and for MMR revealed no significant difference in uptake levels for all immunisations between the two groups of children (Table 6.6). Secondly, it was found that low birth weight infants were more likely to
experience delay in primary immunisation, compared with their normal birth weight counterparts. However, children in these two groups appeared to be vaccinated with MMR at a rather similar age (Table 6.7).

**Sex variation**
Immunisation status was compared between male and female children; no significant differences were found in uptake rates for all three doses of diphtheria and pertussis nor for MMR vaccine (Table 6.6). However, boys appeared to have completed their primary course of immunisations and received their MMR at a later time than girls (Table 6.7).

**Variation associated with serving computer systems**
In this study cohort, 3,622 children were serviced by NCHS, i.e., resident in the five NWT districts, and 4,219, living in the five NET districts, were serviced by RICHS. The immunisation outcomes were compared between these two groups of residents. The data appeared to indicate that compared with those serviced by NCHS, children serviced by RICHS were more likely to complete primary diphtheria immunisation, but the two groups had similar uptake rates of primary pertussis vaccine. NCHS serviced children seemed to have a slightly higher uptake rate of MMR vaccine compared with the RICHS serviced child population (Table 6.6). NCHS appeared to have made earlier (or better kept) appointments for the third primary and MMR immunisation procedures than did RICHS, as suggested by the finding that NCHS children received these two immunisations at a earlier time compared with the latter group (Table 6.7).

**5.2.3 Multivariate analyses of immunisation status**
The results presented above were derived from uni-variate analyses, by examining an association between immunisation and a specific factor. To allow for the possible effects of other factors on specific univariate associations it is necessary to undertake multivariate analyses. In this section logistic regression models and Cox’s proportional hazards models are presented, with the direction and strength of the association, to show the association between immunisation status and a particular contributing factor, while allowing for the possible confounding effects of other factors.

**Logistic regression analyses**
Three models were fitted separately for diphtheria, pertussis and MMR. Table 6.8 lists the response and candidate predictor variables for the logistic regression models, with the definitions and dummy values which were assigned according to their initial associations with uptake of the immunisations (see Table 6.6).

Tables 6.9 to 6.11 show logistic regression models for the uptake of immunisations against diphtheria, pertussis and MMR, respectively. Variables included in each final model are listed in their order of stepwise inclusion in the model. Five, four and five variables were isolated as significant contributing factors influencing the uptake rates of the three immunisations. Variables immunisation location, the number of children in the family (family size), mobility status and type of district were identified as common factors associated with coverage of all these three immunisation procedures. The same negative sign of the regression coefficient of
the common factors suggested that they affected uptake of these immunisations in the same direction.

Table 6.8—Definition of the response and candidate predictor variables in logistic regression analyses for uptake of immunisations against D3, P3 and MMR

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value assigned</th>
<th>D3</th>
<th>P3</th>
<th>MMR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Response variable</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>received</td>
<td>received</td>
<td>received</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>not received</td>
<td>not received</td>
<td>not received</td>
<td></td>
</tr>
<tr>
<td><strong>Predictor variable</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Immunisation location</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>GP surgery</td>
<td>GP surgery</td>
<td>GP surgery</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>health clinic</td>
<td>health clinic</td>
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<td></td>
</tr>
<tr>
<td>3</td>
<td>other</td>
<td>other</td>
<td>other</td>
<td></td>
</tr>
<tr>
<td><em>Maternal age (years)</em></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>&lt;40</td>
<td>&lt;40</td>
<td>&lt;40</td>
<td></td>
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<td>≥40</td>
<td>≥40</td>
<td>≥40</td>
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<tr>
<td><em>No. children in family</em></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>one</td>
<td>one</td>
<td>one</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>two</td>
<td>two</td>
<td>two</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>three</td>
<td>three</td>
<td>three</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>four</td>
<td>four</td>
<td>four</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>five+</td>
<td>five+</td>
<td>five+</td>
<td></td>
</tr>
<tr>
<td><em>One parent</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>no</td>
<td>no</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td><em>Serviced by</em></td>
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<td></td>
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</tr>
<tr>
<td>1</td>
<td>RICHS</td>
<td>—</td>
<td>RICHS</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>NCHS</td>
<td>—</td>
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<td></td>
</tr>
<tr>
<td><em>Type of district</em></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>rural/suburban</td>
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<td>rural/suburban</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>inner city</td>
<td>inner city</td>
<td>inner city</td>
<td></td>
</tr>
<tr>
<td><em>Type of resident</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>stable</td>
<td>stable</td>
<td>stable</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>mobile</td>
<td>mobile</td>
<td>mobile</td>
<td></td>
</tr>
</tbody>
</table>

† : Not considered a candidate variable in the model because of its insignificant association with the outcome variable at the α = 0.1 level (Table 6.6).

Table 6.9—Logistic regression model for diphtheria immunisation uptake

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient (β)</th>
<th>Standard error (σ)</th>
<th>Odds ratio (φ)</th>
<th>95% C.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-6.13</td>
<td>0.29</td>
<td>0.42</td>
<td>0.37, 0.49</td>
</tr>
<tr>
<td>Immunisation location (2 to 3)</td>
<td>-0.86</td>
<td>0.07</td>
<td>0.54</td>
<td>0.48, 0.59</td>
</tr>
<tr>
<td>No. of children in family (2 to 5)</td>
<td>-0.29</td>
<td>0.04</td>
<td>0.74</td>
<td>0.69, 0.81</td>
</tr>
<tr>
<td>Mobility status (stable/mobile)</td>
<td>-0.82</td>
<td>0.17</td>
<td>0.44</td>
<td>0.32, 0.61</td>
</tr>
<tr>
<td>District (rural or suburban/city)</td>
<td>-0.39</td>
<td>0.10</td>
<td>0.68</td>
<td>0.56, 0.82</td>
</tr>
<tr>
<td>System (RICHS/NCHS)</td>
<td>-0.27</td>
<td>0.09</td>
<td>0.76</td>
<td>0.64, 0.91</td>
</tr>
</tbody>
</table>

Table 6.10—Logistic regression model for pertussis immunisation uptake

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient (β)</th>
<th>Standard error (σ)</th>
<th>Odds ratio (φ)</th>
<th>95% C.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>4.36</td>
<td>0.23</td>
<td>0.53</td>
<td>0.48, 0.59</td>
</tr>
<tr>
<td>Immunisation location (2 to 3)</td>
<td>-0.63</td>
<td>0.05</td>
<td>0.53</td>
<td>0.48, 0.59</td>
</tr>
<tr>
<td>No. of children in family (2 to 5)</td>
<td>-0.32</td>
<td>0.03</td>
<td>0.73</td>
<td>0.68, 0.77</td>
</tr>
<tr>
<td>Mobility status (stable/mobile)</td>
<td>-0.59</td>
<td>0.16</td>
<td>0.55</td>
<td>0.41, 0.76</td>
</tr>
<tr>
<td>District (rural or suburban/city)</td>
<td>-0.20</td>
<td>0.10</td>
<td>0.82</td>
<td>0.67, 0.99</td>
</tr>
</tbody>
</table>
Table 6.11—Logistic regression model for MMR immunisation uptake

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient (β)</th>
<th>Standard error</th>
<th>Odds ratio (β)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>4.90</td>
<td>0.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immunisation location (2 to 3)</td>
<td>-0.58</td>
<td>0.06</td>
<td>0.56</td>
<td>0.50, 0.63</td>
</tr>
<tr>
<td>No. of children in family (2 to 5)</td>
<td>-0.28</td>
<td>0.03</td>
<td>0.76</td>
<td>0.71, 0.80</td>
</tr>
<tr>
<td>District (rural or suburban/city)</td>
<td>-0.42</td>
<td>0.08</td>
<td>0.66</td>
<td>0.56, 0.77</td>
</tr>
<tr>
<td>Mobility status (stable/mobile)</td>
<td>-0.75</td>
<td>0.14</td>
<td>0.47</td>
<td>0.36, 0.62</td>
</tr>
<tr>
<td>One-parent (no/yes)</td>
<td>-0.30</td>
<td>0.09</td>
<td>0.74</td>
<td>0.62, 0.88</td>
</tr>
</tbody>
</table>

A negative sign of the regression coefficient, β, indicates that a child was less likely to have completed his/her primary or MMR immunisations, compared with his/her peer in the reference category of the same variable. In the absence of internal correlation among the included predictor variables, the coefficient β equals the natural logarithm of the odds ratio for the association between immunisation uptake and the two values of a predictor variable. For instance, the odds of being vaccinated with MMR for a child resident in an inner city district would be 66% of that for a child living in a rural or suburban district, allowing for immunisation location, family size, mobility status and one-parent family status (Table 6.11), and there would be a decrease in the odds of being vaccinated with third diphtheria by a factor of 0.74 as the number of children in the family increased by one “unit”, allowing for the other four factors included in the model (Table 6.9).

Survival data analyses

Because immunisation age was so skewed that even data transformation could not normalise its distribution, the association of immunisation age with factors was investigated using survival data analysis. Cox’s proportional hazards models were fitted separately for the age at the first (starting the immunisation course) and third (completing the course) doses of diphtheria and at the MMR, the response variable being the immunisation age and potential independent (prognostic) variables being those identified associated with immunisation age at the α = 0.1 level by Kruskal-Wallis one-way analysis of variance (Table 6.7).

Due to variations in the initial association between the age at different immunisation procedures and factors (Table 6.7), grouping of the potential prognostic variables also varied in the multivariate analysis for different immunisation procedures. Table 6.12 lists the definitions of these potential prognostic variables used for the models of age at the three immunisation procedures.

Tables 6.13 to 6.15 show the models for the age at the first and third doses of diphtheria and for MMR immunisation. The estimates of Cox’s proportional hazards models listed in the above three tables suggest that (1) five, six, and five factors were associated with the age at immunisations of the first and third doses of diphtheria and MMR, respectively; (2) the common risk factors included in all three models were the number of children in the family, maternal age and one-parent family status; and (3) immunisation location and type of system serviced were associated with the age at two immunisation procedures; with birth weight, type
of district and mobility status being factors related to the age of one immunisation procedure.

Table 6.12—Definition of the response and potential prognostic variables in survival data analyses for the age at D1, D3 and MMR immunisations

<table>
<thead>
<tr>
<th>Variable</th>
<th>Dummy value</th>
<th>D1</th>
<th>D3</th>
<th>MMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response variable</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immunisation age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth weight (grams)</td>
<td>1</td>
<td>≥ 2500</td>
<td>≥ 2500</td>
<td>— t</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>&lt; 2500</td>
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<td>—</td>
</tr>
<tr>
<td>Child's sex</td>
<td>1</td>
<td>— t</td>
<td>male</td>
<td>male</td>
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<tr>
<td></td>
<td>2</td>
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<td>female</td>
<td>female</td>
</tr>
<tr>
<td>Immunisation location</td>
<td>1</td>
<td>other</td>
<td>other</td>
<td>GP/health clinic</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>GP surgery</td>
<td>GP surgery</td>
<td>other</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>health clinic</td>
<td>health clinic</td>
<td>/ t</td>
</tr>
<tr>
<td>Maternal age (years)</td>
<td>1</td>
<td>&lt; 20</td>
<td>&lt; 20</td>
<td>&lt; 20</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>20 - 29</td>
<td>20 - 29</td>
<td>20 - 29</td>
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<tr>
<td></td>
<td>3</td>
<td>30 - 39</td>
<td>30 - 39</td>
<td>30 - 39</td>
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<td></td>
<td>4</td>
<td>≥ 40</td>
<td>≥ 40</td>
<td>≥ 40</td>
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<tr>
<td>No. children in family</td>
<td>1</td>
<td>one</td>
<td>one</td>
<td>one</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>two</td>
<td>two</td>
<td>two</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>three</td>
<td>three</td>
<td>three</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>four</td>
<td>four</td>
<td>four</td>
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<tr>
<td></td>
<td>5</td>
<td>five+</td>
<td>five+</td>
<td>five+</td>
</tr>
<tr>
<td>One parent</td>
<td>1</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Served by</td>
<td>1</td>
<td>RICHS</td>
<td>RICHS</td>
<td>RICHS</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>NCHS</td>
<td>NCHS</td>
<td>NCHS</td>
</tr>
<tr>
<td>Type of district</td>
<td>1</td>
<td>— t</td>
<td>rural/suburban</td>
<td>— t</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>—</td>
<td>inner city</td>
<td>—</td>
</tr>
<tr>
<td>Type of resident t</td>
<td>1</td>
<td>— t</td>
<td>stable</td>
<td>stable</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>—</td>
<td>mobile</td>
<td>mobile</td>
</tr>
</tbody>
</table>

†: Not considered a potential prognostic variable in the model because of its insignificant association with the outcome variable at the α = 0.1 level (Table 6.7).

‡: GP and health clinic children were combined because of their almost identical immunisation age.

Table 6.13—Results obtained from applying Cox’s proportional hazards model to the first diphtheria immunisation, in the ten districts

<table>
<thead>
<tr>
<th>Factor</th>
<th>Coeff.</th>
<th>SE</th>
<th>Exp(Coeff.)</th>
<th>95% C.I.</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of children in family (2-5)</td>
<td>-0.19</td>
<td>0.01</td>
<td>0.83</td>
<td>0.81, 0.84</td>
<td>0.0001</td>
</tr>
<tr>
<td>Maternal age group (2 to 4)</td>
<td>0.13</td>
<td>0.02</td>
<td>1.14</td>
<td>1.10, 1.18</td>
<td>0.0001</td>
</tr>
<tr>
<td>Immunisation location (2 to 3)</td>
<td>-0.13</td>
<td>0.02</td>
<td>0.88</td>
<td>0.84, 0.91</td>
<td>0.0001</td>
</tr>
<tr>
<td>Birth weight (≥2500/&lt;2500g)</td>
<td>-0.20</td>
<td>0.05</td>
<td>0.82</td>
<td>0.74, 0.90</td>
<td>0.0001</td>
</tr>
<tr>
<td>One-parent family (no/yes)</td>
<td>-0.10</td>
<td>0.04</td>
<td>0.90</td>
<td>0.84, 0.98</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Table 6.14—Results obtained from applying Cox’s proportional hazards model to the third diphtheria immunisation, in the ten districts

<table>
<thead>
<tr>
<th>Factor</th>
<th>Coeff.</th>
<th>SE</th>
<th>Exp(Coeff.)</th>
<th>95% C.I.</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of children in family (2-5)</td>
<td>-0.26</td>
<td>0.01</td>
<td>0.77</td>
<td>0.76, 0.79</td>
<td>0.0001</td>
</tr>
<tr>
<td>Type of district (non-city/city)</td>
<td>-0.32</td>
<td>0.03</td>
<td>0.73</td>
<td>0.68, 0.77</td>
<td>0.0001</td>
</tr>
<tr>
<td>Maternal age group (2 to 4)</td>
<td>0.18</td>
<td>0.02</td>
<td>1.20</td>
<td>1.15, 1.25</td>
<td>0.0001</td>
</tr>
<tr>
<td>System (RICHS/NCHS)</td>
<td>0.23</td>
<td>0.03</td>
<td>1.26</td>
<td>1.19, 1.33</td>
<td>0.0001</td>
</tr>
<tr>
<td>Immunisation location (2 to 3)</td>
<td>-0.13</td>
<td>0.03</td>
<td>0.88</td>
<td>0.83, 0.93</td>
<td>0.0001</td>
</tr>
<tr>
<td>One-parent family (no/yes)</td>
<td>-0.17</td>
<td>0.04</td>
<td>0.84</td>
<td>0.78, 0.91</td>
<td>0.0001</td>
</tr>
</tbody>
</table>
Table 6.15—Results obtained from applying Cox’s proportional hazards model to the MMR immunisation, in the ten districts

<table>
<thead>
<tr>
<th>Factor</th>
<th>Coeff.</th>
<th>SE</th>
<th>Exp(Coeff.)</th>
<th>95% CI.</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>System (RICHS/NCHS)</td>
<td>0.86</td>
<td>0.03</td>
<td>2.36</td>
<td>2.23, 2.51</td>
<td>0.0001</td>
</tr>
<tr>
<td>No. of children in family (2-5)</td>
<td>-0.17</td>
<td>0.01</td>
<td>0.84</td>
<td>0.83, 0.86</td>
<td>0.0001</td>
</tr>
<tr>
<td>Maternal age group (2 to 4)</td>
<td>0.10</td>
<td>0.02</td>
<td>1.11</td>
<td>1.06, 1.15</td>
<td>0.001</td>
</tr>
<tr>
<td>Mobility status (stable/mobile)</td>
<td>-0.36</td>
<td>0.07</td>
<td>0.70</td>
<td>0.61, 0.80</td>
<td>0.001</td>
</tr>
<tr>
<td>One-parent family (no/yes)</td>
<td>-0.14</td>
<td>0.04</td>
<td>0.87</td>
<td>0.80, 0.94</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Explanation of a coefficient depends on its sign; a positive coefficient means that a (random) child was more likely, and a negative coefficient less likely to be vaccinated at a given age, relative to a child in the reference group. For example, at a given age the probability of being vaccinated with the first diphtheria for a child registered at a community health clinic would be 88% of that for a GP child, who would have a probability of receiving first diphtheria 88% of that for a child attending an “other” immunisation location, when other factors were equalised (Table 6.13). For the third diphtheria, the probability of receiving the vaccine at any given age would increase by 1.2 times as maternal age increased by one “group”, allowing for family size, type of district, type of system serviced, immunisation location and one-parent family status (Table 6.14).

6.3 DISCUSSION

Childhood immunisation is a key public health activity. The European region of the WHO set a target for 1990 of 90% coverage for primary immunisations against diphtheria, pertussis, tetanus (DPT) and measles [Begg and Noah, 1985]. The achievement of the WHO target is a component of the Government’s 1991 objectives for health authorities [DH, 1989] and also forms part of the immunisation payment structure of the new general practitioner contracts [NHS, 1990]. Tremendous efforts have been made to increase uptake of immunisations for British pre-school children, and improvement has been achieved over the last few years [Begg et al, 1989; Nicoll et al, 1989]. Despite this improvement in immunisation uptake, cover rates are still less than wholly satisfactory in many local districts in this country [White et al, 1992; White and Leon, 1992].

Reasons suggested for failure to reach immunisation targets refer both to deficits in the services provided and to the characteristics of the client population. Service problems include the low priority attributed to immunisation services in resource allocation, insufficient training of health professionals, and divided responsibility of community health services [Nicoll et al, 1989]. Factors relating to practice organisation have also been implicated [Jarman et al, 1988; Peckham et al, 1989]. Population characteristics, which have been found to influence immunisation uptake rates, relate to measures of social deprivation [Begg et al, 1988; Jarman et al, 1988]. Additionally, the attitudes and beliefs of parents are often used in conjunction with criticisms of the services to explain failures to attend for immunisations [Hull, 1987; Brambleby and Hanrahan, 1989; Klein et al, 1989; Nicoll et al, 1989; Peckham et al, 1989]. Some studies have suggested that poor communication between health professionals also influences childhood...
immunisation uptake rates in certain areas, particularly in inner city districts [Rawson et al., 1980; Morris et al., 1988; Jefferies et al., 1991].

6.3.1 Have the targets been met?

Immunisation uptake rates are assuming considerable importance as performance indicators for health authority provider units and general practices. Appreciable variations in uptake of immunisations occur between various localities and for different groups in the child population [Baker et al., 1984; Begg and White, 1987; Jamn et al., 1988; Begg et al., 1989; Li and Taylor, 1991]. According to the computer system records of the present study cohort in the ten districts from the two regions, nearly 90% of the total 7,841 children in the study cohort had been vaccinated against diphtheria, tetanus and poliomyelitis by the age of 19 to 21 months. The uptake rates for pertussis and MMR immunisations were less satisfactory; 85% and 82%, respectively, in the ten districts as a whole (Table 6.2).

The present results indicated that one of the problems in getting at least 90% of the target child population fully vaccinated was that some children failed to complete their immunisation procedures. More than 90% of the children had received the first and second doses of diphtheria, tetanus and poliomyelitis immunisations, and the gap in uptake between the first and the third doses was two to four per cent.

It is not clear why some children had not been fully vaccinated with one or two doses missing. Possible reasons include: (1) as a child grows up his/her parents may have less frequent health visitor contact and hence be less well informed about immunisations; (2) parents, especially mothers, may have to go back to work as the infant becomes less “dependent” making it less likely that a child will be taken to a clinic/surgery to be vaccinated; (3) the timing of immunisation sessions or venues may be inconvenient, especially for older infants and toddlers; (4) mobile families are difficult to trace resulting in “no appointment received” [Peckham et al., 1989]; and (5) as children become older they may present for immunisation with coincidental infectious diseases which are thought (often erroneously), both by health professionals and parents, to be contraindications to certain immunisations [Nicoll and Ross, 1985; Peckham et al., 1989].

However, if we look at immunisation levels for various groups of children with different demographic, family and health services characteristics, some groups of children seem likely to have extreme difficulties in achieving the 90% uptake target for pertussis and MMR (see Table 6.6). The results suggest that health services should target attention at those children who are the least likely to meet the immunisation targets.

6.3.2 Have immunisation procedures been given on time?

A new schedule was introduced in May 1990 with primary immunisations given at age two, three and four months [DH, 1990]. This new schedule differs considerably from the old immunisation schedule, and has been thought not only to ensure protection at an early age, but also to provide an overall increase in coverage [White et al., 1992]. Children in the present study
cohort were born between January and March 1990, and therefore, it has been difficult to assess exactly whether they were vaccinated at recommended ages. I compared the age at diphtheria and MMR immunisations separately, following the recommendations of the old national schedule, and noted that even with the old schedule (3, 5, 8.5 months), some 10 to 59% of vaccinated children had their immunisations late by up to eight weeks and 4 to 8% had not been vaccinated until more than 8 weeks beyond the recommended age (Figure 6.5). These proportions would have been greater if children who were recorded as not yet vaccinated had been taken into account.

Data from the ten districts revealed that some children were at a higher “risk” of being late vaccinated than others (tables 6.13 to 6.15). It is unlikely that the late receipt of immunisations for these children in the high “risk” groups were due to variations in the immunisation schedules since all the ten districts were conforming to the national immunisation schedule and the results were derived from multivariate analysis allowing for related factors. Possible reasons for the delay include that these children and families with “adverse” characteristics were less well informed about immunisations and that immunisation sessions were less efficiently organised [Alberman et al, 1987], especially in some child health clinics [Li and Taylor, 1991].

Another reason for late immunisation in some groups of children would be the failure of immunisation call and recall systems. One of the chief functions of the immunisation module of a child health computing system is to send every client an appointment invitation when the procedure is due, which asks the child to attend an immunisation session [CHCC, 1987; Horne and Roy, 1988]. My results suggest that this chief function of the call and recall system has been sub-optimal in many localities. Nearly 60% of the immunisation procedures were carried out opportunistically, i.e., were recorded as unscheduled. This proportion reached over 75% for inner city children (Figure 6.3).

It may be argued that it is not crucially important whether a child attended for a “scheduled” or an “unscheduled” immunisation “since some of the ‘unscheduled’ visits were appropriate and on time and presumably will be increasingly so with the adoption of parent held records” [Richards, personal communication, 1991]. However, children receiving unscheduled immunisation procedures were found to be vaccinated far later compared with those attending scheduled sessions. The data from the five NET districts demonstrated a considerable delay ($\chi^2 = 7.8$, $P < 0.01$) in the age at third diphtheria immunisation for “unscheduled” children compared with those vaccinated at a scheduled appointment; the median age differed by almost a month—171 against 197 days. Attendance for unscheduled immunisations might be related to children being registered at child health clinics rather than general practices. Parents might be less likely to respond to a clinic appointment because immunisation times there are often less flexible and less convenient for families, especially for working parents and/or for parents with more children in the family to take care of [Peckham et al, 1989; Li and Taylor, 1991].

An additional consequence of a high unscheduled attendance would be difficulties (feasts or famines) in organising immunisation activities at clinics, GP surgeries and in the child health computing departments.
Much effort, money and manpower has been spent in developing and operating the immunisation module of the child health computing systems. If most of the appointment invitations sent are not kept by clients, the justification for this module is less obvious.

### 6.3.3 Who should routinely vaccinate children to improve the uptake?

Currently in this country, most immunisation procedures are routinely carried out either at community child health clinics or at general practitioner surgeries, although some procedures are carried out opportunistically, e.g., while a child is hospitalised [Riley et al., 1991]. Some districts offered a domiciliary immunisation service [Begg and White, 1987].

The data from the ten study districts showed that overall, more than half (58.0%) of children were registered at general practitioner surgeries for immunisations and 37.3% at community child health clinics, with the remaining 5% at other premises. Great variation in immunisation location has been noted in this study between inner city and non-inner-city areas (Figure 6.1). The majority (93.9%) of children attended the initially “allocated” immunisation location to receive their immunisation procedures. Inner city children were more likely to be recorded as having been vaccinated at another premise from their parents’ original choice, and the main reason for this change was found to be a shifting of health clinic children to GP surgeries for immunisations (figures 6.1 and 6.2; Table 6.1). This was probably due to the encouragement for immunisation procedures to be done at general practices under the new GP contract [NHS, 1990]. Another possibility was that inner city children were less stable than those resident in rural and suburban areas, resulting in the actual immunisation location being untraceable for these mobile children, and their records being incomplete in the child health computer system.

My results demonstrated that children registered at a general practice surgery for due immunisations had much higher uptake rates compared with those attending a child health clinic or other premises; uptake rates for the third pertussis, for example, were 89.6%, 80.6% and 64.4% for the three groups of children respectively, and rates for MMR were 88.2%, 76.5% and 58.7% respectively. Logistic regression models for diphtheria, pertussis and MMR immunisations confirmed the effect of immunisation location on the uptake rates (tables 6.9 to 6.11). For example, with other factors adjusted the odds on being fully vaccinated against pertussis were 0.53 and 0.28 (0.532) for the latter two groups of children compared with 1.00 for GP children, and the corresponding values for MMR vaccines were 0.56 and 0.31 (0.562) to 1.00. In addition, GP children were more likely to start and complete primary immunisations at an earlier time compared with children in the health clinic group (tables 6.13 and 6.14).

The coverage variation in favour of general practitioner surgeries was also suggested by a significant correlation \( r = 0.75, P < 0.02 \) between uptake and ratio of children attending GP to non-GP premises; districts with a higher proportion of children attending GPs versus child health clinics for immunisation procedures were found to have higher uptakes (Figure 6.7). Ritchie et al [1992] has recently observed that by late 1991, 76 (80%) of the surveyed general practices in Grampian, Scotland, had achieved at least 90% levels.

The reasons for these differences in immunisation status between children attending different
immunisation locations were possibly that (1) general practitioners were encouraged to
vaccinate children and meet the target by the immunisation payment policy under the new
practitioner contracts [NHS, 1990]; (2) communication between general practitioners and
clients was more efficient and the contact with clients' own family doctors and other members
of their primary health care with regard to immunisations was more effective; and (3) immuni­
sation session time/venue was more flexible and convenient for the clients, especially for working
parents (most GP surgeries run an evening or/and weekend clinic session). The poorest uptake
was for children attending outside district immunisation locations or private doctors; this was
probably linked to the fact that these children were extremely difficult to trace and communica­
tion between districts and between child health departments and private doctors was sub­

It has been suggested that immunisation should be done by a nurse without, necessarily, the
presence of a doctor [Jefferson et al, 1987]. This policy has been implemented in a few places
in Great Britain where health visitors and nurses vaccinate children in domiciliary as well as
clinic settings [James, 1984; Begg and White, 1987; Jefferson et al, 1987; Ramaiah, 1990]. It
seems probable that vaccinating certain children at home particularly those in "difficult" families
who are less likely to attend for immunisation at a clinic may significantly improve uptake rates.
This would require more active and direct involvement of health visitors and nurses in pre­
school immunisation schemes. However, this proposed policy is not universally popular and
doubts have been expressed relating to manpower, training and appropriateness [Thompson,
1984].

6.3.4 Why do inner city districts have lower immunisation uptakes?

Previous studies have shown that childhood immunisation coverage is considerably lower in
high deprived inner city areas compared with low deprived non-city areas [Jarman et al, 1988;
Begg and White, 1989; Adams and Appleby, 1990]. The present data from the ten districts in
NET and NWT regions confirmed this variation. The results derived from this study
demonstrated that inner city children were not only less likely to be fully vaccinated, but also
more likely to receive the procedures at a later time compared with their counterparts in rural
and suburban districts (tables 6.9 to 6.11 and 6.13 to 6.15).

Many recent studies have revealed reasons for lower immunisation uptake in certain groups of
the child population. However, most of the studies examined the association of uptake with
certain factors by direct comparison of coverage between groups of children with little
consideration of other factors which might have confounding effects on the association under
investigation. It is difficult to demonstrate the strength of an association with direct coverage
comparisons. My study, using multivariate analysis techniques, by considering simultaneously
most (even though not all) of the important possible factors, has demonstrated the strength as
well as the direction of the uptake-factor associations. By these techniques, four, three and four
factors (in addition to the type of district), respectively, have been identified as influencing
diphtheria, pertussis and MMR immunisation coverage. The results of this study, obtained
from analysis on an individual child basis, confirmed some findings from previous studies,
most of which were undertaken on the basis of aggregated data from health districts as a whole
Although previous studies have suggested that higher population mobility contributed to lower uptake of immunisations in inner city areas [Jeffries et al., 1991], there has been little published data examining other specific contributors influencing, possibly uniquely, immunisation performance in inner city areas, compared with rural and suburban areas. My results showed that four apparently important factors had significant independent influences on childhood immunisation uptake. Even though these factors seemed to affect both inner city and rural/suburban populations, and the influence of some factors appeared even greater in rural and suburban districts than in inner cities (see Chapter Eight), would they produce the same effects on the overall immunisation coverage in these two types of district?

It was observed that the proportion of the population with these four adverse factors (living in a larger family, attending a non-GP premise for immunisation, living with one-parent and moving between districts) was appreciably different between inner city and rural/suburban areas: 61.3% of inner city children registered at a non-GP premise compared with only about 20% of rural and suburban children, 27.6% of inner city families had three or more children compared with 21.6% of non-city families, 15.9% children in inner cities were recorded as living in a one-parent family and this figure was about 12.8% in rural/suburban districts, and finally, in inner city districts there were more than 18% of children who had moved into the current resident district from outside (during a period of 19 to 21 months) compared with less than 10% in rural and suburban areas (Figure 6.7).

The larger proportion of children in inner cities who were affected by the four adverse factors would "result" in fewer children receiving full immunisation procedures, compared with children in non-city areas. For instance, the odds of being vaccinated for a movement-in
resident child was about half of that for a continuously resident child, and the proportion of mobile children in inner city districts was nearly double that in rural and suburban districts. Thus, the size of population in inner city districts affected by this factor alone was almost twice as big as in rural/suburban districts.

Additionally, it was found that children resident in inner city areas were more likely to have more than one of these adverse factors. Figure 6.8 illustrates the proportions of children with one, two, three or all four of these adverse factors in the two types of district. The figure shows that the proportion of children with adverse factor(s) was always greater in inner city than in non-city districts; 48.4%, 24.5%, 3.1% and 0.2% of inner city children with one, two, three, or all four respectively, and in rural and suburban districts 36.9%, 9.1%, 0.6% and 0.1%. The difference in the proportions was unlikely to have occurred by chance ($\chi^2 = 719.3$, $P < 0.001$ on 4 degrees of freedom).

Epidemiologically, the four factors identified from the data from the ten districts had a similar influence on individual children in both inner city and non-city districts, with factors “family size”, “type of resident” and “family status” having an apparently greater influence on the non-inner-city population as suggested by greater values of odds ratios regarding immunisation uptake (see Chapter Eight, Figure 8.2). From the public health point of view, i.e., improving overall childhood immunisation coverage however, the adverse factors appear more important in inner city than in non-city areas because of the far higher proportion of the population in inner cities affected by these factors both individually and aggregately. It seems probable that strategies taken to alter these four adverse factors would produce far more benefit in inner city areas, and as a result, the uptake of immunisations would be sharply improved.
It seems worth pointing out that the variable type of district appeared in all three final logistic regression models (tables 6.9 to 6.11). This suggests that, in addition to the factors identified as being related to uptake, other factors might also be associated, for example, social class and ethnic group of children [Baker et al, 1984; Peckham et al, 1988]. These two factors, which were, unfortunately, not recorded in the present child health computing systems or recorded in too unstandardised a form to be used in the analysis, might also be distributed differently usually unfavourable to inner city districts [Haskey, 1988]. It seems likely that if these two factors, plus other possible factors, which might relate to immunisation uptake had been recorded and analyzed in the models, type of district would have been eliminated from the final models as this factor seems likely to play only an indirect role in influencing immunisation uptake rates.

6.3.5 Targeting “problematic” populations to improve immunisation uptake

It is recognised that it is not an easy task to alter risk factors and improve overall performance of immunisation. However, strategies could be taken to increase childhood immunisation coverage [Nicoll et al, 1988] utilising available knowledge. Some strategies appear to be extremely important and necessary in inner city areas where coverage has been far from satisfactory. According to the results from this study, encouraging and supporting general practitioners to undertake immunisations would greatly improve overall coverage, especially with the new payment policy under the general practitioner contract [NHS, 1990], which encourages GPs to commit themselves to childhood immunisation services with, in some places, an associated increase in uptake of immunisation rates [Ritchie et al, 1992; White et al, 1992].

On the other hand, community child health clinics in inner city areas where most children, at present, attend for immunisations, should make more effort to improve their immunisation performance. Running off-office-hour immunisation sessions, e.g., evening or/and weekend sessions as in some GP surgeries, might make the service more accessible for “difficult” families, e.g., working parents. Children vaccinated at places outside the resident district require more effective call and recall systems, and the communication (e.g., exchange of immunisation information) between health professionals and localities should be optimised/improved. This should result in fewer children missing their immunisation procedures [Morris et al, 1988].

An important problem influencing children being fully vaccinated is the high mobility of the target population, particularly in inner city areas [Morris et al, 1988]. It is extremely difficult to get these children vaccinated and on time. The introduction of child health computing systems, which keeps up-to-date information about family movements [Ross and Begg, 1991], has overcome these difficulties to some extent, despite some unsolved problems [Jefferies et al, 1992]. Compatibility of different child health computing systems and other health computing systems between districts, free and efficient exchange of accurate and updated information between localities and standardisation of format of information to be exchanged would further improve the ability of computing systems to deal with the higher mobility of inner city populations. Coordination and communication between health professionals, e.g., health visitors, general practitioners, immunisation coordinators, hospital medical officers and child
The present results from the ten districts suggested that children in high risk groups regarding overall immunisation uptake also faced more difficulties in receiving immunisations on time. Some adverse factors were found to be associated with delayed immunisation but not with the "final" uptake rate (tables 6.11 to 6.13). For example, children with low birth weight had similar final uptake rates to those with normal birth weight, but generally were more likely to start the primary immunisations at a later time compared with their normal birth weight counterparts. These results suggest that a higher proportion of low birth weight children started and completed their primary immunisation procedures at a rather later age than normal birth weight children. Late immunisation may put these children in a dangerous position because low birth weight babies may be more vulnerable to certain infections and, if infected, have more serious complications. There is evidence that infants born pre-term are at particular risk of infection when herd immunity is poor and an epidemic is possible in a community [Berenbaum et al., 1985]. Therefore, it is at least as important for low birth weight infants to be vaccinated at the earliest possible time as it is to obtain a high total population immunisation uptake. Little progress appears to have been made in vaccinating on time low birth weight babies since Roper and Day [1984] reported delayed immunisations for low birth weight infants. This seems likely to be linked to the fact that low birth weight may be considered by health professionals as a relative contraindication to immunisation. Thus, health professionals as well as the parents need education to ensure that low birth weight infants are effectively protected and receive their immunisations at the routine ages.

In summary, "problematic" families with adverse factors should first be targeted, then provided with additional health service support. These families usually have more problems in attending clinics for immunisations because of isolation, more children to take care of, not receiving appointments because of frequent change of address, or because of the parents having little knowledge about the immunisations and the relevant infections. Support from health professionals (e.g., general practitioners, community nurses and health visitors) would help them have the children vaccinated and fully protected on time.

### 6.3.6 RICHS versus NCHS

The results derived from the present study cohort in the ten districts showed few differences in immunisation outcomes between RICHS and NCHS; the former system appeared to have produced higher coverage of diphtheria immunisation, while children serviced by the latter system seemed to have been vaccinated, notably with MMR, at an earlier age. However, the evidence, I suggest, would not be strong enough to help conclude that RICHS was more effective than NCHS or the other way around because (1) differences were only identified in one or two (but not all) immunisation procedures and the trend was not overwhelmingly in favour of one system or the other; (2) even though the analyses were based on consideration of some relevant factors, certain important factors, which were not available in this study, might also influence the performance of a child health computer system, hence affect outcome comparisons between the two systems, e.g., knowledge of health professionals about contrain-
indications to certain vaccines, components of social class and ethnic origin of the population serviced; and (3) the most important thing is that the results were obtained from only one birth cohort, and a conclusion could only be made when long term trends in the immunisation outcomes were apparent in favour of one system or the other.

However, "COVER" data [CDSC reports, PHLS] seems to show that the child population serviced by RICHS had a more marked improvement in immunisation uptake compared with those serviced by NCHS; up until the end of 1988 coverage of both diphtheria and pertussis immunisations had been higher in NWT where NCHS had been implemented, but since that time, when RICHS was introduced in NET, uptake of these two immunisations, comparatively, improved more rapidly there, than in NWT on NCHS (Table 6.9). From this over three year term trend and particularly the time point where the more rapid improvement in immunisation uptakes coincided with the introduction of the new child health computer system it may be reasonable to link the more rapid increase in immunisation uptakes to the introduction of the new system in NET region.

![Figure 6.9](image)

**Figure 6.9—Percentage uptake of immunisations for children aged 18 months in NET and NWT regions, 8/1987 to 2/1992**
(Source: COVER report, PHLS)

Theoretically, the two types (on-line processing for RICHS and batch processing for NCHS) of system have their own advantages and disadvantages [Walker, 1983; also see Chapter Two]. Although there seemed some evidence that RICHS was associated with the more rapidly improvement in immunisation uptake (Figure 6.9), was more likely to be appreciated by its operating staff in terms of user-friendliness and by health visitors in terms of correctness of immunisation uptake rates (see Chapter Five), these indirect pieces of evidence need to be validated by more convincing hard data. However, it is almost certain that, in addition to the design of the child health computer system, human elements would play a key role in ensuring high quality performance of a system no matter what type the system is, e.g., the training of relevant staff and encouragement in using the system in the most efficient ways [Rigby, 1982; Newman, 1983; Walker, 1983; Rigby, 1985; Ross and Begg, 1991].
7.0 PREVIEW

Over the last few years, pre-school health surveillance programmes have received much attention, particularly as more general practitioners have committed themselves to this work. Some parts of the programme, e.g., the early detection of certain disorders, such as pre-symptomatic phenylketonuria and congenital hypothyroidism have demonstrated definite preventive benefits. However, many procedures require to have their effectiveness proven, especially in relation to their costs [Butler, 1989].

The two main areas of debate on health surveillance programmes for pre-school children are clinical efficacy and economic justification (cost effectiveness). By and large, there is little evidence in the literature, to allow a judgment one way or the other on these two fundamental issues. In practice, however, despite the uncertainties, health surveillance programmes are widely recommended [Hall, 1991] and incorporated into the health service policies of most local health authorities and increasingly in general practitioner surgeries. As most district health authorities in this country have introduced child health computing systems, including a pre-school health module to schedule health surveillance procedures and to record the relevant information for individual pre-school children [CHCC, 1983; Home and Roy, 1988; Ross and Begg, 1991], health surveillance is now a major part of community child health work, consuming considerable time and resources.

The coverage rate of health surveillance is one of the measures indicating the performance of child health services. Previous surveys, most of them undertaken in individual general practices, suggested wide variations between localities and for the procedures at different target ages [Butler, 1989]. There seem to have been no surveys aimed at investigating coverage on a larger scale, e.g., in a district as a whole, or possible factors associated with uptake. The implementation of pre-school health modules in child health computing systems which record relevant information enabled the present investigation.

Although the recommendations of the Joint Working Party on Child Health Surveillance [Hall, 1991] are increasingly being followed there is no generally agreed national schedule for preschool health surveillance and many local health authorities have adopted individual policies. Therefore, the content of surveillance programmes (i.e., the procedures and number of screening tests required) varies between localities. Such variation and the lack of an agreed “standard” can make it difficult to evaluate comparatively surveillance performance within and between localities.

The main purpose of this chapter is to demonstrate overall coverage of the health surveillance
programmes, to investigate the association of coverage with certain socio-demographic and service factors, and to assess the benefit (or lack) of the programme, initially clinical yield, but with implications for cost efficiency.

### 7.1 METHODS

#### 7.1.1 Districts included in this part of study

Among the ten study districts in NET and NWT, six were running live on pre-school module, three from each region: HAR, BRT and PNK in NWT, and ISL, WEX and BHB in NET. These six districts were similarly categorised as low deprived rural and suburban and high deprived inner city districts. Each type consisted of three districts.

#### 7.1.2 Study subjects

Study subjects were children born in January to March 1990 and continuously resident (at-birth and transfer-in residents) in these six districts running the pre-school module. Children who subsequently moved into the current resident district from outside, i.e., movement-in residents, were excluded from the analysis as were children moving out. Data on major demographic and familial characteristics and uptake and outcomes of the health surveillance programmes were extracted from child health computer systems when the children in the study cohort were aged 19 to 21 months.

#### 7.1.3 Performance of health surveillance programmes

Performance was assessed in two aspects. The first was coverage, a measure of the extent to which the programme reached the target population. In these six districts all resident children under three years were scheduled to attend the surveillance programmes at three target ages (excluding neonatal examination): the first at about six weeks of age, the second at about eight months and the third between 18 and 24 months. The upper age when the third surveillance assessment should have been completed (24 months) had not been reached by children in this cohort. However, all should have been assessed at the first and second target ages, i.e., at six weeks and eight months. Time constraints allowed only an evaluation of the performance of the first two programmes for this three month birth cohort.

Three indicators were evaluated: (a) the proportion of children who had attended the six week and/or the eight month checks; (b) the proportion of children who had attended both the six week and eight month checks, and (c) the proportion of children who had attended for health checks at neither of the two target ages.

The second aspect of the evaluation was the outcomes of a specific screening test—an indicator of the productivity of the test. For this purpose the outcomes of "hearing test" were investigated. (The rationale for using this test will be presented in the Result section.)
The outcomes of a screening test in a surveillance programme are (arbitrarily) recorded under the following categories:

1) **Satisfactory (S)**—no positive conditions were found or suspected, hence no management required;
2) **Problem (P)**—a problem was found that might be medical, emotional or social;
3) **Observation (O)**—a condition was found that required further observation;
4) **Treated (T)**—a previously identified condition was found which was already being treated;
5) **Referred (R)**—a newly identified problem/concern was found which was referred for second or third tier assessment—a “positive” finding;
6) **Not examined (N)**—a child attended for the programme, but did not receive a particular screening test (e.g., attended for hearing test but had a cold, or proved unable to cooperate with the procedure).

For the purpose of this study and because of the very small numbers recorded in the categories 2, 3, 4 and 5, the outcomes were re-categorised as “satisfactory” (category 1), “unsatisfactory” (categories 2 to 5) and “not examined” (category 6). Firstly, I looked at the proportions of children falling into each of the re-grouped three categories, which would present some information about the yield of the test at the two target ages. Secondly, due to lack of confirmatory data from referral sources recorded in the computer systems I compared the outcomes of this test between the six week and the eight month checks, on a single child basis, to provide some information about the sensitivity and specificity of the test.

### 7.1.4 Definition of study variables and data analysis

In the descriptive study, three indicators measuring the performance (coverage) of health surveillance programmes were presented. In the analytic investigations, however, only the third indicator was used, i.e., whether a child had attended for at least one of the assessments. The “explanatory” variables in this part of study were defined the same way as in the immunisation analyses (Chapter Six, Section 6.1.3) excluding the variable “mobility status” since this study focused only on at-birth and transfer-in residents; i.e.,

- **Type of district**—low deprived rural and suburban districts and high deprived inner city districts;
- **Number of children in the family (family size)**—from single child family to family with five or more children;
- **Maternal age**—younger than 20 years, 20 to 29 years, 30 to 39 years and 40 years or over;
- **Type of family**—one-parent family and two-parent family;
- **Birth weight**—less than 2,500 grams and 2,500 grams or over; and
- **Examination location**—general practitioner surgery and child health clinic.

To investigate the association between uptake of primary immunisations and coverage of health surveillance, a child was defined as having completed the primary immunisation course if
he/she had received all three doses of D(P)T plus Polio vaccines, otherwise he/she was considered not to have completed the primary immunisations.

Data were analyzed in much the same way as those were for immunisation status (see Section 6.1.4), following the steps of descriptive presentation, uni-variate analysis and multi-variate analysis.

7.2 RESULTS

7.2.1 Descriptive data

Number of children included

In the six districts where the pre-school module of the child health computing system was running live, a total of 4,221 children were recorded as being born into the three month cohort and being continuously resident in one of the districts up till the end of October 1991. Among them were 2,478 (58.6%) living in the three low deprived rural and suburban districts and 1,748 (41.1%) in the three high deprived inner city districts.

Coverage of surveillance programmes

There were 3,060 children who were recorded as having attended for the six week and 3,204 for the eight month surveillance programmes, giving overall coverage rates for the continuously resident population in the six districts of 72.5% and 75.9% for the two checks respectively. Data in Table 7.1 show that 950 (22.5%) of children had attended for only one of the two target programmes and 2,659 (63.0%) attended for both, with 612 (14.5%) not having attended either of the assessments.

Table 7.1—Attendance rates of health surveillance programme at two target ages in the six districts

<table>
<thead>
<tr>
<th>Total No. of children</th>
<th>No. (%) of children attended for</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6 weeks</td>
</tr>
<tr>
<td>4221</td>
<td>3060 (72.5)</td>
</tr>
</tbody>
</table>

7.2.2 Coverage and associated factors (uni-variate analyses)

In the investigation of factors influencing coverage of health surveillance programmes, the outcome variable was whether or not a child had attended for at least one of the two checks, at six weeks and/or eight months. The relationship between this outcome and the factors studied is shown in Table 7.2. Individual outcome-factor associations were tested by chi-square (or for trend) statistics. The analyses show that all the factors except "birth weight" appeared to be associated with coverage of health surveillance, the associations being significant at the 0.01 or 0.001 levels.
Table 7.2—Summary of the association between coverage of health surveillance and factors

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total no. of children</th>
<th>No. (%) attended for at least one programme</th>
<th>( \chi^2 )</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of district</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low deprived</td>
<td>2473</td>
<td>2169 (87.7)</td>
<td>23.0</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>High deprived</td>
<td>1748</td>
<td>1440 (82.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of children</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One</td>
<td>1835</td>
<td>1603 (87.4)</td>
<td>17.1</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Two</td>
<td>1364</td>
<td>1142 (83.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three</td>
<td>646</td>
<td>539 (83.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Four</td>
<td>218</td>
<td>194 (89.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Five or more</td>
<td>135</td>
<td>107 (79.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal age (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 20</td>
<td>216</td>
<td>199 (92.1)</td>
<td>24.0*</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>20-29</td>
<td>2367</td>
<td>2061 (87.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-39</td>
<td>1468</td>
<td>1219 (83.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 40</td>
<td>95</td>
<td>74 (77.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of family</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One-parent family</td>
<td>613</td>
<td>553 (90.2)</td>
<td>14.0</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Two-parent family</td>
<td>3418</td>
<td>2881 (84.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth weight (grams)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 2500</td>
<td>393</td>
<td>326 (83.0)</td>
<td>1.9</td>
<td>&gt; 0.1</td>
</tr>
<tr>
<td>≥ 2500</td>
<td>3823</td>
<td>3274 (85.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Examination location</td>
<td>GP surgery</td>
<td>2550 (80.4)</td>
<td>178.0</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>Health clinic</td>
<td>1607 (95.1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( *: \) Chi-square test for trend.

7.2.3 Factors influencing coverage (multivariate analyses)

The binary outcome variable in logistic regression analysis was whether (1) or not (0) a child had missed both the six week and eight month surveillance programmes, while the explanatory variables (candidate variables for inclusion in the logistic regression model) were those which have been found significantly associated with the outcome at the \( \alpha = 0.1 \) level in the univariate analysis, i.e., type of district, the number of children in the family, maternal age, type of family and examination location (Table 7.2). The number of children in the family was converted into a binary variable, \(< 5 \) and \( \geq 5 \) children in the family since the first four groups of children had a similar attendance rate, with the last group (\( \geq 5 \) children in the family) having a rather lower rate.

Four variables were included in the final logistic regression model. They were, in order of stepwise inclusion, examination location, the type of district, the number of children in the family, and maternal age. Table 7.3 presents the model with coefficient (\( \beta \)), standard error (S.E.) of the coefficient, odds ratio and the larger-sample 95% confidence intervals (95% C.I.) of the odds ratio.

The sign of coefficient \( \beta \) indicates that, allowing for other variables included in the model, a child attending a general practitioner surgery, resident in a high deprived district, living in a very large family (5 or more children in the family), or born to an older mother was more likely
to miss both surveillance programmes. For instance, the odds on not attending (or not being recorded as attending) either of the surveillance programmes (at six weeks and eight months) for a random child who was registered at a community health clinic for health surveillance was 20% that for his peer attending a general practitioner surgery, and the odds for a child from a family with 5 or more children was 2.3 times that for a child from a smaller family (with fewer than 5 children). The model also suggests that each "group" increase of maternal age would "result" in a 1.4 times increase in the odds of missing both surveillance programmes.

Table 7.3—Logistic regression model for the attendance status of health surveillance programmes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient (β)</th>
<th>S.E.†</th>
<th>Odds ratio</th>
<th>95% C.I.†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-1.30</td>
<td>0.08</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Examination location (GP/HC)</td>
<td>-1.60</td>
<td>0.19</td>
<td>0.20</td>
<td>0.14, 0.29</td>
</tr>
<tr>
<td>Type of district (Score&gt;0/score&lt;0)</td>
<td>-0.56</td>
<td>0.21</td>
<td>0.57</td>
<td>0.38, 0.86</td>
</tr>
<tr>
<td>No. of children (&lt;5/&gt;5)</td>
<td>0.84</td>
<td>0.32</td>
<td>2.32</td>
<td>1.23, 4.33</td>
</tr>
<tr>
<td>Maternal age group (2 to 4)⁴</td>
<td>0.34</td>
<td>0.17</td>
<td>1.41</td>
<td>1.01, 1.96</td>
</tr>
</tbody>
</table>

†: Standard error of β.
‡: 95% confidence internal of odds ratio.
¶: Maternal age groups 1 to 4: <20, 20-29, 30-39, and ≥40 years.

7.2.4 Association between uptake of primary immunisation and coverage of health surveillance programme

Of the 4,221 children 3,803 had completed their primary immunisations and 418 (9.9%) remained with uncompleted courses. These 418 children had a far lower attendance rate of health surveillance (49.5%), compared with those who had completed primary immunisations (89.5%, Table 7.4).

Table 7.4—Coverage of health surveillance programmes for children who had or had not completed primary immunisation course in the six districts

<table>
<thead>
<tr>
<th>Primary immunisations</th>
<th>Total No.</th>
<th>No.</th>
<th>%</th>
<th>χ²</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completed</td>
<td>3803</td>
<td>3402</td>
<td>89.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not completed</td>
<td>418</td>
<td>207</td>
<td>49.5</td>
<td>481.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total</td>
<td>4221</td>
<td>3609</td>
<td>85.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7.2.5 Content of health checks in the six districts

Table 7.5 lists screening tests routinely undertaken at the six week and eight month checks for the target pre-school population in the six study districts. A total of 27 screening “tests” were

1: See footnote of Table 7.3
recorded in the computer systems of the six districts as required procedures when an eligible pre-school child attended. By studying the manuals of health checks in the individual districts it was noted that some of these "different" tests had the same purpose or took the same measures. For example, in some districts the term "growth" was used to indicate the overall status of a child's "weight", "height/length" and/or "head circumference", the latter three being separately recorded in the computer system of other districts. Some terms used in one district had the same meaning as other terms used in another district, for instance, "gross motor" and "motor skills", "fine motor/fine move" and "manipulation". For some terms it was difficult to equate the tests even though they sounded the same, e.g., "general examination", "physical examination", "physical status" and "system examination". Some districts included a check of the hips within one of the above examinations but others recorded it separately. In some districts unique tests were included in the health checks to be recorded, for example, "oral", "sleep" and "neuro-development". The latter check might be a part of "system examination" in another district.

### Table 7.5—Routine screening tests at the six week and eight month checks in the six districts

<table>
<thead>
<tr>
<th>Screening test</th>
<th>WEX</th>
<th>BHB</th>
<th>ISL</th>
<th>HAR</th>
<th>PNK</th>
<th>BRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behaviour</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fine motor/fine move</td>
<td>-</td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General examination</td>
<td>+</td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genitalia</td>
<td>-</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td></td>
</tr>
<tr>
<td>Gross motor</td>
<td>-</td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growth</td>
<td>+</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td></td>
</tr>
<tr>
<td>Head circumference</td>
<td></td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td></td>
</tr>
<tr>
<td>Hearing</td>
<td>+</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Height/length</td>
<td></td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hips</td>
<td>+</td>
<td>(+)</td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Locomotion</td>
<td></td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td></td>
</tr>
<tr>
<td>Manipulation</td>
<td>+</td>
<td>(-)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Morphology</td>
<td></td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor skills</td>
<td></td>
<td>(+)</td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neuro-development</td>
<td></td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neurological examination</td>
<td></td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Oral</td>
<td>+</td>
<td>(-)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td></td>
</tr>
<tr>
<td>Physical examination</td>
<td></td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Physical status</td>
<td></td>
<td>(+)</td>
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<td>Red reflex</td>
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<td>Sleep</td>
<td></td>
<td>(+)</td>
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<td></td>
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<tr>
<td>Speech/language</td>
<td>-</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Social skills</td>
<td></td>
<td>(+)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Squint</td>
<td>-</td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System examination</td>
<td></td>
<td>(+)</td>
<td></td>
<td></td>
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<tr>
<td>Vision</td>
<td></td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
</tbody>
</table>

Signs in parentheses indicate screening test at the eight month check.

By and large, the contents listed in Table 7.5 could be generalised into broad categories. However, for the purpose of this study it was not possible to analyze all categories of health checks undertaken in the six districts because (1) not all districts used the same name for recording a check, for example, check for "hips" was undertaken in only three of the districts;
(2) a broad-category check undertaken in one district might be broken down to more than one category in another; and (3) it was difficult to equate some “tests” between districts and some of the detailed procedures were similar but others differed. For these reasons, I decided to use one assessment as an indicator for evaluation. Hearing was selected because (1) “hearing” was included in the routine procedures of all the six districts and in both six week and eight month surveillance programmes, which would enable comparisons of the outcomes between districts and between programmes at the two target ages; (2) “hearing” has been a frequently used test to evaluate the performance of health surveillance programmes [Butler, 1989]; and (3) “hearing” is probably a single “test” for the ability to hear but with important implications for speech and language development.

7.2.6 Outcomes of hearing assessments

Three general patterns can be noted in Table 7.6 which demonstrates attendance status at the hearing assessment. Firstly, not all children who attended at a target age appeared to have received the scheduled hearing assessment. Secondly, the vast majority of screened children were found to be “normal” (satisfactory). Thirdly, the proportion of “positive” (unsatisfactory) cases was generally higher at the eight month than at the six week check, i.e., more children were positive or suspected positive at eight months.

Table 7.6—Results of hearing “test” at the two target ages for the children resident in the six districts

<table>
<thead>
<tr>
<th>Surveillance result</th>
<th>At 6 weeks</th>
<th>At 8 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resident population</td>
<td>4221</td>
<td>4221</td>
</tr>
<tr>
<td>Total (%) attended</td>
<td>3060 (72.5)</td>
<td>3204 (75.9)</td>
</tr>
<tr>
<td>No. (%) checked</td>
<td>2557 (83.6)</td>
<td>2897 (90.4)</td>
</tr>
<tr>
<td>No. (%) satisfactory</td>
<td>2546 (99.6)</td>
<td>2865 (98.9)</td>
</tr>
<tr>
<td>No. (%) unsatisfactory</td>
<td>11 (0.4)</td>
<td>32 (1.1)</td>
</tr>
</tbody>
</table>

What was the relationship between the outcomes of these two checks? Were children identified or suspected “positive” (unsatisfactory) at six weeks also identified or suspected “positive” at the eight month check? How many children who were suspected or identified “positive” at eight months had been identified “normal” at the six week check? In order to investigate this relationship, the outcomes at these target ages were compared in individual children. Table 7.7 presents the comparison data. It was found that at the six week check where 2,546 children had been checked and found “satisfactory”, 333 (13.1%) did not attend for the eight month programme, 208 (8.2%) attended but were not recorded as examined at the eight month programme, 1,983 (77.9%) were found “satisfactory” and 22 (0.9%) found “unsatisfactory” at the eight month surveillance programme. Among the 11 children identified as “unsatisfactory” at the six week check, 3 (27.3%) did not attend at eight months, 3 (27.3%) attended but were not apparently examined at eight months, 5 (22.2%) were found “satisfactory” and none had the same “unsatisfactory” outcome as at the six week check.
Table 7.7—Comparison of outcomes of the hearing ‘test’ at six weeks and 8 months for children resident in the six districts

<table>
<thead>
<tr>
<th>At 8 months</th>
<th>Did not attend</th>
<th>Not checked</th>
<th>Satisfactory</th>
<th>Unsatisfactory</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did not attend</td>
<td>612 (52.7)</td>
<td>37 (3.2)</td>
<td>502 (43.2)</td>
<td>10 (0.9)</td>
<td>1161 (100.0)</td>
</tr>
<tr>
<td>Not checked</td>
<td>69 (13.7)</td>
<td>59 (11.7)</td>
<td>375 (74.6)</td>
<td>0 (0.0)</td>
<td>503 (100.0)</td>
</tr>
<tr>
<td>Satisfactory</td>
<td>333 (13.1)</td>
<td>208 (8.2)</td>
<td>1983 (77.9)</td>
<td>22 (0.9)</td>
<td>2546 (100.1)</td>
</tr>
<tr>
<td>Unsatisfactory</td>
<td>3 (27.3)</td>
<td>3 (27.3)</td>
<td>5 (45.5)</td>
<td>0 (0.0)</td>
<td>11 (100.1)</td>
</tr>
<tr>
<td>Total</td>
<td>1017</td>
<td>307</td>
<td>2865</td>
<td>32</td>
<td>4221</td>
</tr>
</tbody>
</table>

Percentage exceeds 100% due to rounding of numbers.

7.3 DISCUSSION

7.3.1 Why were movement-in residents excluded from this study?

In this part of the study children who were not registered at birth as resident in the districts were excluded; if movement-in residents had been included in the data analysis, coverage figures would have been distorted because only some would have had a computer record of their involvement with a surveillance programme which itself might have been different from that being undertaken in the selected study districts. If a child moved into one of the study districts, say, at the age of ten months, from a district where no computerised health surveillance programme was operating, data were unlikely to be available even if he or she had been screened at six weeks and/or eight months. The inclusion of such a child in the denominator for the coverage rate would, undoubtedly, influence the overall coverage rate of the new district of residence, i.e., result in that rate being underestimated, with further distorting effects on the results of outcome-factor associations.

7.3.2 Schedules for a health surveillance programme

Unlike the schedule of immunisations where a timetable for routine immunisation procedures is clearly defined and all eligible children are required to be vaccinated by the schedule [DH, 1990; 1992], schedules of health surveillance for pre-school children have been controversial [Butler, 1989]. In addition to the issues of general efficacy and cost-effectiveness of health surveillance programmes, the following two questions are also under debate. (1) At what age should a child be screened? (2) What medical conditions should be screened for in the programmes, i.e., what screening tests should be undertaken?

There seems to be no general agreement on the two questions. Review of previous literature revealed no fewer than 24 different combinations of screening ages for the under-five child population [Butler, 1989]. There has been no agreement even among child health “experts” in this regard [Curtis Jenkins, 1976]. However, four age points do appear to be coming more
widely accepted as the target ages for pre-school surveillance for a child under five (excluding neonatal screening)—six weeks, seven to nine months, 18 to 24 months and three and a half years. These four target ages were incorporated into the health surveillance programmes in more than half of 90 area health authorities (AHAs) surveyed in England [Connolly, 1982], mentioned in more than half of 35 previous references on health surveillance [Butler, 1989], and have also been recommended in the recent report of the Joint Working Party on Child Health Surveillance [Hall, 1991].

In the present study, the timetable for pre-school health surveillance programmes was found to be similar in all six districts; all children resident in the districts were required to be screened at about six weeks, six to nine months, 18 to 24 months, and three (and a half) years. However, the content of each assessment varied among the six districts, reflecting differences in policy. It was noted that 27 “different” screening tests were recorded in the computer systems as routine health check procedures in the six districts. Some “tests” were substantially the same or similar in different districts. A specific assessment undertaken in one district might be included in a combination of more than one procedure required in another district. Some tests, required in different districts, overlapped. Overall, however, there was variation among the districts, more marked in some than others (Table 7.5). The chief reason for this variation is likely to be related to the lack of hard scientific evidence demonstrating whether or not a specific screening test should be carried out routinely at any specific time for the general pre-school population [Butler, 1989].

Health surveillance programmes for pre-school children have been running for a long time. However, there is little agreement regarding many fundamental issues. Health professionals have differing opinions about the value of surveillance [Holt, 1974; Curtis Jenkins et al., 1978; Gilbert et al., 1984; Hoekelman, 1975; Yankauer, 1973; Hutchison and Nicoll, 1988]. These different opinions among health professionals reflect the lack of scientific evidence for the screening programmes and the general lack of “standard” or “reference tests” against which screening procedures used to detect disorders among children in the community can be validated. Even where such “standard” or “reference tests” exist they are far from precise and there is a lack of consistency of interpretation among health professionals [Butler, 1989].

7.3.3 Productivity of screening

As introduced in Chapter Two one of the major criticisms of child health surveillance is the apparent low productivity of surveillance programmes in relation to their cost. The principal measures of productivity of a screening programme are its yield (defined as the number of cases of a condition that are correctly identified by the programme), its sensitivity (defined as the proportion of people with the condition who are correctly identified on being screened), its specificity (defined as the proportion of people without the condition who are correctly identified on being screened), and its positive predictive value (defined as the proportion of positive screening results that are correct) [Butler, 1989].

An example of the low productivity of pre-school surveillance was given by Bolden [1976] who reviewed 150 children under five in 1975 and found only three (2%) children with
confirmed defects first identified in a screening clinic. Of these, only one (less than 1%) might have remained undetected but for the clinic. From these figures, Bolden concluded that running developmental screening clinics was expensive and yielded very little return.

Is Bolden's experience typical? Only a handful of data sets are available from which the productivity of a screening programme can be estimated and many of these are small samples. Butler [1989] concluded that the productivity of screening among pre-school children is largely unknown.

Although it seems an area for very useful future research, the question of whether pre-school surveillance programmes are cost-effective in these six districts is beyond the scope of the present study. However, the computerised data derived from the six districts indicate that, overall, in the screening for hearing problems, 32 (1.1%) children at the eight month check were recorded as “unsatisfactory”. The proportion of children identified or suspected positive was lower at the six week programme, being 0.4%. Unfortunately, there was no available independent reference data allowing comparisons to be made with the computing system so I was unable to calculate the productivity of the programmes in these six districts. However, if we assume that all the initially identified cases were subsequently confirmed to be truly defective, i.e., no false positive, the yield of the eight month programme for hearing “test” would be 1.1% and 0.4% at the eight month and six week checks, respectively. There seems little doubt that the true yields of these checks would be lower because of false positive cases.

Despite that there were no reference results available from second or third tier assessments (appointments made as a result of the “unsatisfactory” findings at the primary screening) which would confirm the accuracy and productivity of these programmes, a comparison of the six week and eight month data suggested the possibility of high false positive and false negative rates. For instance, of the 11 children who were identified as “unsatisfactory” cases with hearing problems at six weeks, none was “confirmed” as “unsatisfactory” at the eight month check. On the other hand, 32 children were identified with hearing problems at the eight month check, but 22 of them had been identified as “normal” and none had been screened as “unsatisfactory” at the six week check (Table 7.7). In this regard it is likely that these 32 children had developed a hearing problem between the two check intervals. However, the possibility could not be ruled out that some of these children were identified as “normal” at the six week check even though problems had already existed at that time (false negative). On the other hand, it is almost certain that some children who did not attend or who attended but were not examined at the target ages had problematic hearing. Therefore, it seems reasonable to believe, according to these data, that the sensitivity and specificity of hearing “tests” in the surveillance programme were low with a high proportion of false positive and false negative cases. This appears to be the case at least in the six districts during the study period.

Furthermore, it could be anticipated that even among the genuine “positive” cases there were a number of cases who had only a trivial condition, e.g., transient hearing loss associated with a head cold, that would have little impact, even if not identified, on the health and development of the child. On the other hand, adverse impact of some defects, notably some congenital defects, even though identified at primary health checks, may not be preventable or curable at present.
because of a lack of effective intervention. These two factors would, to some extent, increase the marginal cost of such screening programmes.

These results seem to suggest that routine screening for defects of hearing at the age of six weeks and eight months on a population basis in these districts failed to produce high yields and support Bolden's argument about the lack of effectiveness of surveillance programmes for pre-school children. However, the present data are limited especially regarding the productivity of the programme. Further, more detailed, research is needed to incorporate independent validation of reported positive and at least a sample of "negative" cases to assess possible false negatives.

It appears that many district health authorities have introduced health surveillance programmes in a very haphazard fashion, without prior appraisal, subsequent audits, or general monitoring of the programmes [Butler, 1989]. An assessment of "speech and language" was required at six weeks as a routine screening procedure for all children in five of the six districts. However the proportion of children actually recorded as having their "speech/language" assessed at this age was very low (less than 30% in all the districts). The yield however would be problematic even if there was 100% coverage. Some might doubt such an assessment's feasibility or reliability before a child was able to speak. The low coverage per se of this assessment at six weeks would suggest differing opinions about the test; some may have undertaken the procedure as required by local policy; others may have decided not to do it because they did not know how to, or suspected the validity of the procedure.

Another example of the haphazard nature of surveillance programmes is the "hearing test" which was required as routine at the six week check in all six study districts. Some districts required a "real" test (e.g., response to sound startles or to a bell at 15 cms) to screen for hearing loss despite the warning of the Joint Working Party on Child Health Surveillance "do not attempt hearing test at six weeks" because "there is no simple clinical test of hearing suitable for primary care use in this age group" [Hall, 1991]. In fact, the present data showed that the attempt to identify hearing defects (by asking parents or/and "real" tests) at six weeks on a population basis produced little return in the study districts; only 0.4% of children were initially identified (Table 7.6) and the true yield would be lower than this figure due to the sensitivity being very likely less than 100%.

It is essential to evaluate the effectiveness of a screening test before it is introduced on a routine basis, particularly at the present time when the validity, specificity, sensitivity and cost effectiveness of many screening procedures for pre-school children are under debate. The evaluation must based on hard scientific evidence. Only when a well defined screening test is able to produce a cost-effective high yield, should it be recommended for a defined target population.

At the present when there is no agreed national schedule of pre-school health surveillance, individual health authorities (district health authorities, FHSAs and appropriate provider units) decide the pattern of health surveillance activities for pre-school children in their area. Every such group should seize the opportunity to make full use of computerised child health data to
evaluate on a whole population basis, the most effective and economic schedules and content of health surveillance and to provide generally compatible scientific and population based evidence to establish a national "standard" core programme for pre-school surveillance.

This core programme and local programmes should include practical guidelines for surveillance, including schedules, content, who should carry out the screening tests and who a child should be referred to if suspected as positive on a particular assessment. More importantly, every scheduled screening test should be standardised. A controversial test should not be recommended or continued on a large scale before it has been proven to have a reasonably high yield. The “core” programmes described in Hall’s book [1991] might reasonably form the basis, if validated and demonstrated to be cost effective, of a national schedule. Meanwhile, widely accepted (even though not at present standardised) terminology should be used to reduce confusion and make the information comparable between localities and among health professionals. Furthermore, all health staff undertaking surveillance procedures should be properly trained to reduce falsely identified cases, i.e., to increase the sensitivity and specificity of the screening test and to ensure that test results are interpreted in the same way.

As well as scheduling and recording the initial surveillance procedures, the pre-school module of a child health computing system should operate in such a way as to enable the recording of information from second and third tier referral assessments; referral health professionals should provide the computing system with confirmatory information about the assessment of a referred child. The recording of these “expert” assessments would provide invaluable information, important for the evaluation of a health surveillance programme, especially at the present stage when there are many uncertainties about such programmes.

7.3.4 Cover and factors influencing cover

Surveillance programmes usually aim to reach all children within a given age range for each individual screening test [Hall, 1991]. The proportion of the target population that is actually screened within the relevant time period is, therefore, one indicator of the effectiveness of a screening programme. Although there may be some difficulties in the interpretation of coverage rate of a screening programme, a higher coverage rate among the target population remains an important goal [Butler, 1989].

Data from the six study districts showed that the overall coverage rates of the six week and eight month programmes were 72.5% and 75.9%, respectively. There appear to be no agreed national or even local targets with which to compare these rates. Compared with the median rates (just over 80%, [Butler, 1989]) obtained from previous reported figures and supposing the populations are comparable, there seems to have been little overall progress in terms of coverage over the last ten years or so.

In addition to those children who missed the surveillance programmes at both target ages (about 15%), some 23% of children attended for surveillance at only one target age. Thus only 63% of the target population were recorded as having been screened at both target ages. If we had taken into account only those children who were actually screened for hearing defects, the coverage
rate would have even been lower (tables 7.2 and 7.6). The results therefore suggest that the performance of the surveillance programme with regard to coverage rate in these six districts as a whole has been sub-optimal.

Many previous studies, most done between the mid-seventies and mid-eighties, revealed various factors that could influence coverage of health surveillance. These factors can be categorised as: mobility of the population [Rowlands, 1975; Zinkin and Cox, 1976; Curtis Jenkins et al., 1978; Mayall and Grossmith, 1985], the attitudes of parents towards their children’s health and development [Rowlands, 1975; Biswas and Sands, 1984], the vigour with which non-attenders are followed up and home examinations performed (Zinkin and Cox, 1976; Fisher et al., 1983), the accuracy of the population records and the adequacy of the call systems that were used [Heward and Clayton, 1980; Berkely et al., 1984; Burke and Bain, 1986], the rigidity with which screening was tied to specific ages [Barber et al., 1976], and the extent to which surveillance was linked into other services such as the weighing and immunisation of babies [Biswas and Sands, 1984; Karmali and Madeley, 1986]. The present results, derived from population based data in the six districts, and from investigating on an individual child basis and by multivariate analyses, confirmed some of the previous findings.

Data obtained in these six districts revealed that children registered at a general practitioner surgery for screening, resident in a high deprived inner city district, coming from a very large family (with five or more children in the family), and being born to an older mother were less likely to be screened at the target ages.

**Examination location**

Many general practitioners have been undertaking pre-school surveillance programmes for years. Since the introduction of the new general practitioner contract in 1989, more general practitioners have been qualified and encouraged to undertake screening procedures on pre-school children and more GPs are expected in future to participate in pre-school surveillance. In these six study districts as a whole 61.3% of children were attending GP surgeries for pre-school surveillance. However, compared with that for children attending a community health clinic, coverage of surveillance appeared to be poorer in GP surgeries; the odds on *missing both screening programmes* (at six weeks and eight months) for a child registered at a GP surgery was 5 times that for his peer attending a community health clinic. This result is the opposite of uptake for immunisations where general practices did better than health clinics (see Chapter Six). The problem may relate partly to communication problems with the child health computer staff not being notified of checks which have been undertaken, but there are various other possible reasons.

Previous studies have shown that general practitioners may be involved in pre-school surveillance in a number of different ways; some GPs organise clinics in their own surgeries or health centres and are personally involved in pre-school screening [Powell, 1985; Burke and Bain, 1986]; some are involved because child health screening clinics are held in their practices [Baker, 1985; Burke and Bain, 1986]; some undertake surveillance in special clinics or opportunistically [Powell, 1985; Burke and Bain, 1986]; and some GPs do community child health clinic sessions [Macfarlane and Pillay, 1984] as an acting clinical medical officer (CMO).
Such variation in the involvement of GPs in pre-school surveillance would be expected to result in differences in scheduling, implementation and recording of the screening procedures. Some GPs or practices may arrange appointments with their serviced population based on their individual schedules. Many more, at the present stage, would make no appointment and limit their involvement in this work to opportunistic screening carried out in the course of other, usually parent-initiated consultations.

General practitioners are usually independent of local health authorities and they have more “freedom” to choose the pattern of their surveillance practice, even though the agreement under the 1989 contract is that district health authorities set the programme (with FHSAs); GPs should follow this programme if they are to be paid for surveillance work. By and large, preschool surveillance has been controversial with little evidence to prove its cost-effectiveness. Many GPs consider running routine screening programmes to be a very expensive exercise [Butler, 1989]. Another factor which might affect GP’s attitude to, and hence performance and coverage of, pre-school surveillance is the fact that there have been no targets set, unlike immunisation programmes, on which the GP’s extra payment is based. A yearly payment can be claimed but the low level set for this payment might be thought “not worth it”. These factors might, at least partly, explain why many GPs undertake screening programmes only on an opportunistical basis, mostly to meet parents’ requests and might be less than wholly concerned about returning completed surveillance information to the district child health computer departments. This situation would be more likely if a GP is working single-handed with few assistant staff available [Jarman et al, 1988].

On the other hand, community health clinics, which are run by district health authorities, are more likely to incorporate systematic screening programmes for children at specified ages, reflecting the DHA’s policy on pre-school surveillance. It would be more likely that health clinics hold special screening sessions for children, no matter whether the assessments be undertaken by clinical medical officers (CMOs), by health visitors, or by general practitioners working on a paid sessional basis as acting CMOs, or even by hospital doctors. Because of, possibly, better communication between child health departments where child health computing systems operate, and health clinics, either by direct electronic link or by liaison with health visitors (or other health staff) who are usually health clinic attached at present, the clients would be more likely to keep an appointment for surveillance screening, and it would be more likely that completed forms were returned. Another possibility is that as more and more immunisation procedures are undertaken at general practices, due, at least partly, to the new GPs contract and the new payment policy (see Chapter Six), freed up resource at health clinics previously used for immunisation have become available for pre-school surveillance.

The type of districts

Previous and present studies have shown the effect of the “inner city” factor on immunisation uptake [Begg and White, 1987; Jamian et al, 1988; Li and Taylor, 1991; also see Chapter Six]. This factor also had a great effect on health surveillance; with other confounding factors controlled, a child resident in a high deprived inner city district had nearly twice the odds of missing the screening programmes as did a child living in a low deprived outside city (rural or suburban) district (Table 7.3). However, it is likely, as for immunisations, that this “inner city”
factor is only an indirect factor with other factors playing a direct, crucial role.

Children resident in high deprived inner city districts are more likely to have adverse factors affecting uptake of health services. For instance, they are more likely to be living in a larger family with more dependent children, to be from a minority ethnic group, to be in a disadvantaged social class, to be born to an older mother, or to change their addresses more frequently. All these factors have been confirmed to be related adversely to the utilisation of health services [Baker et al., 1984; Scrivens, 1984; Begg and White, 1987; Haskey, 1988; Jarman et al., 1988; Riley et al., 1991]. As shown in the previous chapter, inner city children are not only more likely to be affected by a disadvantageous factor, but also tend to be affected jointly by more than one adverse factors (see Section 6.3.4).

Therefore, it was not surprising to find a lower coverage of health surveillance in high deprived inner city districts. The many disadvantages overwhelmed the beneficial effect of attending a child health clinic for surveillance (more children in inner city districts were registered at health clinics). Ethnic group and social class (which were not available in the present computing systems) are likely contributing factors to the lower coverage rate in inner city districts.

**Family size and maternal age**

Variables family size (the number of children in the family) and maternal age were also included in the final logistic regression model for surveillance attendance status. The estimates of the model suggest that a child from a very large family, i.e., with five or more children in the family, was more likely not to attend for the screening programmes, with the odds being 2.3 times that for a child from a smaller family (with fewer than five children in the family). The model also indicated that each “unit” of increase of maternal age group would be responsible for an increase of approximately 41% in the odds of not attending for the screening programmes (Table 7.6).

These two factors have also been associated with immunisation uptake, but the pattern of influences on surveillance coverage was different. Firstly, for immunisation, as the number of children in the family became larger, the coverage rate went down steadily, whereas for surveillance an effect from family size was only seen when the number of children was five or more (tables 7.2 and 7.3). Secondly, younger age of the mother became a 'promoting' factor for children to attend for surveillance, whereas children of young mothers tended not to be vaccinated.

Although there is no clear evidence it seems possible that younger mother feels less secure regarding child development than older mothers who have had previous children and so attend for surveillance checks. It is also possible that health professionals have effectively “targeted” teen-aged mothers as being in particular need of health service support/assessment [Sheridan, 1962; Alberman et al., 1986]. Another possibility might be that the call and recall systems for immunisation and screening procedures operated in different ways, so that some families were well informed of immunisation but not of surveillance programmes or the other way around [Biswa and Sand, 1984; Karmali and Madeley, 1986].
7.3.5 Inverse care laws

A higher coverage rate is an indicator suggesting better performance of screening programmes, but is by no means the only one. When interpreting the coverage rate of a surveillance programme, one should ask: is there a biased attendance for surveillance programme in the target population? In other word, how many of the children who are most likely to be defective actually attend for the programme? In the real world, it is often the case that those who present for screening are generally less likely to suffer the condition being screened for than the target population as a whole [Pill et al., 1988].

A previous study in Paddington demonstrated that children living in that high deprived inner city area were more likely to be socially disadvantaged and not to receive satisfactory health surveillance during their pre-school years. The children were by and large more likely to have problems of one kind or another on entry to school and to experience difficulty in their learning and behaviour during their later school years [Whitmore and Bax, 1986]. The present results of health surveillance as well as immunisation uptake appear to support their findings. Even though no convincing evidence (e.g., secondary or tertiary referral assessment results) was available to confirm that children in high deprived inner city districts had a higher prevalence of developmental or behavioural problems, they were found less likely to use the pre-school surveillance services as evidenced by their lower attendance rates (tables 7.2 and 7.3). This so called “inverse care law” [Tudor Hart, 1971] was further evidenced by the fact that children from larger families (with five or more children) had a far lower coverage of health surveillance; this factor was used as one of the criteria defining the high risk children who “are in a group with a higher risk of developmental problems than the study population as a whole”, but “not brought to child health clinics, and thus not using available services” [Zinkin and Cox, 1976].

This inverse care law may not be applied to surveillance programmes only. The results of immunisation status previously presented in Chapter Six seem also to be in favour of this argument. Children who did not attend for health surveillance were found less likely to have been properly vaccinated (Table 7.4). Previous experience and present evidence seem sufficient to indicate that children living in an environment with adverse factors are less likely to receive satisfactory health care during their pre-school years, and “Clinics may, therefore, be said to be catering for those for whom the need is least” [Fisher et al., 1983].

Therefore, the health service should not only make efforts to increase coverage or uptake of its programmes among the population, but also to target with particular care “difficult” populations that are usually in greatest need of services. When evaluating the performance of a health programme, the extent to which “difficult” populations have been included and provided with appropriate care should be considered in addition to examining the overall coverage or uptake of the programme.
8.0 PREVIEW

Epidemiology is broadly defined as "the study of health and illness in human populations", and the range of topics includes not only chronic and acute diseases, but also the quality of health care and relevant disciplines [Kleinbaum et al., 1982]. Epidemiological studies are concerned with the health of population groups—the distribution of diseases or health-relevant characteristics in groups (descriptive epidemiology) and the factors influencing this distribution (analytic epidemiology). The purpose of most epidemiological studies in community health, and in the health field generally, is the collection of information and the analysis of such information, which will provide a basis for action or intervention, whether immediately or in the long run [Abramson, 1984]. Many processes and procedures have been involved in the present project, and the validity (systematic error) and precision (random error) depend, as always, on the extent to which these processes and procedures had been pursued according to epidemiological discipline and principles.

This chapter aims to review and discuss the methodology employed throughout this project, from study design to statistical analysis, from the selection of study subjects to generalisation from the results, to evaluate the merits and drawbacks of the methods used in this project and to discuss what questions have been answered and what issues need further investigation.

8.1 GENERAL CONSIDERATION OF THE STUDY DESIGN

Generally speaking, the design of this project was observational including descriptive and analytic studies and qualitative and quantitative investigations. The data came from two main sources, computerised child health systems and pre-coded self-administered questionnaires. Investigations of immunisation status and health surveillance programmes were based on data derived from the child health computing systems. Health professionals were also approached in this project to seek their opinions about child health computing systems and relevant child health activities (qualitative investigation), and their opinions were analyzed quantitatively to provide more indicative information (quantitative investigation).

Theoretically, observational research is often believed to be the most practical and feasible to conduct because the study factor is not manipulated. This type of study is, quite often, less expensive and takes less time than other types of studies. These advantages are particularly apparent as most of the data used in this project had been obtained from routinely collected data bases—child health computing systems—and was already available for analysis. However, the major limitation of observational designs is that they afford the investigator the least control
over the study situation; therefore, results are generally more susceptible to distorting
influences, and because the investigator achieves relatively little control in the design stage,
observation studies tend to be unique, making them relatively more difficult to replicate and,
therefore, might make scientific generalizations less secure [Jamison, 1980].

8.2 SELECTION OF SUBJECTS

8.2.1 Why was the three month birth cohort selected?

One of the objectives of this project was to investigate, based on the computing system data, the
outcomes of immunisation and health surveillance programmes and their associations with
certain factors. A three month birth cohort of children born in January to March 1990 was
selected for study because:

1. only by the end of 1989 had all (but one) districts in NET introduced the new child health
computing system (RICHS) and data been transferred to the new system from various
previously used child health systems. The universal format used for recording information in
the new system enabled extraction of data using the same downloading techniques and so
facilitated data management and analysis;

2. this project was planned to start at the beginning of 1990 with data collection being
completed by the end of October 1991. Therefore, the investigator was able to have close con­
tinuing observation of the study subjects over nearly two years;

3. by the end of October 1991 when the collection of computing data was completed, children
in this cohort were aged 19 to 21 months, which made investigation and comparisons possible
in terms of the immunisation and health surveillance programmes. The coverage of primary
immunisations has usually been calculated at 18 months of age [Begg et al, 1989], and all
children in this cohort should have received their MMR vaccines by the end of October 1991.
By the age of 19 months children should also have attended for the six week and eight month
surveillance programmes and some would have attended for the 18-24 month checks;

4. based on mid-year 1988 OPCS population estimate, a three month birth cohort would
provide a large enough child population in each of the individual health districts for statistical
analyses.

8.2.2 Why were the ten districts selected?

Another main objective of this project was to evaluate the performance of RICHS used in NET
and to compare the relative merits of that system with NCHS. The NWT region was considered
because it shared many geographic and population similarities with NET and was using NCHS.
Resource and time constraints precluded studying all 30 health districts of the two regions in
this project, but there would be no need to do so anyway from an epidemiological point of
view. It was decided to select sample districts from the two regions, five from NET and five from NWT, taking into account the following aspects:

1. Type of district—inner city or rural/suburban: more weight was given to inner city areas since greater variation was expected in terms of the study outcomes.

2. Deprivation: districts selected covered a wide range of Jarman score, a measure initially developed to assess general practitioners’ potential workload [Jarman, 1983; 1984] and widely used as a practical summarised baseline measure of population feature in health terms [Carr-Hill and Sheldon, 1991; Main and Main, 1991; Jarman, 1991].

3. Whether the district was using the pre-school module so allowing an investigation of the pre-school health surveillance programme: at the end of May 1990 only six districts in NET were using the module.

4. Accessibility: because there was only one investigator involved in this study and because much time would be spent visiting child health departments and health visitor venues to carry out the questionnaire studies, geographically easier accessibility of the district was taken into account in selecting the districts.

5. Comparability: districts were first selected in NET, then paired with one from NWT that mostly nearly matched in terms of the proportion of population under five, district location (rural, suburban or inner city) and Jarman score (see Table 3.1). It was expected that this matching of individual districts would minimize the possible confounding effects on the main comparison results.

6. Thus, the study districts were not randomly selected but, within the limitations of an observational study and taking time and resources constraints into consideration, were considered appropriately representative to meet the aims and objectives of the project.

8.2.3 Selection bias

General consideration
An important concern in any observational study is the possibility of undetected flaws in either the research design or the analysis, which leads to spurious conclusions. Difficulties of this sort are generally referred to as problems of validity in estimation of effect. A distortion that may result when estimating the association of interest is usually called a bias [Kleinbaum, 1982]. One of the sources of bias is selection bias which denotes a distortion in the estimate of effect resulting from the manner in which subjects are selected for the study population. Before we go further to discuss selection bias itself, let us have a brief look at the child population hierarchy of this project.

The study population is the collection of individuals from which the study data have been obtained; it often called the sample in ordinary statistical jargon. In this project the study population was the children who were born in January to March 1990 (19 to 21 months by the
time data were analyzed) and resident in the ten districts. The target population is the collection of individuals from which one has sampled (though not necessarily in a representative manner) and about which one wishes to make statistical inferences with respect to the study objectives. Due to methodological features of the study design, the study population may not be representative of the target population (i.e., there may be systematic error). The target population for this study were those children aged 19-21 months (no matter when they were born) resident in all districts of NET and NWT regions. The external population is the collection of individuals to which one wishes to generalize the study findings. It could be viewed as, in this project, children aged 19 to 21 months resident in any area in this country.

In an epidemiological study, what should be considered are [Kleinbaum et al, 1982]: internal validity issues concerning whether or not conclusions about the target population (children resident in all districts of the two regions and 19 to 21 months of age) are spurious because of methodological flaws in the study design, and external validity issues, concerning whether or not the study findings could be generalized to populations outside the two regions (i.e., the whole British child population aged 19 to 21 months).

In this study, it was difficult to obtain sufficient information to quantify precisely the extent (i.e., size) of the bias. However, it may be possible to determine the direction of any bias. "Direction" of a bias refers to whether the effect actually being estimated (θ⁰) either exceeds or lies below the true effect (θ), regardless of the actual size of the bias, based on the definition of bias:

\[
\text{BIAS} = (\theta^0 - \theta) / \theta
\]

From the definition of bias given in this equation, it follows from simple algebra that the bias will be positive when θ⁰ exceeds θ, and negative if θ⁰ is less than θ. A positive bias would lead to overestimation of a factor-outcome association and a negative bias would result in underestimation. A more commonly used terminology distinguishes between biases that are toward the null and away from the null. The direction of the bias is defined as being toward the null if θ⁰ is closer than θ to the null value of the effect measure (e.g., closer to one if a ratio measure is under consideration), provided that θ and θ⁰ are both either larger or smaller than the null value. If the bias is toward the null, then the observed effect appears (in the data) to be weaker than it really is (in the target population). The direction of bias is away from the null if θ⁰ is farther than θ from the null value of the effect measure, again provided that θ and θ⁰ are both on the same side of the null value. Thus, if the bias is away from the null, then the observed effect appears (in the data) to be stronger than it really is (in the target population) [Kleinbaum, 1982].

Direction of bias for some factor-outcome associations

The ten study districts might not be representative of the two regions (target population) since they were selected in a non-random manner. Thus, conclusions about some factor-outcome associations might be spurious because of this flaw in the sampling scheme.

To investigate the direction of selection bias, examples were presented concerning immunisa-
tion outcome-factor associations. Odds ratios of being vaccinated with the third pertussis vaccine were separately estimated for children resident in inner city and rural/suburban districts by fitting two separate logistic regression models for the two types of district. Figure 8.1 illustrates the associations between pertussis immunisation uptake and four factors in the inner city and rural/suburban districts. It is clearly shown that the associations of family type-immunisation, family size-immunisation and mobility-immunisation were stronger in rural/suburban districts than in inner city districts, as evidenced by the odds ratios being farther away from infinity (1.0) in the former than in the latter type of district, whereas the immunisation location-outcome association was stronger in inner cities.

When selecting districts, a higher weight was given to inner city districts, with the ratio of inner city to rural/suburban areas being 6:4 (1.5). The real ratio of the two types of district in the two regions was, however, 10:20 (0.5). Thus, the study population comprised more children from inner city districts compared with the real proportion in the target population. Therefore, there has been a selection bias which might have led to a biased estimation of the factor-immunisation associations:
1. For the associations of family type-immunisation, family size-immunisation and mobility-immunisation (Figure 8.1 A, B and C), since the effects of the three factors were stronger in rural/suburban districts, and in the target population the real proportion of children from these districts was larger, the \( \theta^o \) estimated from the study population was likely to be less than the true measure of effects (\( \theta \)) in the target population, leading to a negative bias. That means that the real effects of the factors family type, family size and mobility on immunisation uptake might have been underestimated.

2. On the contrary, the effect of the factor immunisation location (Figure 8.1 D) might have been overestimated as the \( \theta^o \) was likely to exceed \( \theta \) (positive bias).

**Generalisation of the effects**

There was some evidence to suggest a biased selection of the study population. Therefore, when generalising the effects of factor-immunisation associations to the target population, i.e., children aged 19 - 21 months and resident in all districts of the two regions, it should be borne in mind that the effects of the factors family type, family size and mobility on the third pertussis immunisation uptake might have been stronger and the effect of the factor immunisation location weaker in the target population.

Could the study findings be generalised to populations outside NET and NWT, i.e., was the external validity powerful enough to allow such a generalisation? There was not sufficient information to evaluate the external validity in this project. However, the study findings could be viewed as generating hypotheses for further investigation. Some previous national studies [Begg and White, 1987; Jarman \textit{et al}, 1988; Peckham \textit{et al}, 1989] have shown similar effects on immunisation status, which suggests that the results derived from the ten districts have certain indicative values.

**8.2.4 Selection of health professionals**

In this project, child health managers, computing system operating staff and health visitors in the ten study districts were approached and their opinions about child health computing systems and relevant child health activities were sought by asking them to complete a pre-coded self-administered questionnaire. I intended to generalise their response to the questionnaire to a larger population, i.e., the target population which could be expanded to including the child health managers, computing system operating staff and health visitors in all districts in the two regions. Even though all child health managers and operating staff were studied (the general response rate was 100%), it is impossible to be even reasonably certain that this group were representative of the larger group comprising all their colleagues in both regions (issue of internal validity), and it would be even more difficult to determine the external validity, i.e., to generalize the findings to all areas of this country. The likely ethnic and social characteristics of staff in London and surrounding districts probably make internal validity more likely than external.

For health visitors, the overall response rate was 87.6%, which meant 48 (12.4%) eligible health visitors did not respond to the questionnaire. It was possible to compare basic characteris-
tics of those who responded with those who did not. Table 8.1 shows the comparative data on respondent and non-respondent health visitors in the ten study districts from information provided by their managers when the interviews were set up.

Table 8.1—Comparative background information of respondent and non-respondent health visitors in the ten study districts

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Respondent</th>
<th>Non-respondent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number (%)</td>
<td>340(87.6)</td>
<td>48(12.4)</td>
</tr>
<tr>
<td>Work years (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1</td>
<td>37(10.9)</td>
<td>6(12.5)</td>
</tr>
<tr>
<td>1-2</td>
<td>36(10.6)</td>
<td>4(8.3)</td>
</tr>
<tr>
<td>≥3</td>
<td>267(78.5)</td>
<td>38(79.2)</td>
</tr>
<tr>
<td>χ² (P)</td>
<td></td>
<td>0.30(&gt;0.75)</td>
</tr>
<tr>
<td>District type of working (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural/suburban</td>
<td>170(50.0)</td>
<td>21(43.8)</td>
</tr>
<tr>
<td>Inner city</td>
<td>170(50.0)</td>
<td>27(56.3)†</td>
</tr>
<tr>
<td>χ² (P)</td>
<td></td>
<td>0.43(&gt;0.50)</td>
</tr>
<tr>
<td>Post type (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full time</td>
<td>247(72.6)</td>
<td>31(64.5)</td>
</tr>
<tr>
<td>Inner city</td>
<td>93(27.4)</td>
<td>17(35.4)†</td>
</tr>
<tr>
<td>χ² (P)</td>
<td></td>
<td>0.98(&gt;0.25)</td>
</tr>
</tbody>
</table>

†: Percentage exceeds or is below 100% due to rounding of numbers.

As presented in Chapter Five, health visitors' year or work, district type and post type were the most significant factors associated with their opinions about child health computing systems and other relevant child health activities. Data in Table 8.1 suggests that health visitors who responded and those who did not respond to the questionnaire were not significantly different in terms of these basic characteristics. So, there is no evidence to suggest that those 48 non-respondent health visitors produced much distortion in the results derived from their 340 respondent colleagues.

It is difficult to conclude at this time that these 340 health visitors, 10 child health managers and 68 computing system operating staff, who responded to the questionnaire study, were representative of their colleagues working in the two regions as a whole (the target population) and even more difficult to the external population (e.g., all the counterparts in various areas in this country). Nevertheless, these health professionals can be considered a population in the sense that all its members, taken collectively, comprised an identifiable group [Kleinbaum et al, 1982]. And the findings derived from this population provide some virgin information about the opinions of health professionals, which have, so far, been scantily reported.

8.3 INFORMATION BIAS

Information bias refers to a distortion in the estimate of effect due to measurement error or misclassification of subjects on one or more variables. Major sources of information bias include invalid measurement, incorrectly recorded data, omissions or imprecisions. Among the various sources of such error are the use of a "measurement device" that has a built-in or induced defect, or an incomplete or erroneous data source. Whatever the source of error in the
information obtained, a study subject may, as a result, be misclassified in terms of outcome and/or exposure (factor) status. In the following sections, the possibility of this sort of bias will be discussed.

### 8.3.1 Misclassification of outcome status

Since the main data source of this study was the child health computing systems, one of the major potential sources of information bias would be the misclassification of outcome status. It is possible that a vaccinated child had been recorded in the computing system as not having received the vaccine [Rawson et al., 1980; Jefferies et al., 1991; Rao, 1992]. Previous studies have suggested that instability of the child population was one of the most important reasons for under-reporting of immunisation status, i.e., a vaccinated mobile child was more likely not to have his/her immunisation status recorded in the computing system than a vaccinated stably-resident child. If this situation was true for the cohort of the present study, what influence could be produced by misclassification of immunisation status?

I investigated the effect of misclassification of immunisation status on the association between mobility and immunisation status, assuming that (1) the study population was a good representation of the target population; (2) for both stable and mobile groups of children the specificity observed in the study population was 1.0, i.e., false positive = 0 (it was considered very unlikely that a truly unvaccinated child had been misclassified as vaccinated); (3) for “stable” children immunisation status was misclassified with a sensitivity of 0.95, i.e., false negatives = 0.05 (5% truly vaccinated subjects had been identified as unvaccinated); while for mobile children, immunisation status was misclassified with a sensitivity of 0.90, i.e., false negatives = 0.1. Based on the sensitivity and specificity assumptions a fourfold table representing the “real” situation in a hypothetical target population (Table 8.2 B) could be rearranged according to the observed data obtained from the study population (Table 8.2 A).

<table>
<thead>
<tr>
<th></th>
<th>(A) Study population</th>
<th>(B) Target population (hypothetical)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stable</td>
<td>Mobile</td>
</tr>
<tr>
<td>Vaccinated</td>
<td>5829</td>
<td>798</td>
</tr>
<tr>
<td>Not vaccinated</td>
<td>899</td>
<td>315</td>
</tr>
<tr>
<td>Total</td>
<td>6728</td>
<td>1113</td>
</tr>
</tbody>
</table>

\[
CIR^* = \frac{5829/6728}{798/1113} = 1.21
\]

\[
CIR = \frac{6136/6728}{887/1113} = 1.14
\]

CIR* = Cumulative incidence ratio estimated from study population;

CIR = “Real” cumulative incidence ratio in the hypothetical target population.

The direction of information bias could be determined by comparing the observed cumulative incidence ratio (CIR*) with that (CIR) in the hypothetical target population. We can see that the direction of information bias is away from the null as suggested by CIR* being farther than CIR from the null value of the effect measure (i.e., farther away from 1.0). This type of away from
the null bias indicates that the observed effect appearing in the data was stronger than it really was in the target population, suggesting that the real association between mobility and immunisation status might have been weaker in the target population if the above assumptions were true.

The effect of information bias on district type-immunisation status could also be determined by a similar approach. Since inner city districts generally have a larger proportion of mobile population, it is possible that immunisation uptakes in inner city areas are more likely to be under-reported by the computing system, i.e., higher false negative cases would be expected compared with rural and suburban districts. (This hypothesis was supported by the perceived views of health visitors [see Chapter Five].) Therefore, the direction of information bias was also more likely to be away from the null value, i.e., the district type-immunisation status association was likely to have been overestimated by the study population data due to misclassification of the outcome variables.

8.3.2 Omissions of “exposure” variables

In this project, much effort has been made to investigate the associations of immunisation status and uptake of health surveillance programmes with certain factors (exposure variables). There is no doubt that, in addition to correct classification of the outcome variables, the validity of the association would depend very much on complete recording of these exposure variables.

As has been presented in Chapter Four, the variables type of district and mobility status were recorded for all study subjects in the ten districts. Other exposure variables, however, were omitted in the computing system records for some children. These omissions, like misclassification of outcome variables discussed above, might also result in, to some extent, information bias.

Table 8.3 shows the number and percentage of subjects who had their exposure variables recorded in the computing systems. These were variables identified as factors potentially associated with third diphtheria, pertussis and/or MMR immunisation status, i.e., the \( \chi^2 \) associated \( p \) values were less than or equal to 0.1 (see Table 6.6).

<table>
<thead>
<tr>
<th>Residence status</th>
<th>At-birth</th>
<th>Transfer-in</th>
<th>Moving-in</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of subjects</td>
<td>5009</td>
<td>1719</td>
<td>1113</td>
<td>7841</td>
</tr>
<tr>
<td>No. with all variables ( ^\d ) completed</td>
<td>4663</td>
<td>1489</td>
<td>247</td>
<td>6399</td>
</tr>
<tr>
<td>Percentage</td>
<td>93.1</td>
<td>86.6</td>
<td>22.2</td>
<td>81.6</td>
</tr>
</tbody>
</table>

\( ^\d \) Includes the variables type of district, type of resident, family size, immunisation location, family type and maternal age.

In the logistic regression analysis, observations containing missing dependent or independent
variables were not used to compute estimates, i.e., only the data of those subjects who had both the outcome variable and all explanatory (exposure) variables completed were used. Examination of the completeness of these variables demonstrated that the overall proportion of subjects with all these exposure variables recorded in the computing systems was 81.6%. Were the outcome-factor associations distorted by the 18% who failed to be included in the regression analysis due to missing values? There is insufficient available information to demonstrate whether or not those subjects differed significantly from the 82% from whom outcome-factor association estimates were derived. If these two groups of subjects were similar in terms of the distribution of all explanatory variables we would say that the estimates were valid. Otherwise, some sort of bias might have been resulted, but it is impossible to say whether and in what direction any bias occurred.

However, 93.1% and 86.6%, respectively, of at-birth and transfer-in residents had complete variables, but only 22.2% of moving-in residents had complete and so could be included in the logistic regression analysis to generate the estimates (Table 8.3). This indicates that the main source of any distortion of the estimates (if it existed) was from mobile residents.

8.4 CONFOUNDING

_Condounding_ is a bias that results when the study factor effect is mixed, in the data, with the effects of extraneous variables. This bias can result from causal relationships relating the study factor and the other (so-called _confounding_) variables to each other and to the outcome status in the population of interest. Thus, a _confounder_ is a “risk factor” for the outcome under study whose “control” in some appropriate way (either singly or in conjunction with other variables) will reduce or completely correct a bias when estimating the (true) outcome-factor relationship [Kleinbaum, 1982]. Broadly speaking, a risk factor is any variable that the investigator determines to be “causally related” (though not necessarily a “direct” cause) and antecedent to outcome status (i.e., to immunisation status in this case) on the basis of substantive knowledge or theory and/or on previous research findings.

Possible confounders in the study estimating the immunisation-factor associations included _ethnic group_ and _social class_ of the study subjects. It has been previously reported that ethnic origin and social class are two important factors influencing childhood immunisation uptakes [Baker _et al_, 1984; Peckham _et al_, 1989], and these two variables might also relate to some (if not all) of the study factors. For instance, a child from a minority ethnic group, who is more likely to be unvaccinated [Baker _et al_, 1984], may also be more likely to be living in a larger family and/or living with one-parent and/or experiencing extremes of maternal age, and a child living in a lower social class family (more likely to be unprotected by immunisations) may be more likely to experience other social or environmental disadvantages, e.g., larger family, extremes of maternal age, living in underprivileged inner city areas and one-parent [RCP, 1991].

Even though the effect of these two possible confounders was suspected, the direction and size of any bias associated with ethnic group and social class, which would depend on the distribution of the two variables in the study population, could not be determined because of the
lack of such information in the present child health computing systems.

8.5 CONSIDERATION OF QUESTIONNAIRE STUDY

Questionnaires are one of the frequently used data sources in medical or epidemiological studies. The quality of questionnaire data will depend on the validity of the questionnaire, which refers to the efficiency with which an instrument actually measures what it purports to measure. It also rests on the reliability of the questionnaire, which is essentially a measure of the questionnaire's ability to distinguish the extent to which a variable apparently fluctuates as a result of errors of measurement as opposed to real changes in the object of measurement itself [Bennett and Ritchie, 1975]. The validity and reliability of a questionnaire substantially depend on the design of the questionnaire, e.g., the content, structure, wording, length, question sequence and layout. If the questionnaire data are collected by interviewing respondents, the quality of the data will also much depend on the quality of the interviewer.

In the following sections I will discuss some relevant issues about the questionnaire study employed in this project.

8.5.1 The respondents

Child health managers, computing system operating staff and health visitors in the ten study districts were approached and asked to complete a questionnaire. These health professionals were approached and surveyed because one of the study objectives was to investigate the attitudes of computing system users about the system. These staff were considered the most important users of the computing system and the providers of computing system data. Their training in, understanding of, enthusiasm towards and attitudes about the computing system would affect, to a great extent, the performance of the system. As discussed in Chapter Two, these health professionals play a key role in the functioning of a computing system, from data collection, data management, data inputting and updating, to data forwarding and appointment generation, and finally, at the completion of the appointment ensuring the recording of the service to the target child population. It was expected that data from these staff would provide very important information to assess the effectiveness of child health computing systems, and from this information, strategies might be developed to improve the performance of the systems.

It was initially decided to include a sample of general practitioners working in the study districts, since it was and is believed that, like the health staff mentioned above, general practitioners also play an important part in using and providing computing system data as part of their child health activities. For this section of the study a postal questionnaire was developed because general practitioners are comparatively widely scattered geographically and so very difficult to study in their premises. Unfortunately, this plan had to be abandoned due to a very low response to the postal questionnaires. The importance of general practitioners in ensuring optimal functioning of child health computing systems has been previously described [Rawson et al, 1980; Newman, 1983; Scott, 1990; Jefferies et al., 1991], views supported by the opinions of health visitors in the present study (see Chapter Five). As primary child health
activities are increasingly undertaken in general practice rather than community child health clinics in association with the new general practitioner contract, GP's commitment to child health computing systems will be critical in meeting the objectives of the services. Therefore, it seems important to assess GPs' attitudes to such a computing system to ensure that the present systems meet GPs' needs and the needs of the child health services.

8.5.2 Contents

Pilot work, which included detailed discussions with experienced public health workers and health visitor managers about the project and drafts of the questionnaires, and a pilot questionnaire survey in which some child health managers, computing system operators and health visitors in non-participating districts, suggested key areas of information needed to meet the objectives of the questionnaire study. For system operators the focus was placed on the use of the current child health computing system. It was confirmed that the information should include (1) present work on the child health computing system, and (2) training in using the system. For health visitors it was considered necessary to obtain information about (1) present work, (2) attitudes to the present child health computing system (mainly the quality of the computing system data since they were the main users of the system), (3) general training in child health, and (4) the opinions about their relationship with relevant health staff. For child health managers in addition to the information about their personal views about the computing system, it was thought important to obtain some data on aspects of the management of child health services in their localities.

Obviously the greater the number of topics that a questionnaire covers, the less information will be omitted; but on the other hand, a long questionnaire will be difficult to process and it may also make the respondent reluctant to give full responses so that information loss will then occur through respondent fatigue [Bennett and Ritchie, 1975]. Therefore, when deciding the content of the questionnaires the principle followed was to collect the minimal amount from an individual which would provide sufficient information in the light of the study objectives. It was hoped that as little as possible relevant information would be lost by having pre-tested questionnaires, after evaluation by experienced public health workers and having undertaken a pilot questionnaire survey. Furthermore, in this study the respondent was permitted to add personal comments concerning information which he/she felt was important but which had not been adequately covered by the questionnaire. This provision of additional space under a heading like "free comment" at the end of a questionnaire is said to reduce information loss [Mellner, 1970].

8.5.3 Type of questionnaire

Broadly, questionnaires can take two types: an administered questionnaire (interview) and a self-administered questionnaire [Bennett and Ritchie, 1975; Abramson, 1984]. In this study, all three questionnaires for the three groups of respondents took the latter type.

The self-administered questionnaire has several advantages. First, standardisation of measurement, in that all subjects are asked precisely the same questions. Closed questions (to
be discussed in next section) are often used to refine the method still further and this strict standardisation of format improves test-retest repeatability [Collen et al., 1969]. Second, it removes a source of bias by eliminating the interviewer, and saves considerable costs for training interviewers [Hall, 1972]. However, two important disadvantages of self-administered questionnaire are that it can only be used where simple and straightforward questions can be formulated and understood with the aid of written instructions and that it requires respondents to be able to express themselves in writing and to be able to write.

The decision to use self-administered questionnaires was influenced by two factors. First, funding constraints meant it was impossible to employ “professional” interviewers and more importantly train them to interview many respondents and groups in ten study districts. Second, it was practical to use a self-administered questionnaire, supported by written and oral instructions. Some of the respondents had had experience in completing similar questionnaires. Postal questionnaires for surveys have been shown to provide very poor response rates and hence lead to bias in the results because returns are not representative of the whole population [Burgess and Tierney, 1970]. It was confirmed in this study that postal questionnaires sent to general practitioners produced very low response rates while visiting child health group premises resulted in high response rates, meaning little or no non-response bias (Table 8.1).

It proved possible in every district to organise a specific meeting or use a regular meeting to undertake the questionnaire study. With the cooperation of the managers, meetings were attended by most respondents.

### 8.5.4 The construction of questionnaires

The writing of questionnaire items begins with the selection of a question type. Broadly speaking two main question types may be used, “open” and “closed”. An open question does not suggest any specific response. The respondent is allowed to answer freely, in his own words, and his response is recorded in full. A closed question is one which requires the respondent to choose his answer from a given, limited selection [Abramson, 1984]. Most questions in this study were closed.

Several advantages are apparent in using closed over open questions in such a study. Firstly, the information to be obtained from a respondent should accurately describe the situation for all possible respondents. For example, for the question “for what module of the present system are you mainly responsible”, the four modules and an “other” option provided a full range of possible answers from all respondents. Secondly, closed questions allow quick coding methods with minimal additional effort, and hence facilitate statistical evaluation. Lastly, closed questions, for which responses were simple to complete (by “ticking” or “circling” an option rather than “writing” a full statement), required less time so reducing the risk of respondent fatigue which would affect the quality of information obtained [Bennett and Ritchie, 1975].

A variety of types of closed questions were employed depending upon what information was required from the respondents. A “dichotomous” question represents a choice of two alternatives such as yes/no. A “multiple choice” question offers a choice of response to
complete statements; the respondent chooses the one which describes his/her opinion or position best. This type of question is particularly useful for the investigation of experiences which a respondent might find difficult or embarrassing to formulate. For instance, question 12 in the health visitor questionnaire provided seven alternatives for health visitors to choose from.

The most frequently used type of question was a “rating scale”, which is a special form of the multiple choice question in which respondents “quantify” their response. Rating scales vary in form [Bennett and Ritchie, 1975], but a “interval scale” was used in the present questionnaires, with an appropriate graduation of response. Not every point on the five-point scale had a definition but only two extremes at each end of the scale. For example, “not at all” (point 1) and “very useful” (point 5) were defined on the two sides of the scale for the question “do you think the training was useful for your practical use of the system?”. It was considered that interim point definitions might be too ambiguous. This sort of interval scale with only two end point definitions is believed to be more suitable for investigating attitudes or opinions [Bennett and Ritchie, 1975].

8.5.5 Strategies to improve the quality of questionnaire data

In this study, several steps were taken to ensure that the questionnaire would provide as high as possible quality data. These steps included the following.

(1) To keep the questionnaire as simple as possible and the questions as relevant as possible to the study objectives. The initial discussions and feedback proved invaluable for modifying the questionnaire and the pilot survey provided more direct and detailed information for finalising the questionnaire.

(2) To obtain the cooperation and support of directly responsible staff, so ensuring the highest possible response rate. Discussions were held with each child health manager about the project and the questionnaire for his/her computing system operating staff, and about the time and venue, when and where all (or at least most of) the local staff would be present for the questionnaire study. Similarly, times and venues were arranged with each patch or locality health visitor manager to ensure that all (or most of) her health visitors were present at a regular meeting which the investigator would attend for the study.

(3) To help the respondent at the time. I attended each of the organised meetings for child health managers and computing system operating staff, and the regular patch meetings for health visitors. Whenever necessary, clear oral explanations of the questions were given.

(4) To check the questionnaires immediately whenever possible after completion on the spot—every questionnaire for child health managers and computing staff. If a question was left open or unclearly answered, the respondent was asked to complete it and assistance was given if the respondent did not understand the question. Only completed and clearly answered questionnaires were accepted as final for these staff.

For health visitors an immediate post-completion check was impossible because they were
allowed seven to ten days to complete the questionnaires. Thus, the answers obtained had to be accepted as final: there was no opportunity for uncertain responses to be probed. However, more time was given prior to completion to explain and ask the respondents to read carefully each of the questions. If a question remained unclear a further explanation was given until no uncertainty was expressed.

(5) To remind the managers to get non-respondent’s questionnaire back. Only a very few computing system operating staff did not complete the questionnaire at the meeting—because they were absent. Some health visitors did not return the questionnaire either because they did not attend the meeting or because they just did not respond. Managers were provided with some spare copies of the questionnaire for absent staff to complete. Two weeks later the managers were contacted by phone with a list of names of staff who had not returned their questionnaire, and a month later the managers were reminded again of those who remained unresponsive.

With these “quality control” strategies [Bennett and Ritchie, 1975; Abramson, 1984], the response rates were 100% and 87.6% for child health managers/system operating staff, and health visitors respectively, and the proportions of eligible questions not answered were less than five per cent for all three groups of respondents.

It has to be acknowledged that the validity and reliability of the subjective questionnaire study has not been objectively evaluated, i.e., there is no independent validation of the staff’s responses. Ideally, the accuracy and reliability etc. should have been directly assessed in the individual districts and compared with the subjective assessments. Health visitor opinions might have been compared with hard evidence to assess the validity of their points. However time and resource constraints made this impossible to undertake during the present study. The present results however appear to provide virgin information in this field and certainly should be the basis of future research.

8.6 CONSIDERATION OF STATISTICAL TECHNIQUES

The processing and analysis of collected data are very important in an epidemiological study and the statistical techniques used have to be appropriate. The major task of statistic analysis in medical studies is to draw inference, from observations on a relatively small group (sample), about a larger group (population) from which the sample is drawn. In other words, the aim of statistical methods goes beyond the mere presentation of data and includes the drawing of inferences from them.

8.6.1 Why is statistical study required?

A statistical study is more concerned about group than individual subjects. Data collected from an individual are of little predictive power and are unlikely to be generalisable due to variability, possibly wide variability, between individuals. It would be dangerous to draw specific conclusions about the performance of a child health computing system from a single observation of one health visitor. Attitudes are likely to vary greatly among health visitors due to previous training and experience, work load, enthusiasm and support, etc. Only when a group
of health visitors has been investigated in an appropriate manner would it be safe to draw a conclusion (and then only a tentative conclusion, bearing in mind the specifics and limitations of the sampled group in relation to the generality). If a child resident in a high deprived inner city district was found not to have been vaccinated, it would not necessarily follow that inner city children, in general, would be less likely to receive immunisations; this conclusion could only be safely made when such evidence was clearly demonstrated from the observation of a group of inner city children.

One important objective of this project was to investigate factors associated with less satisfactory utilisation of immunisation and pre-school surveillance services by certain groups of children in the study cohort. Because of the limitations of observational study design, control of study factors has only been possible at the stage of data analysis rather than that of design. For instance, when a specific factor-outcome, say, immunisation location-immunisation uptake association was studied, other factors which were potentially confounders of this particular association, such as family size, the type of districts, etc. had to be allowed for (controlled for), or the conclusion might be misleading. Control is possible by matching study subjects for various factors except the one under study, but sometimes this is very difficult during the early phase of a study. However, this can be (easily) undertaken during data analysis, using appropriate statistical techniques, e.g., multi-variate analysis.

For such reasons much effort has been put into statistical analyses in this project. What statistical techniques to employ was dependent on the features of the data and the objectives of the analysis. The following sections present some considerations of the statistical methods.

8.6.2 Comparison of proportions

One of the most widely used statistical techniques in analysing categorical data in this project is the chi-square test. Chi-square tests allow the comparison of two or more proportions [Armitage and Berry, 1987]. The simplest chi-square test tests the hypothesis (called null hypothesis represented by $H_0$) that two variables, row and column, in a cross-tabulation, are independent of each other. An example of this test is to see whether the proportions of children being vaccinated with MMR (uptake rate of the immunisation) were similar for children in two groups; those living in one-parent families and those in two-parent families. The null hypothesis ($H_0$) to be tested was that the uptake rates in the two groups of children were the same, i.e., these two variables were independent of each other.

A statistic often used to test the null hypothesis is the Pearson chi-square, which is a calculation based on the summarised difference between the observed ($O$) and expected ($E$) numbers of cases falling into each cell of a cross-table, taking into account the degrees of freedom which can be viewed as the number of cells of a table that can be arbitrarily filled when the row and column totals (margins) are fixed [Norušis, 1988]. The calculated chi-square is compared to the critical points of the theoretical chi-square distribution to produce an estimate of how likely (or unlikely) this calculated value is if the two variables are in fact independent. In the above example, the Pearson chi-square statistic was 10.49. If type of family and immunisation (MMR) uptake rate were independent, the probability that a random sample would result in a
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chi-square value of at least that magnitude was less than 0.001 on 1 degree of freedom. If the probability is small enough (usually less than 0.05 or 0.01), the hypothesis that the two variables are independent is rejected. The small probability (less than 0.01) in this particular example allowed rejection of the null hypothesis that the type of family and immunisation (MMR) uptake rate were independent of each other. Therefore we have strong statistical evidence to show that the immunisation (MMR) uptake rate was significantly different between children from one-parent families and those from two-parent families in a larger population from which the sample was selected.

In hope of improving the approximation in the case of a 2 x 2 table, particularly with small expected numbers (< 5) in some cells of the table, *Yate's correction for continuity* was applied, i.e., subtracting 0.5 from positive differences between observed and expected frequencies (the residuals) and adding 0.5 to negative differences before squaring [Mantel, 1974].

**8.6.3 Logistic regression model**

In one sense logistic regression is a special class of general linear regression aimed at investigating whether and how an outcome variable of interest is affected by a set of factors. In many cases the interest factor is a binary variable (two exclusive categories), for instance, whether or not a child had been vaccinated by the age of 19 to 21 months in this three month birth cohort. In such a case with the objective being to study whether and how the proportion of children being vaccinated was affected by the type of district they were resident in, by the immunisation location they registered to attended, and so on, multiple regression analysis can be used to meet the objective. Ordinary linear regression has several draw backs when used to investigate such associations: firstly, the response variable is constrained to lie between the values zero and unity, and secondly, the assumption of error terms with equal variance is unlikely for this type of response [Everitt, 1989].

Therefore, it is more useful to postulate a linear model for the response variable after applying a *logistic transformation*, which takes the equation as [Everitt, 1989]:

\[ \lambda = \log_e \left( \frac{p}{1-p} \right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k \]

As applied to the above immunisation example in this study, \( p \) was the probability that a randomly chosen child was vaccinated, and \( 1-p \) was the probability of not being vaccinated for the child. So, \( \left( \frac{p}{1-p} \right) \) was the odds on being vaccinated. Entries of \( x_1 \) to \( x_k \) were variables included in the model and tested as being possibly related to the response variable (immunisation status), and \( \beta_1 \) to \( \beta_k \) were the regression coefficients of the corresponding variables respectively, measuring the amount of increase (if \( \beta_i \) is positive) or decrease (if \( \beta_i \) is negative) in the value of \( \log_e \left( \frac{p}{1-p} \right) \), i.e., the log odds of being vaccinated, when the corresponding variable \( x_i \) increased 1 “unit” with other factors included in the model stabilised. While \( \beta_0 \) was the log odds of being vaccinated for a child with a “standard” (i.e., reference groups) set of independent variable values [Kleinbaum *et al.*, 1982].

The logistic regression model could not only estimate the association between the response and any one of the explanatory variables but also the strength of the association, allowing for other
CONFIDING” variables. Based on the data and by maximum likelihood estimation the ratio between the probabilities of being and not being vaccinated for a child with a combination of specific factors was estimated from a fitted logistic regression model. In the process of modelling, only those explanatory variables or interaction terms tested and found to have made a significant contribution \( p < 0.05 \) to the variation in immunisation status were included in the final regression model. The intention was to get a model which would be substantively interpretable and as simple (parsimonious) as possible but with minimal distortion to the representation of the model of the data. Thus, to keep the model simple any occasional observations with large (\( \geq 1.96 \)) standardised Pearson residuals were included in the regressions.

When a final model was reached the adequacy of the model, i.e., the extent to which the model represented the data, was examined by checking the standardised Pearson residuals for each observation point which could be made available from the GLIM package [Aitkin et al, 1989]. Large values of the residuals (\( \geq 1.96 \)) indicated failure of the model to fit at the corresponding observation points. For the fitted models in this study the proportion of Pearson residuals with values \( \geq 1.96 \) was found to be less than 3\% of all observations, suggesting that the models, generally, fitted the data reasonably well. An attempt was made to reduce the proportion of observations with large residuals by including complicated interaction terms in the models, but this tended to make the models far more difficult to interpret. Thus, a poor fit was accepted at these points as random variation on occasion, to simplify the models without weakening much their predicting power.

In the process of modelling it sometimes occurred that high-order interactions were inexplicably significant. This phenomenon, called overdispersion, was evidenced by the residual deviance being much greater than the corresponding degrees of freedom. This overdispersion, whenever it occurred, was dealt with by refitting the sequence of models after declaring the ratio of the residual deviance to its degrees of freedom as the scale parameter. Odds ratios and confidence intervals were obtained using the standard errors of parameter estimates from the refitted models [McCullagh and Nelder, 1983; Aitkin et al, 1989].

8.6.4 Cox’s proportional hazards model

In many medical investigations a principal variable of interest is the time until an event occurs, for example the time to being vaccinated. In the study of immunisation status one of my interests was to compare the times for different groups of children (living in rural/suburban and inner city districts for example), and to identify important prognostic factors for delay. A particular feature of immunisation time data was that the distribution was so skewed that even data transformation could not normalise it. In addition, the purpose was to investigate a set of covariates to immunisation age, which could hardly be realised by standard statistical analysis. One technique which has been developed for this situation and which has found wide use in medical research is Cox’s regression [Cox, 1972].

The Cox’s regression model takes the form of

\[
\log \lambda(t) = \alpha(t) + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k
\]
and is referred to as a *proportional hazards model*. The term "proportional hazards" arises because for any two individuals at any point in time the ratio of their "hazards" is a constant. In the model, \( h(t) \) is the Hazard Function, defined as the probability that an individual experienced an event (e.g., being vaccinated in this study), in a small time interval, given that the individual has "survived" up to the beginning of that interval. In this model because the baseline function, \( \alpha(t) \), i.e., the dependence of \( h(t) \) on \( t \), does not have to be specified explicitly, the model is essentially non-parametric, namely the estimates depend only upon the order in which events occur, not upon the exact times of occurrence. Entries of \( x_1 \) to \( x_k \) are explanatory (prognostic) variables, and the estimation of \( \beta \) and inferences are developed by considering the information supplied at each time that an event occurred. The full power of the proportional hazards model comes into play when there are several covariates to consider and the equation represents a multiple regression model. The strength of the relation of the factor to the time interval is determined by comparing each coefficient, \( \beta \), with the appropriate standard error; if the ratio is large (\( > 1.96 \) or \( > 2.58 \) for instance) the null hypothesis that \( \beta = 0 \), that is exponential (\( \beta = 1 \), is rejected (at the 5% or 1% levels), indicating that the variable is related or strongly related to survival time, allowing for other variables. Interpreting the coefficient estimates proceeds in the same way as in ordinary multiple regression. However, the coefficient does not present the exact probability that an event occurred in a short time interval, but the ratio of their "hazards" (or rate in this study) for any two individuals at any point of time.

The theory [Lee, 1980] was borrowed from Cox's regression to analyze the relation of factors to immunisation time. The end point event observed was being vaccinated, and the "survival" time was the time from a child's birth to the immunisation being given. The PHREG (Proportional Hazards REGression) procedure in SAS software [SAS Institute Inc. 1991] was used to fit a proportional hazards model. By stepwise selection where the criteria for entry into or stay in a model of a variable were 0.1 and 0.05, respectively, some factors meeting the selection criteria were identified as strongly related to immunisation age. For instance, three factors were identified related to the age at MMR immunisation; the type of district, immunisation location, and family size. The sign of the coefficient indicated the direction of the association. For example, the ratio of immunisation rate of MMR at any given age of children registered at community health clinics to those at general practitioner surgeries was 0.88 (not the probability of being vaccinated), indicating that the former group of children were, generally, vaccinated at a later age compared with the latter group of children. Low birth weight (< 2,500g) children, on average, started their primary immunisations at a later age compared with normal birth weight (\( \geq 2,500g \)) counterparts, with a ratio of the probabilities of being vaccinated against the first diphtheria at any given age being 0.81 for the former group of children to 1.00 for the latter, even though they had a similar final uptake rate at the age of 19 to 21 months.

The Cox's regression model is particularly useful to analyze correctly *censored* data. Censored observations arise when study subjects have not reached the end point of interest by the end of the study period; consequently their exact "survival times" are not known—all that is known is that these are greater than some value. Censored observations may also apply to immunisation age data in this study. For instance, some children had not been vaccinated by the age of 19 to
21 months which was the end point of study period. However, these children were not included in the Cox's regression analysis. Censored observations are considered when an event has not occurred by the end of study, but eventually will occur some time later after the study period. This may not be the case for immunisations; some children may get vaccinated after a study period, but some children may not receive the immunisation at all. Therefore, it was not thought appropriate to regard unvaccinated children as censored observations or to include them in the survival data analysis.

The proportional hazards model assumes that for two different sets of covariate values, \( z_1 \) and \( z_2 \), the hazard functions are related as follows:

\[
\frac{h(t, z_1)}{h(t, z_1)} = e^{\beta(z_1 - z_2)}
\]

This assumes that the two hazard functions are proportional, or put simply that the hazard ratio does not change with time. If this assumption is seriously violated, then the proportional hazards model would be invalid [Everitt, 1989; SAS Institute Inc., 1991]. This important assumption was assessed by including a new variable, time-dependent explanatory variable \( x(t) \). An example of testing for proportionality of hazards is presented below.

By stepwise analysis, five covariates were included in the final proportional hazards model for the age at MMR immunisation (Table 6.15). Suppose, for instance, that there is some suspicion that children from two parent families and those from one parent families have nonproportional hazards, the rates for two-parent children increasing more with time than for single-parent children, a possible model then would be:

\[
\log(h(t)) = \alpha(t) + \beta_1(SYS) + \beta_2(SIZE) + \beta_3(MAGE) + \beta_4(MOVE) + \beta_5(OPF) + \beta_6(OPF)t
\]

To test for proportionality of hazards, the parameters \( \beta_1 \) to \( \beta_5 \) are estimated and a test carried out to see whether \( \beta_6 \) differs significantly from zero. By the analysis of the parameter estimates, the null hypothesis \( (\beta_6 = 0) \) was not rejected; the chi-square statistic was 1.75 and the associated \( p \) value was 0.19 on one degree of freedom. So the time-dependent variable \( (OPF)t \) could be removed from the model, and the assumption that two- and one-parent children had proportional hazards was valid. If the test indicates an insignificant departure from the proportional hazards for the two groups, a graphic check on the proportionality assumption for these two groups of children, by plotting estimates of the survival function against time (age in weeks), should also display approximately constant differences of the survival functions over time (Figure 8.2) [Kalbfleisch and Prentice, 1980].

Other time-dependent variables were investigated in a similar fashion to test proportionality of hazards between groups for different variables included in the proportional hazards model. The evaluation analysis suggested that the models without time-dependent variables were valid.

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1 : SYS = Type of systems serviced; SIZE = family size; MAGE = Maternal age; MOVE = Mobility status; OPF = One-parent family status.
Many of the statistical studies presented in this paper involved the comparison of two or more groups of subjects. When presenting comparison results, I have included, wherever appropriate, the 95% confidence interval (the ends of this interval are called confidence limits), as well as the associated $p$ values.

In most medical studies, it is advantageous to present sample statistics as estimates of results that would be obtained if the total population were studied, rather than just providing $p$ values usually dichotomised into “significant” or “non-significant” [Gardner and Altman, 1989]. Essentially confidence intervals become relevant whenever an inference is to be made from the study results to the wider world. Such an inference will relate to summary, not individual, characteristics—for example, rates, regression coefficients, etc. The calculated interval will provide a range of values within which one can have a chosen confidence that it contains the population value. The usual degree of confidence presented is 95% [Bulpitt, 1987; Lancet, 1987], but others can be used, e.g., 90% or 99% [Gardner and Altman, 1987].

In a statistical sense, the 95% confidence interval of an estimate from a sample means that if a series of identical studies were carried out repeatedly on different samples from the same population, and a 95% confidence interval for that estimate calculated in each study, then, in the long run, 95% of these confidence intervals would include the population statistic which is inferred from the sample estimate [Gardner and Altman, 1989]. For example, the odds on being vaccinated with the third pertussis vaccine for a mobile child was 0.55 (relative to 1.00 for a stable counterpart) with the 95% confidence interval of 0.41 to 0.76. This odds ratio is
estimated from a sample including all children resident in the ten study districts and born within the three months. The 95% confidence interval means, put simply, that there is a 95% chance that the indicated range, 0.41 to 0.76, includes the “real” odds ratio of the “population”.

The width of a confidence interval associated with a sample estimate depends partly on its standard error, and hence on both the standard deviation and the sample size. It also depends on the degree of “confidence” that one wants to associate with the resulting interval. Larger sample sizes and smaller variability (between subjects, within subjects) will give more precise results and a narrower confidence interval. As would be expected, greater confidence that the population statistic is within a confidence interval is obtained with wider intervals—for example, the 99% confidence interval for the odds ratio presented above would be 0.37 to 0.84, compared with 0.41 to 0.76 for the 95% confidence interval.

There is a close link between the use of a confidence interval and a two sided hypothesis test. If the confidence interval is calculated then the result of the hypothesis test can be inferred at an associated level of statistical significance. The relationship is shown in Figure 8.3, which is graphed using the data from the proportional hazards model for the age at first diphtheria, i.e., the ratio of immunisation rates for two- and one-parent child populations (see Table 6.13). The null hypothesis to be tested is that the ratio of immunisation rates of these two groups is unity, i.e., \( \exp(\beta) = 1 \). Figure 8.3 shows that the \( p \) value is greater than 1% because unity is (just) inside the 99% confidence interval but less than 5% (and, of course, less than 10%) since the 95% (and 90%) confidence interval does not include unity; so in this case, \( 0.01 < P < 0.05 \). By contrast, had unity been within the 95% confidence interval this would have indicated a non-significant result at the 5% level.

![Figure 8.3](image-url)

Figure 8.3—Relation between confidence interval and the two sided hypothesis test, using the ratio of immunisation rates (first diphtheria) at any given age for two- and one-parent child populations
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The confidence interval thus provides a range of possibilities for the population value, rather than an arbitrary dichotomy based solely on statistical significance. It conveys more useful information but at the expense of precision in the $p$ value. Even though in this example, the 95% confidence interval covers a fairly wide range of possible ratio of immunisation rates between the two populations, the population parameter of this ratio would be much more likely to be near to the middle of the confidence interval than towards the extremes, i.e., the best estimate of the population ratio is 0.85 derived from the sample.

8.7 SOME LIMITATIONS OF THE PROJECT

It was thought that, in general, the study was undertaken in line with epidemiological discipline and that data were handled within the limits of statistical theory. However, due to the constraints of study time and resources and data availability in the child health computing systems, some limitations have to be acknowledged. These need to be considered when evaluating the project, especially generalising the results obtained to the wider world.

1) A large part of this project was observational. There are some disadvantages with this type of epidemiological study, in particular control to minimize confounding effects over the study factors can only be undertaken during the stage of data analysis.

2) The ten study districts were not selected in a completely random manner and therefore some selection bias might be expected when findings are generalised to the target population.

3) The children studied were a total population—a three month birth cohort; however these three months may not applicable to other time periods.

4) The attitudes of general practitioners to child health computer systems were not evaluated. It is believed that their assessment would provide useful information to improve the performance of the systems.

5) The quality (validity and reliability) of the questionnaire data was not quantitatively evaluated.

6) Unlike data collected from *ad hoc* epidemiological surveys, whose quality can be controlled during the stage of data collection, it has to be assumed that the accuracy of the computer system data used in the present study was reliable. Bias might have resulted due to misclassification and omission of variables in the computer systems.
How can the quality of child health system data be improved? And how can the health services improve the performance of immunisation and health surveillance for pre-school children? It has been realised that to meet these two general goals is not an easy task and will rely upon the efficient cooperation of many relevant health professionals and health policy makers. Some strategies will require legislative back-ups [Walker, 1980; Rigby, 1981; Walker, 1983; RCGP, 1983; Moules, 1987; Nicoll et al, 1988; Butler, 1989; Hall, 1991, Ross and Begg, 1991]. Some changes may easily be made and benefits seen in a short time, but others may be difficult and take a long time. Some decisions can be made by the health service itself, many others, however, can only be made with the cooperation of decision makers in other fields, e.g., education.

This final chapter devotes to presenting a summary of results, followed by the summarised conclusions and recommendations based on the results.

9.1 SUMMARY OF RESULTS

This project was undertaken in ten health districts in NET and NWT regions, and the study subjects comprised a three month birth cohort of children and health professionals working with child health computing systems. The project examined the quality of data available in the computing systems operating in ten districts, assessed the attitudes of health professionals to the computing systems and relevant aspects of child health services and evaluated the performance of pre-school immunisation and health surveillance programmes, using computing system data.

9.1.1 Child health computing systems

The general quality of child health computer data was considered high, and information variables were generally complete. However, the records for unstable child population were less than satisfactorily complete; only 22.3% of movement-in resident children had all the six examined important information variables completed, compared with 84.1% and 93.7% of transfer-in births and at-birth residents. One of the factors for incomplete information variables was associated with inefficient transfer of health records between localities when children moved. Another factor related to incomplete information was poor standardisation of recording the information in the computing system between localities/systems. Clerk errors was also
found a contributing factor to incompleteness of computer data.

Notification time of births to child health computing systems was mainly associated with type of resident district and birth place; it took much more time for a newborn in inner city district or delivered outside mother's resident district to be registered in the child health system. Direct linkage between maternity computing systems and child health systems could shorten the notification time. One of the main reasons for delayed birth notification was duplicative registration of children in a non-responsible district; it was found that up to nearly 60% of records stored in child health computing systems were those who did not live in the correspondent district.

Some discrepancies were identified between child registers of the child health systems and relevant FHSA systems; 5.4% and 2.9% of children could have missed from child health system records in two inner city districts. Even though, child health computer system data appeared to be more reliable than FHSA system data in terms of the completeness of child register.

9.1.2 Attitudes of health professionals

The overall response rate for health visitors in this study was 87.6%, and 100% for child health managers and their computer operating staff. It proved impossible to obtain data from general practitioners at the time the study was undertaken.

Child health managers in the study districts stated that their child health computing system had produced much benefit, e.g., daily work had been speeded up, the system had proved user-friendly, much repetitive manual work and duplication of recording had been avoided.

However, the performance of child health computer systems were considered by most health visitors as not being optimal in terms of not providing easy access to the system data, not reducing paper work in their child health activities and not avoiding duplicative work in child health records. Health visitors were generally satisfied, nevertheless, with the quality of child health computer data (updating and accuracy).

The RICHS system in NET was considered more user-friendly, compared with the national system as used in NWT.

According to computer system operating staff in the ten districts, changes of address and names were the most important factors related to inaccuracies in the computer data. Errors in original documents and poor standardisation of record codings also contributed.

The proportion of untrained operating staff was considerably greater in NET than in NWT districts. Desire for further training in using the computer system was stronger for those staff who had not previously received formal training in all types of districts regardless of their length of experience with the system.
More experienced health visitors were as likely to want further training in preventive child health (e.g., immunisations and health surveillance) as their less experienced colleagues. However, their requirements for training in this field were less likely to be met; less experienced health visitors were more likely to be offered training.

Data from the ten study districts suggested that running more child health clinic sessions did not necessarily result in higher uptakes of immunisations, instead, uptake rates increased as a higher proportion of children attended general practices for immunisations.

Inconvenience of immunisation session times and venues was considered by the child health managers as the most important factor causing non-attendance at immunisation appointments by the clients. The limited data (only ten district child health managers were interviewed) seemed to indicate that forwarding immunisation appointments to clients about two weeks (rather than one week) in advance would help reducing the proportion of non-attendance.

Immunisation uptake rates using child health computer data were considered by half of health visitors as under-estimated. The most important factor contributing to the under-estimation was believed to be inadequate communication between general practices and child health departments. Poor exchange of data between child health clinics and the local child health department was considered less relevant.

### 9.1.3 Immunisation status and influencing factors

Children resident in inner city districts were more likely to be vaccinated at child health clinics, while those in rural and suburban areas at general practitioner surgeries. In general, scheduling arrangements were poor, particularly in inner cities where 76% of immunisation procedures were given opportunistically (unscheduled procedures) and these opportunistically vaccinated children were found to complete their immunisation course at a considerably later time compared with those vaccinated on scheduled appointments.

Overall, the 90% target has not been met for this three month birth cohort by the age of 19 to 21 months; the uptake rates for P3 and MMR were found to be 84.5% and 81.8% with the rates for other vaccines being about 88.3%. A considerable proportion of children received their immunisations rather late even compared with the "old" immunisation schedule.

By and large, five risk factors were identified for low uptake of immunisations; living in a high deprived inner city district; being "allocated" to an immunisation location other than a general practitioner surgery, moving between districts, living with one parent and living in a larger family. Children in inner cities were more likely to possess these five adverse factors and more likely to be affected by the combination of these adverse factors, compared with their counterparts in rural and suburban areas.

Limited data suggested that the RICHES system implemented in NET region would be associated with more rapid improvement of immunisation uptake rate compared with the national system as being used in NWT region.
9.1.4 Pre-school health surveillance programmes

The study was undertaken in six of the ten districts where computerised pre-school surveillance data were available. Wide variation was found among the six districts in coverage of health surveillance programmes; the attendance rates were from 57% to 82% for the six week check and from 70% to 83% for the eight month check.

Overall coverage of health surveillance programmes in the six districts was 72.5% and 75.9% for the six week and eight month checks, respectively. Only 63% of children attended health checks at the two target ages (six weeks and eight months).

Overall, four risk factors were identified as being associated with lower attendance for surveillance checks, i.e., registered to attend a general practitioner surgery, resident in an inner city district, living in a larger family (≥ 5 children) and being born to an older mother.

There was a significant association between uptake of primary immunisation and coverage of health surveillance programme; children who had not completed their primary immunisation course were less likely to attend health checks at both target ages.

Wide variation was found in the content of health checks among the six districts studied despite the similar ages at which children were required to receive screening tests. A total of 27 screening “tests” were recorded in the computer systems of the six districts as required procedures when an eligible pre-school child attended. However, it was noted that some of these “different” tests had the same purpose or took the same measures; some terms used in one district had the same meaning as other terms used in another districts; some districts included a check within a broad examination category but others recorded the check separately; and in some districts unique tests were included in the health checks to be recorded.

Not all children who attended at a target age were received the scheduled hearing assessment. The vast majority of screened children were found to be “normal” (satisfactory). The proportion of “positive” (unsatisfactory) cases was generally low although the proportion was higher at the eight month (1.1%) than at the six week check (0.4%).

Some discrepancies have been identified between outcomes of the six week and eight month hearing assessments; these discrepancies suggested high false positive and false negative rates for hearing assessment at the two target surveillance ages.

9.2 CHILD HEALTH COMPUTING SYSTEMS

9.2.1 Usefulness of computing system data

In addition to providing assistance in service organisation, child health computing systems are a major source of child health statistics and, perhaps more importantly, for a comprehensive as-
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Assessment of child health services, by providing large data sets on a population basis. Routinely collected computerised data are cheaper and take less time to provide results compared with ad hoc epidemiological surveys. All system records rely upon good quality and complete data. The computing systems can quickly identify defaulters of health care and possible factors influencing less than optimal utilisation of child health services. The systems can also provide continuous feedback to service providers and health care planners, and the data can be used to assess the effectiveness of health care for children so that strategies can rapidly be modified to improve the services.

The findings from the present evaluation study are likely to be useful for the development of new modules as well as revision of present RICHS and NCHS modules. Generally, the system main users considered that the computer data are well completed and of high quality (in terms of accuracy and updating). However, some limitations have been found. For instance, the present systems are not powerful enough to deal with mobile child populations, especially in inner city areas; there is a lack of standard coding, e.g., for ethnic groups across different localities, and some information is not well completed particularly for movement-in residents. Since this evaluation was of comparatively short duration (essentially a cross-sectional study), it may only be a reflection of performance at that time. Therefore, ongoing and built-in evaluation seems highly desirable to ensure optimal utilisation of this invaluable data source.

9.2.2 Recording of non-residents

Many non-resident children were found to be registered with details kept in the computing system. There seems little use for these records in the district not responsible for the child's health care, even though the child may have been born in the district. Duplication of recording of non-resident children in non-home districts seems a waste of staff time and may result in delayed notification to the home district where the child normally lives.

I recommend that districts not record non-resident children in their computing system or keep the records unless they will be used/are of relevance to the local service (e.g., for maternity statistics). When a child is born outside his/her district of residence, the Notification of Birth should be sent as soon as possible to the responsible authority, preferably directly from the hospital where the child is born.

9.2.3Forwarding of Notification of Birth

There appeared to be significant delay in forwarding the Notification of Birth to the child health departments. This notification should occur within 48 hours and is particularly important where the maternity home is not in the child's district of residence. Once the child is registered in the computing system the health visitor should be notified as soon as possible to facilitate her statutory work. This flow of information is particularly important now, when the immunisation schedule starts from the second month of life, as well as for the health visitor's initial home visit.

Electronic linkage should be established, wherever possible, between child health computing
systems, the maternity computer systems in hospitals and the systems for health visitors. Such a linkage would speed up essential information exchange between health professionals.

9.2.4 Built-in checking for data accuracy

Some errors in the recording of information were found to be due to computing system operators. Some errors might be avoided with revision of the computing system programmes by developing built-in data checking capacity. Examples of the possible revision of the programmes are given below.

When the current address of a child is entered into the computer, the system should, by data checking programmes, identify whether the child is a resident or not, and automatically record the child as a resident if the address is within the responsible district’s boundary. The current district code should also be automatically recorded, e.g., “F04” if the child lives in West Essex, or “F07” if in Hampstead, and so on. Similarly, if a child has moved out of the district, the system should be able to identify where the child has moved to, and accordingly record a new correct residence district code by checking the new address entered by the clerk. The residence status should be automatically changed to the code representing “movement-out”. This automatic data checking could be easily dealt with by the computer where system files containing the postal, street and district codes have already be established in the systems. If this work was automatically done by the computer many errors would be avoided.

This recommendation applies to other situations as well. For instance, when mother’s date of birth is entered, the system should be able to check the validity of the information. If the data entered are out of valid range, e.g., subtraction between the child’s date of birth and the mother’s reveals a ridiculous maternal age, say, under 10 or over 60 years, the system should not accept the information and give a warning to the operating staff to check. Birth weight, gestational age and other variables could also be set a nominal range which the system would accept as valid, or a warning be given on the screen. I believe that this strategy would greatly improve the validation and quality of child health computing systems.

The registration module should also be modified so that incompatible codes generate a query response. Automatic updating of residential status should be provided through an electronic record of postal addresses and district codes when changes of address are notified.

9.2.5 Improving completeness of computer data

Some important variables are not recorded at all in some districts (e.g., ethnic status), or are missing in too many children’s records. Because of their potentially great usefulness for administrative, epidemiological and clinical management, all agreed variables should be recorded, whenever available. Some new information needs to be added to child health computing systems such as the occupation of parents which would provide information about social class—one of the most important social factors influencing the utilisation of health services.
The present format of the Movement-in Form is not detailed enough to provide adequate information about a child who has moved from one district to another. The Movement-in Form should include all the same information recorded on the Notification of Birth plus any updated information, e.g., change of address, immunisations received, where and when, and other health care procedures received. An alternative is that a copy of Notification of Birth should be provided, together with a specifically designed form on which the information about events since birth is recorded, both to be sent to the child's new resident district. The possibility of electronic transfer of this information, at least within a region, should be explored, and then expanded to include all regions in the country.

An agreed standardised coding system should be employed across the region and, where available, a national standard should be used for recording each relevant piece of information. Poor standardisation of coding systems certainly makes the exchange and the comparison of information very difficult between localities, if not impossible, especially with the extremely high mobility of the child population in some areas and in the country generally. Standardisation would facilitate efficient exchange of information between different health care computing systems in other regions where families may move.

Health visitors and other field health staff should be burdened with as little paper work as possible when recording data for computerisation. Any cards or forms used for this purpose should be as simple as possible, and easy to understand. An optimal format would use only "ticks" or "circles" to record the information, with minimal items requiring words. Efforts should also be made to develop ways of using the information going into health visitors' administrative systems. Compatibility between child health and other community computing systems (or some systems used for both purposes) would avoid much wasted duplicative effort by health visitors, and improve the completeness of child health computing system data.

The identified discrepancy between the child health computing system and FHSA registers reinforces my recommendation for direct linkage between child health and other health care computer systems. In the medium term all child health computing systems should be made compatible so that, at least, the information they contain could be directly exchanged without difficulty. In the longer term this comparability of computer systems should be expanded to include all systems associated with health care for the entire population nationwide.

In summary, all the required information on each child/family should be collected and recorded on the systems. Additional socio-demographic indicators should be agreed and routinely recorded. Standard regional (or national) codes should be agreed and used. The Movement-in Form should be extended to include all the required information without need for further enquiries. The tools for collecting computing system data (e.g., cards and forms) should be made as simple as possible and easy to complete. Free electronic exchange of child health information is required and all health computer systems should be made compatible.

9.2.6 Improving communications

Child health computing systems should have enquiry access at the clinic level so allowing
health visitors and other field health staff to use the system directly. It seems likely that local
data access would help child health systems to cope more effectively with changes of child’s
addresses and names. However, entry access may have disadvantages, e.g., effects on data
accuracy. The benefit and drawback of decentralising entry access to clinic level needs further
careful evaluation.

Efforts should be made to enable health visitors and other primary health workers (e.g., general
practitioners and community nurses) to benefit from (and to feel they are benefitting from) the
computerisation of child health systems. Those involved should be offered easy access to child
health information. For instance, updated information on the child register for a locality, an
area, or a clinic should be regularly produced and fed back to the locality, area or clinic.
Experienced personnel in the district child health office should always be available to deal with
any request on child health records from field health staff.

Immunisation uptake or outcomes of other child health activities should be fed back to the
service providers (e.g., health visitors, general practitioners and community nurses). Communication and exchange of child health data between health professionals, particularly
between general practices and child health departments needs to be improved. In this exchange,
information which ensures a complete up-to-date child register is particular important to share,
as accurate uptake rates require not only data on procedures carried out but also an accurate
denominator. Optimal communication and exchange of information is likely to be of particular
importance in inner city districts where computer data are likely to be less accurate because of
the unstable population.

9.2.7 Training in using the computing system

Before the child health computing system is introduced at clinic level, field staff should receive
training, particularly practical training, in using the system. This is especially important when
data amendment and editing are to be carried out on a local basis.

Less experienced computer system operating staff, e.g., those who have worked with the
computer for less than one year, seem particularly likely to need and benefit from ongoing and
further training. However, all computer staff should be provided with adequate initial training.
Such initial training seems problematic at present, notably in some North East Thames districts.
As well, staff should be trained to deal with problems regarding child health records raised by
field health staff, e.g., health visitors, general practitioners and community nurses.

9.3 IMMUNISATION PERFORMANCE

9.3.1 Improving immunisation service

Child health clinic sessions for childhood immunisations should be made more accessible to the
clients. Running more immunisation sessions along may not necessarily increase uptake of the
service especially for inner city populations. When setting up immunisation sessions the providers should take into account accessibility and the convenience of time and venue, particularly for working parents. Immunisation sessions outside normal office hours may be needed, e.g., evening or weekend sessions, and in some cases domiciliary immunisation service could be recommended, particularly for frequent defaulter families (e.g., large size families or single parent families).

9.3.2 Improving uptake of immunisations

Parents from frequent defaulter families should be encouraged to ensure their children are vaccinated. These families may need to be better informed of and educated about the importance of immunisations and the danger to health if their children are not protected. When visiting homes the health visitors should give particular time and effort to educate these parents.

If a child has moved the previously responsible district health authority should always inform the new resident district about the child and provide all available information about the child’s immunisation status.

Every possible effort should be made to get every eligible child vaccinated. Consideration might be given to bonus payments to parents when a child completes the recommended immunisation schedule or on making completion of a recommended preventive health care programme a prerequisite for school entry.

There should be a review to improve the utilisation of the scheduling system for immunisation appointments. In general, immunisation appointment invitations should be sent out about two weeks in advance. Individual districts, however, should experiment to find out, according to the nature of the local population, how long in advance an immunisation invitation should be sent to the parents.

At present children should be recommended to attend general practitioner surgeries for their immunisations, where a better immunisation uptake appears likely. In the meantime more effort may need to be made in community child health clinics to increase their immunisation uptake rates for children especially in inner city areas where the majority of children at present attend community health clinics rather than general practices.

9.3.3 Training

Health visitors and other staff concerned with childhood immunisations should be provided with regular training opportunities in preventive child health care, particularly contraindications to immunisation, in order for them to deal accurately with parents concerns.
9.4 CHILD HEALTH SURVEILLANCE

9.4.1 Cover of health surveillance and influencing factors

The overall coverage of health surveillance programmes at the two target ages studied (six weeks and eight months) appeared to be less than satisfactory even though there are no present set targets. Little progress seems to have been made since the mid 70’s and 80’s when cover figures reported in earlier literature were compared with the present results (assuming that the populations were comparable). Coverage of health surveillance appeared to be sub-optimal; only 63.0% of the target population attended for both the six week and eight month health checks, with 14.5% having missed health checks at both target ages. I suggest that an indicator of “full” attendance rate should be used to assess the performance of health surveillance programmes. Thus, a child aged 12 months should normally have received both the six week and eight month health checks, otherwise he or she is considered “partly” serviced. More importantly, the proportion of children actually tested for a particular defect, e.g., hearing disorder, should be used in the performance assessment, as a considerable proportion of children who attended did not actually receive the test. Meanwhile, the extent to which children who are at higher risk of developing defects are actually assessed should be taken into account when evaluating coverage of a health surveillance programme.

Factors affecting coverage of health surveillance appeared to be similar to those associated with immunisation uptake, except that general practitioners seemed to have poorer performance of surveillance for pre-school children compared with community child health clinics. There was a correlation between immunisation uptake and surveillance coverage. This finding suggests that strategies taken to improve the performance of one service are likely to increase uptake of the other.

9.4.2 Content of health checks

Wide variation was found in the content of health checks among the six districts studied despite the similar ages at which children were required to receive screening tests. Many test procedures used different terms even though some of the procedures had the same or similar purposes. Some districts required unique tests to be carried out. All these variations suggested different patterns of surveillance services reflecting the varied policies adopted in individual districts. It is highly recommended that a “core” programme be established. Within the “core” programme the same terms and the same format in recording the outcomes of a test should be used. This would facilitate exchange of information and comparison of evaluation results between localities.

9.4.3 Outcomes of surveillance programme

Due to variations in the content of health checks and in the format of recording the outcomes of screening tests across the six districts it was only possible to use the check for “hearing”
problems to estimate the productivity, i.e., the yields, possible false positive and false negative cases. The data suggested a rather low yield of hearing "test" for the general pre-school population at both six weeks and eight months even though the exact estimation was not possible due to lack of confirmatory referral data.

In addition to the need for the establishment of a "core" programme for pre-school health surveillance mentioned above, the format for recording outcomes of a screening test should be compatible between the various child health computer systems used in different districts. If a referral is made the child referred should always be followed and confirmatory second or third tier assessment data be requested and entered into the computer system. This would provide invaluable information for the evaluation of a screening test in terms of its productivity.

At the present time when there are many uncertainties about the effectiveness of many screening tests, the opportunity should be seized of utilizing this available population based data to audit/evaluate the programmes in a on-going way. This will be increasingly important as more districts introduce the pre-school module. District health authorities should in general follow the schedules of pre-school surveillance recommended by the Joint Working Party on Child Health Surveillance [Hall, 1991] when setting up the objectives of their service. Prior to introducing a screening test for the general pre-school population, a pre-appraisal, on-going audit and "final" evaluation should be undertaken on a small sample population to reveal the effectiveness of the test. This evaluation procedure should be extended to the many tests presently used in a haphazard way.
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APPENDICES

A list of tables and figures

**Questionnaires used in the project**
(The questionnaires have been re-formatted for presentation.)
A questionnaire for health visitors
A questionnaire for child health administrators/managers
A questionnaire for the child health staff/VDU operators

**Publications relevant to the project**
# A List of Tables and Figures

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APPENDICES—A QUESTIONNAIRE FOR HEALTH VISITORS

A QUESTIONNAIRE FOR HEALTH VISITORS

Your name (optional) ____________________________ District ___________ ID code ______
Your are now working full/part time. ________ Date ________________

Your answers to these questions provide information for an evaluation study of child health computing systems under the auspices of the regional health authority. It would be a great help if you could answer all the questions. ANSWERS WILL, OF COURSE, BE TREATED AS HIGHLY CONFIDENTIAL.

There are three types of question in this questionnaire. The following examples will help you to see what is required. There are no “correct” answers to the questions, instead we expect you to choose the options that fit you best.

Example 1  Do you think you need some rest when finishing this questionnaire?
0  No => jump to example 3.
1  Yes
(This means that you need some rest when finishing this questionnaire. If No, answer the question of Example 3 directly.)

Example 2  How many hours do you need to rest?
2  hours
(This means that you need 2 hours rest)

Example 3  Is the work you are doing interesting?
Not at all  1  2  3  4  5  Very
(You gave a grade 3 on the 5-point scale from NOT interesting AT ALL to VERY interesting.)

Example 4  Do you think these examples are clear?
Not at all  1  2  3  4  5  Very
(You gave a grade 4 on the five-point scale from NOT clear AT ALL to VERY clear.)

SECTION 1 PRESENT WORK

01. How low have you been a health visitor?
1  < 1 year
2  1–2 years
3  3–5 years
4  6 years or more

02. How long have you worked in this district?
1  < 1 year
2  1–2 years
3  3–5 years
4  6 years or more

03. Are you mainly attached to ... ?
1  Community health clinic/centre
2  General practice
3  Hospital
4  Child development team
5  Day nursery/centre
6  Other _____________________________

04. About how many children under five are there on your caseload?
______ children

05. About how many children on average do you visit at home each month?
______ children/month

06. How do you plan your daily work of child health surveillance/preventive care?
1  by receiving a computer generated appointment
2  by working out appointment through computer
3  by receiving manually generated appointment
4  by working out manually the appointment
5  by other means (Please specify)

07. How do you record your results of child health surveillance/preventive care?
1  by manual forms/cards
2  by computer screen update
3  by other means (Please specify)

08. How many days on average is it from a child's birth until you are notified of this child?
1  < 24 hours
2  25–48 hours
3  3–5 days
4  6–9 days
5  10 days or more

09. Do you think the Notification of Birth generally reaches you in an appropriate time?
In good time  1  2  3  4  5  Too late
10. What do you think the main reasons are for any delay in birth notification?

- Postal delay
  Never happens 1 2 3 4 5 Always happens
- Delay in hospital
  Never happens 1 2 3 4 5 Always happens
- Delay in Child Health Department
  Never happens 1 2 3 4 5 Always happens
- Delay due to other reasons (Please specify)
  Never happens 1 2 3 4 5 Always happens

11. Does this delay cause you inconvenience or lateness in neonatal visits?

Never 1 2 3 4 5 Always

12. What is the usual age (days) for a neonate being first time visited by you?

1 1–2 days 2 3–5 days 3 6–9 days 4 10–15 days 5 16–19 days 6 20–30 days 7 1 month or more

13. Do you think the time for the first visit is...?

In good time 1 2 3 4 5 Too late

14. What do you think are the reasons for any lateness of the first neonatal visits?

- Late receipt of Notification of Birth
  Never happens 1 2 3 4 5 Always happens
- Too busy for you to visit on schedule
  Never happens 1 2 3 4 5 Always happens
- Lack of cooperation from the parents
  Never happens 1 2 3 4 5 Always happens
- Other reasons (Please specify)
  Never happens 1 2 3 4 5 Always happens

SECTION 2 CHILD HEALTH COMPUTER SYSTEM

15. Do you have legal access to the child health computer system (ie, you’ve got your own user’s name and password)?

1 No ⇒ if no, jump to question 21
2 Yes

16. About how many hours each week do you use the system in your daily child health activities? (If none, write a zero.)

_____ hour(s)/week

17. In what way do you have access?

1 Screen enquires
2 Screen amendment/update
3 Both

18. Have you ever been formally trained (ie, attended specifically organised training sessions) to use the child health computer system?

0 No ⇒ if no, jump to question 21
1 Yes (how many) _____ hours

19. Were the training sessions provided by ...?

1 Your department
2 Your district
3 Your region
4 Private personal demonstration
5 Other ______________________
6 Don’t know

20. Do you think the training was useful for your practical use of the system?

Not at all 1 2 3 4 5 Very useful

21. How can you usually get the information held in the child health computer system?

Difficult 1 2 3 4 5 Easy

22. How much has the system reduced your daily paper work in child health activities?

Not at all 1 2 3 4 5 Much

23. How much has the system avoided any duplication in your recording of child health data?

Not at all 1 2 3 4 5 Much

24. How do you think general information held in child health computer system are updated?

Low mark 1 2 3 4 5 High mark
### APPENDICES—A QUESTIONNAIRE FOR HEALTH VISITORS

25. How do you think general information held in the system are accurate?

<table>
<thead>
<tr>
<th>Low mark</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>High mark</th>
</tr>
</thead>
</table>

26. Specifically, do you think the immunisation uptake rates reported by the child health computer system in your area in general are ... ?

<table>
<thead>
<tr>
<th>Underestimated</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Overestimated</th>
</tr>
</thead>
</table>

27. Do you think good or bad communication between the following staff/departments might contribute to any of the discrepancies in immunisation rates?

- GPs/child health department
  - Problematic: 1 2 3 4 5 No problem

- Health clinics/child health department
  - Problematic: 1 2 3 4 5 No problem

- Health visitors/child health department
  - Problematic: 1 2 3 4 5 No problem

- Health visitors/GPs
  - Problematic: 1 2 3 4 5 No problem

### SECTION 3 GENERAL TRAINING

28. About how many days altogether have you attended training sessions on topics of child health (eg. immunisation, health surveillance) during the past one year?

<table>
<thead>
<tr>
<th>Days</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>None (if none, jump to question 31)</td>
</tr>
<tr>
<td>1</td>
<td>&lt;1 day</td>
</tr>
<tr>
<td>2</td>
<td>1-5 days</td>
</tr>
<tr>
<td>3</td>
<td>6-10 days</td>
</tr>
<tr>
<td>4</td>
<td>1-20 days</td>
</tr>
<tr>
<td>5</td>
<td>21-30 days</td>
</tr>
<tr>
<td>6</td>
<td>&gt;30 days</td>
</tr>
</tbody>
</table>

29. Have you been satisfied with the training sessions in general?

<table>
<thead>
<tr>
<th>Not at all</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 Very much</th>
</tr>
</thead>
</table>

30. Do you think the training courses were useful for your practice in child health activities?

<table>
<thead>
<tr>
<th>Not at all</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 Very useful</th>
</tr>
</thead>
</table>

31. How often do you think the training in child health should be provided for you?

<table>
<thead>
<tr>
<th>Days</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>None</td>
</tr>
<tr>
<td>1</td>
<td>Monthly</td>
</tr>
<tr>
<td>2</td>
<td>Quarterly</td>
</tr>
<tr>
<td>3</td>
<td>Half-yearly (how many ___ DAYS)</td>
</tr>
<tr>
<td>4</td>
<td>Yearly</td>
</tr>
<tr>
<td>5</td>
<td>Irregularly</td>
</tr>
</tbody>
</table>

32. Are training sessions ACTUALLY arranged for you in the next six months?

<table>
<thead>
<tr>
<th>Days</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No</td>
</tr>
<tr>
<td>1</td>
<td>Yes (how many ___ DAYS)</td>
</tr>
</tbody>
</table>

### SECTION 4 OPINIONS

33. Do you think there is adequate communication between HEALTH VISITORS and the following health workers from a preventive child health care point of view?

- General practitioners
  - Very poor: 1 2 3 4 5 Excellent

- Staff in district child health office
  - Very poor: 1 2 3 4 5 Excellent

- Hospital medical staff
  - Very poor: 1 2 3 4 5 Excellent

- Community paediatric staff
  - Very poor: 1 2 3 4 5 Excellent

34. How do you feel the communication could be improved? (You may choose more than one answers.)

1. Regular scheduled meetings
2. Shared accommodation, eg. health centre
3. Enforcement of present legislation, eg. birth notification transfer
4. New regulation, eg. compulsory transfer of data (ie. immunisation data from GPs to child health department)
5. Others (Please specify)

### SECTION 5 FREE COMMENTS

Thank you very much for your cooperation. If you have any additional comments that you think might be useful to us please write them below.
A QUESTIONNAIRE FOR
CHILD HEALTH ADMINISTRATORS/MANAGERS

Your name ___________________________ Your department ___________________________
Your district ___________________________ Date ___________________________

Your answers to these questions provide information for an evaluation study of child health computing systems under the auspices of the regional health authority. It would be a great help if you could answer all the questions. ANSWERS WILL, OF COURSE, BE TREATED AS HIGHLY CONFIDENTIAL.

SECTION 1 PRESENT WORK

01. How low have you been working in the present post?
   1  < 1 year
   2  1–2 years
   3  3–5 years
   4  6 years or more

02. How many staff do you have in your department?
    _______ Full time
    _______ Part time

03. How many computer terminals/VDUs for the present child health computer system are installed in your department? (If none, write a zero.)
    _______ Terminals/VDUs

04. Do you think the terminals installed are too few or too many for your day-to-day work?
    Too few 1 2 3 4 5 Too many

05. How many staff in your department get legal access (have user's name and password) to the computer system? (If none, write a zero.)
    _______ Staff

06. How many clerks/VDU operators are employed to run the modules?
   —Registration module
     _______ F/T _______ P/T
   —Vaccination/Immunisation module
     _______ F/T _______ P/T
   —Pre-school module
     _______ F/T _______ P/T

07. How many clerks/VDU operators do you think are needed to run the modules sufficiently according to your situation?
   —Registration module
     _______ F/T _______ P/T
   —Vaccination/Immunisation module
     _______ F/T _______ P/T
   —Pre-school module
     _______ F/T _______ P/T

08. How do you schedule immunisation appointment?
    1  By computer system
    2  By manual system
    3  By combination of the two

09. About how many (%) of the immunisation procedures are done at the recommended time in your district?
    _______ Per cent

10. If you do schedule immunisation procedures, about how many (%) of the appointments are NOT kept by the clients?
    _______ Per cent

11. Some immunisation appointments are NOT kept in practice. What do you think are the factors contributing to the non-attendance? The following questions provide some possible reasons.

   —Number of children booked to be immunised EACH SESSION on average in your district
     Number: _______ Children/session
     Is it ... ?
       Too few 1 2 3 4 5 Too many
   —Appointment sent to the clients
     How many days in advance?
     _______ days in advance.
     Is this notice ... ?
       Too early 1 2 3 4 5 Too late
   —Appointment NOT received by clients
     Never Always
     happens 1 2 3 4 5 happens
   —Session time convenient for clients
     Not at all 1 2 3 4 5 Very
     —Wrong appointment (eg, children moved)
       Never Always
       happens 1 2 3 4 5 happens
<table>
<thead>
<tr>
<th>Question</th>
<th>Response Options</th>
</tr>
</thead>
</table>
2. By manual system  
3. By combination of the two  
4. No appointment as yet ⇒ jump to question 17 |
| 13. About how many (%) of the developmental examination are done at the recommended time in your district? | Per cent |
| 14. If you do schedule developmental examinations, about how many (%) of the appointments are NOT kept by the clients? | Per cent |
| 15. Some examination appointments are NOT kept in practice. What do you think are the factors contributing to the non-attendance? The following questions provide some possible reasons. | Number of children booked to be checked EACH SESSION on average in your district  
Number: _______ Children/session  
Is it ... ?  
Too few 1 2 3 4 5 Too many  
Appointment sent to the clients  
How many days in advance?  
_______ days in advance.  
Is this notice ... ?  
Too early 1 2 3 4 5 Too late  
Appointment NOT received by clients  
Never 1 2 3 4 5 Always  
Session time convenient for clients  
Not at all 1 2 3 4 5 Very |
| 16. Do you send examination result data to the following staff/departments? |  
—FPCs  
Never 1 2 3 4 5 Always  
—Community paediatric staff  
Never 1 2 3 4 5 Always  
—Health clinics  
Never 1 2 3 4 5 Always  
—Individual GPs  
Never 1 2 3 4 5 Always  
—Health visitors  
Never 1 2 3 4 5 Always  |
| 17. Do you send immunisation result data to the following staff/departments? |  
—FPCs  
Never 1 2 3 4 5 Always  
—Community paediatric staff  
Never 1 2 3 4 5 Always  
—Health clinics  
Never 1 2 3 4 5 Always  
—Individual GPs  
Never 1 2 3 4 5 Always  
—Health visitors  
Never 1 2 3 4 5 Always  |
| 18. Do you receive any information related to child health care (eg, immunisation, examination) from the following staff/departments? |  
—FPCs  
Never 1 2 3 4 5 Always  
—Community paediatric staff  
Never 1 2 3 4 5 Always  
—Health clinics  
Never 1 2 3 4 5 Always  |
APPENDICES—A QUESTIONNAIRE FOR CHILD HEALTH MANAGERS

19. It is realised that due to some practical problems, computer reported immunisation coverage rates sometimes are wrong. Do you think computer reported immunisation rates in your district in general are ... ?

Under-estimated 1 2 3 4 5 estimated

20. If they do have some discrepancies, do you think good or bad communication between the following might contribute?

—Child health department/GPs
   Problematic 1 2 3 4 5 No problem

—Child health department/Health clinics
   Problematic 1 2 3 4 5 No problem

21. What has been the turnover of child health posts during the last two years? (If none, write a zero.)

 Staff in _______ Staff out _______

22. Do you think the day-to-day child health activities have been affected by the turnover of the posts?

Not at all 1 2 3 4 5 Severely

23. Do you think your department has benefited since starting to use the present system for child health activities?

Not at all 1 2 3 4 5 Quite a lot

24. How do you think about the present child health system in the following aspects?

—Speeding up daily work
   Not at all 1 2 3 4 5 Much

—Being user friendly
   Not at all 1 2 3 4 5 Much

—Reducing manual work
   Not at all 1 2 3 4 5 Much

25. According to your experience, what have been the main problems or shortcomings of the system you are using?

—Ease of use
   Low mark 1 2 3 4 5 High mark

—Flexibility
   Low mark 1 2 3 4 5 High mark

—Others (Please specify)
   Low mark 1 2 3 4 5 High mark

26. What do you think are the factors contributing to any inaccuracy or out-of-datedness of the data held in the child health computer system? The following are some possible reasons.

—Changes of children’s address
   Never 1 2 3 4 5 Always

—Changes of children’s name
   Never 1 2 3 4 5 Always

—Clerical input errors
   Never 1 2 3 4 5 Always

—Data errors in original documents
   Never 1 2 3 4 5 Always

—Communication with relevant health staff
   Very poor 1 2 3 4 5 Excellent

—Standard of record codings
   Very poor 1 2 3 4 5 Excellent

—Others (Please specify)

27. Do you think there is adequate communication between child health department and the following health workers involved with child health care from an information point of view?

—Health visitors
   Problematic 1 2 3 4 5 No problem

—General practitioners
   Problematic 1 2 3 4 5 No problem

—Clinic clerks
   Problematic 1 2 3 4 5 No problem
APPENDICES—A QUESTIONNAIRE FOR CHILD HEALTH MANAGERS

—Community paediatrician
Problematic 1 2 3 4 5 No problem

—Registrar birth and death
Problematic 1 2 3 4 5 No problem

—Hospital medical staff
Problematic 1 2 3 4 5 No problem

—Others (Please specify)
Problematic 1 2 3 4 5 No problem

28. How do you feel the communication could be improved? (You may choose more than one answers.)
1 Regular scheduled meetings
2 Shared accommodation, eg. health centre
3 Enforcement of present legislation, eg. birth notification and transfer
4 New regulation, eg. compulsory transfer of data (ie. immunisation data from GPs to child health department)
5 Others (Please specify)

SECTION 2 TRAINING

29. Have you ever been formally trained to use the child health computer system? (ie, attending specifically organised training sessions.)
0 No ⇒ if no, jump to question 31
1 Yes ⇒ (how many) ____ hours

30. Do you think this training hours were ...?
Too short 1 2 3 4 5 Too long

31. Do you think refreshing training sessions are needed for you?
Not at all 1 2 3 4 5 Quite a lot

32. How often do you think the training should be provided?
0 None
1 Monthly
2 Quarterly
3 Half-yearly
4 Yearly
5 Irregularly

33. Are any refreshing or updating training sessions ACTUALLY arranged for you in next six months?
0 No
1 Yes ⇒ (how many) ______ STAFF

SECTION 3 ACTIVITIES IN HEALTH CLINICS

36. How many (child health) clinics/centres are there in your district? (EXCLUDING general practice surgeries)
_______ (child health) clinics/centres

37. What is the average TOTAL NUMBER of child health sessions per week run in all these health clinics/centres?
_______ sessions/week

38. In how many of these clinics/centres have computer terminals been installed for the use of child health system?
_______ clinics/centres

SECTION 4 FREE COMMENTS

Thank you very much for your cooperation. If you have any additional comments that you think might be useful to us please write them below.
A QUESTIONNAIRE FOR THE CHILD HEALTH STAFF/VDU OPERATORS

Your name ____________________________ Your department ____________________________
Your district __________________________ Date __________________________

Your answers to these questions provide information for an evaluation study of child health computing systems under the auspices of the regional health authority. It would be a great help if you could answer all the questions. ANSWERS WILL, OF COURSE, BE TREATED AS HIGHLY CONFIDENTIAL.

There are three types of questions in this questionnaire. The following examples will help you to see what is required. There are no “correct” answers to the questions, instead we expect you to choose the options that fit you best.

Example 1. Do you think you need some rest when finishing this questionnaire?

0 No => jump to example 3.
1 Yes

(This means that you need some rest when finishing this questionnaire. If No, answer the question of Example 3 directly.)

Example 2. How many hours do you need to rest?

2 hours

(This means that you need 2 hours rest.)

Example 3. Is the work you are doing interesting?

Not at all 1 2 4 5 Very much

(You gave a grade 3 on the 5-point scale from NOT interesting AT ALL to VERY interesting.)

Example 4. Do you think these examples are clear?

Not at all 1 2 3 5 Very much

(You gave a grade 4 on the five-point scale from NOT clear AT ALL to VERY clear.)

SECTION 1 PRESENT WORK

01. How low have you been working in the present post?

1 < 1 year
2 1–2 years
3 3–5 years
4 6 years or more

02. For what module of the present system are you mainly responsible?

1 Registration module
2 Immunisation module
3 Pre-school module
4 School module
5 Other ______________

03. How long have you worked on the module?

1 < 1 year
2 1–2 years
3 3–5 years
4 6 years or more

04. Do you think the system/programmes you use are user friendly?

Not at all 1 2 3 5 Very much

05. Some information (eg, ethnic group, previous district of residence) for some children in the present system is missing. Do you think it should have been available in the system?

Not at all 1 2 3 5 Absolutely

06. Why do you think the information is missing?

—Data in original documents

Never available 1 2 3 4 5 Always available

—Compulsory entering of the information

Never imposed 1 2 3 4 5 imposed

—Coding standard of the information

Very poor 1 2 3 4 5 Excellent

—Others (Please specify)

Problematic 1 2 3 4 5 No problem

07. Do you think the information held in the system in general is ... ?

Too little 1 2 3 4 5 Too much

08. According to your experience, is the information held in the system up-dated, ie, is it the most recent?

Not at all 1 2 3 4 5 The most

09. What do you think the main reasons could be for any out-of-datedness of the information? The following are some possible reasons.

—Communication with relevant staff

Very poor 1 2 3 4 5 Excellent

—Lack of time to up-date the information

Never Always happens 1 2 3 4 5 happens
10. Do you think the information held in the system is accurate?

Not at all 1 2 3 4 5 The most

11. What do you think contributes to any inaccuracy of the information. The following are some possible reasons.

—Changes of children's address
Never happens 1 2 3 4 5 Always happens

—Changes of children's name
Never happens 1 2 3 4 5 Always happens

—Clerical input errors
Never happens 1 2 3 4 5 Always happens

—Data errors in original documents
Never happens 1 2 3 4 5 Always happens

—Standard of record codings
Very poor 1 2 3 4 5 Excellent

—Others (Please specify)

12. According to your experience, what have been the main problems or shortcomings of the system you are using?

—Ease of use
Low mark 1 2 3 4 5 High mark

—Flexibility
Low mark 1 2 3 4 5 High mark

—Others (Please specify)

Low mark 1 2 3 4 5 High mark

13. How do you think the communication between you and the following health workers involved with child health care from an information point of view? (Some may not be applicable to you. If so, leave them blank.)

—Health visitors
Problematic 1 2 3 4 5 No problem

—General practitioners
Problematic 1 2 3 4 5 No problem

—Clinic clerks
Problematic 1 2 3 4 5 No problem

—Community paediatrician
Problematic 1 2 3 4 5 No problem

—Registrar birth and death
Problematic 1 2 3 4 5 No problem

—Hospital midwife staff
Problematic 1 2 3 4 5 No problem

—Hospital medical staff
Problematic 1 2 3 4 5 No problem

14. How do you feel the communication could be improved? (You may choose more than one answers.)

1 Regular scheduled meetings
2 Shared accommodation, eg. health centre
3 Enforcement of present legislation, eg. birth notification and transfer
4 New regulation, eg. compulsory transfer of data (ie. immunisation data from GPs to child health department)
5 Others (Please specify)

SECTION 2 TRAINING

15. Have you ever been formally trained (ie, attended specifically organised training sessions) to use the child health computer system?

0 No ⇒ if no, jump to question 20
1 Yes ⇒ (how many) _____ hours

16. Do you think this training hours were ... ?

Too short 1 2 3 4 5 Too long

17. Are you satisfied with the training sessions in general?

Not at all 1 2 3 4 5 Very much

18. Give your reasons why you are satisfied or dissatisfied with the training sessions. The following are some possible reasons.

—Theoretical knowledge taught
Too little 1 2 3 4 5 Too much

—Time for practice
Too little 1 2 3 4 5 Too much

—Understandability of teaching
Very poor 1 2 3 4 5 Excellent

—Usefulness for your practical job
Low mark 1 2 3 4 5 High mark
19. Were the training sessions provided by ...? 
   1 Your department
   2 Your district
   3 Your region
   4 Private personal demonstration
   5 Other _______________________
   9 Don't know

20. Do you think regular refreshing or updating training should be provided in the future? 
   0 No
   1 Yes

21. Has it been arranged for you to attend regular refreshing or updating training during the next six months? 
   0 No
   1 Yes

22. Do you think that your attendance at training in the child health computer system is necessary? 
   Not at all  1  2  3  4  5 The most

SECTION 3 FREE COMMENTS

Thank you very much for your cooperation. If you have any additional comments that you think might be useful to us please write them below.
Comparison of immunisation rates in general practice and child health clinics

Jun Li, MD, research fellow, Brent Taylor, PHD, Professor
Department of Community Child Health
Royal Free Hospital School of Medicine
London NW3 2PF


Abstract

Objective—To compare immunisation uptake rates in general practice surgeries and community child health clinics.

Design—Cohort study using data from a computerised child health system.

Setting—Four health districts of North East Thames Regional Health Authority.


Main outcome measures—Immunisation uptake rates at 10-12 months of age, age at immunisation, scheduling performance at the two locations, and odds ratios of outstanding immunisations.

Results—80% of children registered at general practices had completed their third dose of pertussis immunisation compared with 68% of those at health clinics. Median ages at the third dose were 24 weeks and 29 weeks at the two locations respectively. Scheduling was more effective at general practice surgeries. Unscheduled immunisations were more likely to be given after the recommended age. Overall, children resident in rural and suburban areas had greater uptakes than those in inner cities. Odds ratios for not being fully immunised among children registered at health clinics were 1.4 times those among children immunised in general practice and 3.0 times greater among children resident in inner cities than among those in rural and suburban districts. Children who moved into a district, however, were no less likely to be fully immunised than children who were born there.

Conclusions—The immunisation uptake rate was better in general practices than in child health clinics in both inner city and rural and suburban areas. Uptake may be increased with additional support to enable general practitioners to undertake immunisations, especially in inner cities.

Introduction

In Great Britain children are usually vaccinated either at a community health clinic or centre or at a general practice, a few being immunised opportunistically in hospital wards. Normally, shortly after a baby is born the parents receive and sign a consent form which indicates preference for their child’s immunisations to be done at a general practitioner’s surgery or at a community health clinic.

Immunisation uptake in the United Kingdom is improving in association with various strategies, including the computerisation of child health systems. Nevertheless, uptake is still below the targets set by the World Health Organisation and in European countries. Factors associated with the low uptake include social and family characteristics, attitudes of health staff and parents towards the immunisation and the diseases, and health care organisation.

The child health system, which has been computerised in most health districts in Britain, produces an appointment invitation based on the immunisation schedule and the child’s age. The appointment is posted directly to the parents or may be sent via the general practitioner or health clinic. When an immunisation is done detailed information on the immunisation is always asked to be fed back to the child health computing system. Relevant information on a child who moves into a district, including immunisation history, is provided by the previous district, transferred general practitioner records, or the health visitor responsible for the child and the data entered into the computing system.

We have compared the uptake rates of immunisation among children registered at general practitioner surgeries with those among children registered at community child health clinics using data from a computerised child health system in four health districts of North East Thames Regional Health Authority.

Subjects and methods

We studied four health districts in the North East Thames region, which has developed a child health computing system, the North East Thames Regional Interactive Child Health System. This system, similar to the national standard child health computer system, provides various information on individual children. To facilitate the comparisons districts were categorised on sociodemographic and geographical determinants into two types, rural and suburban and inner city areas, each type including two districts.

The study children were born between January and March 1990 and resident in the four districts at the end of January 1991. All the data on these children (aged 10-12 months) were derived anonymously from the computer system after permission had been obtained from district managers and directly responsible staff in each of the four districts. This cohort of children was divided into two groups,
Those registered at a general practitioner’s surgery and those registered at a community child health clinic for their immunisations. There was a small proportion of children (154 out of 3770; 4.1%) whose data on vaccination location were not available in the child health system. These children were excluded from our analyses.

The recommended age for the third dose of the primary course of immunisations was 8.5 months (schedule 3, 4.5, 8.5 months) but has been 4 months since May 1990 (2, 3, 4 months). Thus all the study children should have completed their primary course of immunisations. The uptake of immunisation was calculated as the number of children recorded as being immunised by the end of January 1991 expressed as the percentage of the total number of children in each study category.

The main statistical methods used in the study included a log linear modelling technique, logistic regression, to examine the strength of association between the uptake and the vaccination location after allowing for other important influencing factors. The χ² test and a non-parametric analysis (Kruskal-Wallis one way analysis of variance) were also employed to compare the immunisation uptake state between the two study groups.

**Results**

A total of 1946 (89.8%) of 2167 children resident in rural and suburban areas were registered at general practice surgeries for their immunisation procedures compared with 556 (38.4%) of 1449 children living in inner cities (table 1). The overall uptake of immunisations was greater in general practice than in child health clinics. This was so in both inner city and rural and suburban districts for both the first and the third doses of immunisations (table II).

We compared other aspects of uptake of immunisation against pertussis between the two groups of children, ignoring the type of district they lived in. Overall, 2502 (69.2%) of the children were registered at general practice surgeries and 1114 (30.8%) at child health clinics (table I). As well as having a greater uptake of first immunisations children registered at general practices were less likely to miss the third dose of immunisation than those attending health clinics. Among the children who were immunised with the first dose of pertussis, 11.1% of the general practice registered children (249/2245) had not received the third dose compared with 21.1% of those (201/953) at health clinics (table III). These differences suggested that children at health clinics were not only less likely to be immunised but also less likely to complete their full course of immunisations than those at general practice surgeries.

The children registered at general practice surgeries completed their primary vaccinations at a younger age than those at health clinics, the median ages being 11 and 13 weeks for the first dose and 24 and 29 weeks for the third, respectively (table III). Figure 1 shows that some 53% of children attending general practice surgeries had received their third pertussis vaccination before 6 months of age compared with only about 30% of children at health clinics.

![Cumulative percentage uptake of third pertussis immunisation in two groups of children](image-url)

**TABLE I**—Numbers (percentages) of children registered at two immunisation locations by type of district

<table>
<thead>
<tr>
<th>Type of district</th>
<th>General practice</th>
<th>Health clinic</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural/suburban</td>
<td>1946 (89.8)</td>
<td>221 (10.2)</td>
<td>2167 (100.0)</td>
</tr>
<tr>
<td>Inner city</td>
<td>556 (38.4)</td>
<td>893 (61.6)</td>
<td>1449 (100.0)</td>
</tr>
<tr>
<td>Total</td>
<td>2502 (69.2)</td>
<td>1114 (30.8)</td>
<td>3616 (100.0)</td>
</tr>
</tbody>
</table>

We only provide a partial table here, but the full table can be found in the document. The table provides the number of children registered at each type of clinic for the first and third doses of immunisation.

**TABLE II**—Percentage uptake of immunisations among children registered at two vaccination locations by type of district (whole numbers in parentheses)

<table>
<thead>
<tr>
<th>Type of district</th>
<th>General practice</th>
<th>Health clinic</th>
</tr>
</thead>
<tbody>
<tr>
<td>First dose</td>
<td>Diphtheria: 96.4 (1880/1946)</td>
<td>93.2 (2245/2502)</td>
</tr>
<tr>
<td>Third dose</td>
<td>Diphtheria: 89.3 (1737/1946)</td>
<td>84.2 (2167/2502)</td>
</tr>
<tr>
<td>Inner city</td>
<td>Diphtheria: 96.4 (508/556)</td>
<td>92.2 (187/201)</td>
</tr>
<tr>
<td>Third dose</td>
<td>Diphtheria: 72.8 (405/556)</td>
<td>68.2 (202/297)</td>
</tr>
</tbody>
</table>

![Cumulative percentage uptake of third pertussis immunisation in two groups of children](image-url)

Only about one third of the immunisation procedures given to children registered at health clinics were scheduled compared with about half of those given to children registered at general practices (table III). The remainder were recorded as unscheduled when the parents brought their children to the immunisation centre because they thought the immunisation was due or they attended for other reasons.
reasons. Children, on average, received unscheduled immunisations at a later age than scheduled ones. Figure 2 shows that among the immunised children about 30% of those who received immunisation by appointment (scheduled immunisation) were vaccinated after 6 months of age compared with nearly 45% of those who had been immunised opportunistically (unscheduled immunisation).

When children moved among districts a higher proportion registered with child health clinics than with general practitioners. This resulted in 22.5% of health clinic children being "movements in" (251/1114) compared with 11.4% of children attending general practitioners (283/2502). We considered this factor together with type of district in a multivariate analysis to study the strength of the association of immunisation uptake with vaccination location. Table IV shows the odds ratios of not being immunised with the third dose of pertussis, estimated from a fairly well fitted logit model, for each stated factor after controlling for the others. The odds of not being fully immunised among children registered at a health clinic were 1.4 times greater than those among children registered at a general practice, and the odds were 3.0 times greater among children resident in inner city districts than their counterparts resident in rural and suburban areas. Children who had moved into a district from outside, however, were not at substantially higher risk of not being vaccinated than those who had been resident in the district since birth (Table IV).

Discussion

Our findings suggest that children registered at child health clinics were less likely to be immunised and less likely to be vaccinated at the recommended age than those registered at general practice surgeries. Alberman et al suggested that the difference in uptake of immunisation between vaccination locations might reflect sociodemographic differences between families who use general practice and those who use community child health clinics. Others have also reported the difference in the uptake of immunisation among different minority ethnic groups, and among different social classes. We were not able to investigate this issue as social data are not currently available in the computer system.

We found that more children registered at general practice surgeries attended for the appointed immunisation sessions (scheduled immunisations) than those at health clinics, indicating that the parents of the children registered at general practice surgeries were more likely to receive the immunisation appointments and to be reminded, when necessary, to take their children to attend for immunisations or were more likely to respond to the appointments. It may be that, apart from other possible reasons, immunisation times at general practice surgeries were more flexible and more convenient for the families, especially for working parents.

Our results confirmed that uptake of immunisation was poorer in inner city areas, a finding that has been reported before using a different database. Inner city families face adverse factors which can affect, among other outcomes, the uptakes of childhood immunisation. Vaccination location appears to be a contributory influence.

Jarman et al have pointed out that general practitioners with high case loads, those working in singlehanded practice, and elderly general practitioners are less likely to obtain high uptake of immunisations. This might partly explain our finding that uptake among children at general practice surgeries was higher in rural and suburban than in inner city areas. There were no data in this study on individual general practitioners to allow direct investigation of this possibility.

A high uptake (nearly 90%) of the first dose of primary course at both locations in both types of districts was found in our study, suggesting that contraindications to vaccination could not be the excuse for overall lower uptake of immunisations. The hypothesis that in general mobility of a child population is associated with lower probability of children receiving immunisations was not confirmed by our study. This might reflect the new ease of data transfer associated with computerised systems, especially those that are interactive, like the one we studied, and the encouragement for general practitioners to transfer records quickly because of the targeting provisions of the new general practitioner contract which became operative in April 1990.

This study was based on data from the North East Thames Regional Interactive Child Health System, and each individual child was treated as a basic study.

<table>
<thead>
<tr>
<th>TABLE IV</th>
<th>Odds ratios of not being immunised with third pertussis dose estimated from logit model* for each stated factor after controlling for others with larger sample 95% confidence intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factor</strong></td>
<td><strong>Odds ratio</strong></td>
</tr>
<tr>
<td>Vaccination location:</td>
<td></td>
</tr>
<tr>
<td>General practice</td>
<td>1.0</td>
</tr>
<tr>
<td>Health clinic</td>
<td>1.4</td>
</tr>
<tr>
<td>Type of district:</td>
<td></td>
</tr>
<tr>
<td>Rural/suburban</td>
<td>1.0</td>
</tr>
<tr>
<td>Inner city</td>
<td>3.0</td>
</tr>
<tr>
<td>Resident:</td>
<td></td>
</tr>
<tr>
<td>At birth</td>
<td>1.0</td>
</tr>
<tr>
<td>Moving in</td>
<td>1.2</td>
</tr>
</tbody>
</table>

*Likelihood ratio χ² = 4.7; df = 4; p = 0.32.
unit. It is possible that the mix of social class and ethnic group was different between our general practice and child health clinic study populations. We were not able to investigate this possible source of bias in our results. Social class and ethnic group, however, are not the only factors associated with uptake rates.\textsuperscript{5,6} We found that nearly 90% of children resident in rural and suburban districts were registered at general practice surgeries for immunisations compared with only 38% of those living in inner cities (table I). Could this difference, among other factors, also contribute to the overall lower uptake rates in inner city areas? Previous studies focused mainly on ethnic group and social class and tried to explain lower uptake rates in inner city areas with the different mix in these factors.\textsuperscript{5} Little attention was paid to the possible contribution of immunisation location to the variance of immunisation uptake. Our findings can be viewed as generating a hypothesis for further study on this topic, especially allowing for other factors such as ethnic origin and social class of children.

This child health computer system allows rapid and easy analysis of data on preventive child care with the possibility of rapid feedback to permit improved performance. In addition, such a child health computing system can provide reliable and useful information on the child health services.\textsuperscript{1,14} Our findings have the following implications. Firstly, a topic for further investigation was generated that immunisation location could be a major contributory factor to immunisation uptake in childhood. Secondly, immunisation uptake rate may be increased with additional support and encouragement to enable general practitioners to undertake immunisations, especially in inner city areas where uptake is low. And, thirdly, the data derived from child health computing systems, especially if sociodemographic data—for example, social class, ethnic group—can be collected, could be used for rapid, ongoing, and comprehensive epidemiological assessment of child health service programmes without the need for expensive and difficult "one off" surveys.

This study is part of a project evaluating the regional interactive child health computing system funded by North East Thames Regional Health Authority. We thank all the participant health districts for permission to use their child health data, Mrs H Horne and Mrs M Homersham at the North East Thames Regional Health Authority's computer centre, staff at the computer centre at the Royal Free Hospital School of Medicine, and Drs E M Boothroyd-Brooks and A Lloyd-Evans for advice.

10 Walker CHM. "Batch" or "on-line" for child health—a review. \textit{BMJ} 1980;281:1400-1.
Childhood immunisation and family size

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Keywords: Vaccination/immunisation; child health services; family


Summary
This paper reports an investigation into the associations between the number of children in the family and the vaccination uptake performance of those children. Using data from a child health computer system, the pertussis vaccination status was studied in 3,694 children aged 12 to 14 months. The findings show a strong association between vaccination uptake and the number of children in the family. The uptake rates reduced steadily from 86% for families with only one child to 58% from families with five children or more. Children from larger families were not only less likely to complete their full course of pertussis vaccination, but were also vaccinated later. Logistic regression analysis, which allowed for other associated factors, estimated that one 'child unit' increases in family size decrease the odds of being vaccinated by a factor of 1.7 in rural and suburban families and 1.3 in inner city families respectively. Health professionals involved with the immunisation service should use child health computer data to target their problematic populations more effectively to achieve high vaccination uptake rates.

Introduction
Although overall vaccination coverage in childhood has improved in the United Kingdom (UK) over recent years, the reported rate of vaccination in some localities remains below the targets set by the World Health Organization, which includes those obtained in some European countries. There has also been a recent renewal of interest in the identification of factors influencing childhood vaccination uptake. Child health systems, computerised in most health districts in the UK, have been an important source of information about preventive child health services, including vaccination uptake rates. These systems provide an effective mechanism for scheduling vaccination procedures and for identifying non-attenders for vaccination. Health professionals and service planners could also use the other information recorded on individual children resident in their district to identify factors associated with a reduced uptake of preventive health care. This would provide an opportunity for targeted interventions to improve uptake.

However, most studies assessing coverage of childhood vaccinations have taken the form of one-off epidemiological surveys and, while such studies provide useful information, they are costly in money and time. Nevertheless, health authorities appear to have made little effort in taking advantage of these sophisticated computer systems, e.g. they are designed for a variety of purposes, including the provision of data for epidemiological assessment of certain aspects of child health activities.

This study aimed, therefore, not only to assess the available data from the child health computing system developed in the North East Thames Region (the Regional Interactive Child Health System (RICHS)), but also to examine the associations between the number of children in the family (family size) and vaccination uptake.

Study population and methods
Data were obtained for children who were born between January and March 1990, and resident in five health districts of the North East Thames Regional Health Authority at the end of April 1991. Only limited data were available for children moving into the area during the study period, which precluded their entry into the study. The age of the study cohort ranged from 12 to 14 months, i.e. eight to 10 months after the completion of the primary vaccination course. This age-range is according to the new schedules recommended by the Joint Committee on Immunisation and Vaccination. The chosen outcome indicator was the uptake of vaccination against pertussis, the numerator was the number of children recorded as having been vaccinated by the end of April 1991, and the denominator was the number of children within each study category.

The cohort was divided into five groups:
  i. Only children
  ii. Those children from families with two children
  iii. Those children from families with three children
  iv. Those children from families with four children
  v. Those children from families with five or more children.

To facilitate comparisons, the five study districts were categorised into two types: i. rural and suburban and ii. inner city districts based on geographic and socio-demographic factors. The computing system also recorded maternal age, one-
parent family status and the vaccination location chosen by the parents.

All child health records were obtained anonymously from the child health computing system. The District General Manager, and the staff directly responsible for the child health system in each district, gave permission for the use of the data. The local ethics committee also approved the study.

Factors relating to vaccination uptake were compared among the five groups of children, with appropriate statistical tests for each comparison. Linear logistic regression analysis was used to examine the association between the number of children in the family and uptake of vaccination. In the analysis, the predicted variable was vaccination status (yes or no) and the 'exposure' factor was the number of children, treated as an ordinal variable (1 for an only child, 2 for two children, 3, 4, 5, 6 for families with 4 or more children). Possible confounding variables were considered, ie the type of district (1 for rural and suburban, 2 for inner city districts); vaccination location (1 for general practice, 2 for community child health clinic); one-parent family (yes or no); and maternal age group (1 for 20 to 39 years, 2 for under 20 years and 40 years or over). This grouping for maternal age was because coverage rates for children with mothers under 20 and 40 years or over were similar and lower than the rates for other groups of children. Variables were included in the model if they improved the predictive power of the model at the 5% level. Backward and forward selection techniques were used to reach a 'best' final model.11-12

Results
A total of 3,694 children were included in the study cohort, of whom 2,111 were living in the two rural and suburban districts and 1,583 were resident in the three inner cities. Not all the records of these children were complete; as complete a data set as possible was used for the analyses. Table 1 shows the data completeness for the variables analyzed in this study. More than 95% of the records in the computer system were completed for the number of children in the family, registered vaccination location, maternal age and age at the vaccination. Details of one-parent family status were missing for 7.2% of records. These figures were considered satisfactory for valid statistical analysis. Over 90% (3,694) of the records were completed for all variables, which allowed simultaneous analysis in the logistic regression. The low proportion of 'non-response' should avoid the possibility of information bias in this analysis.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total no. records</th>
<th>No. with missing data</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of children in family</td>
<td>3694</td>
<td>132</td>
<td>3.6</td>
</tr>
<tr>
<td>Registered vaccination location</td>
<td>3694</td>
<td>106</td>
<td>2.9</td>
</tr>
<tr>
<td>Maternal age</td>
<td>3694</td>
<td>92</td>
<td>2.5</td>
</tr>
<tr>
<td>One-parent family</td>
<td>3694</td>
<td>267</td>
<td>7.2</td>
</tr>
<tr>
<td>Age at vaccination</td>
<td>6245</td>
<td>13</td>
<td>0.2</td>
</tr>
<tr>
<td>All the variables†‡</td>
<td>3694</td>
<td>347</td>
<td>9.4</td>
</tr>
</tbody>
</table>

†: First and third doses of vaccination procedures.
‡: Variables for logistic regression analysis.

General inspection
Of the 3,694 children, 2,872 were recorded as having received the third pertussis (P3) vaccination, giving an overall uptake rate at 12 to 14 months of 78% in the five districts. From the 882 children who were recorded as not receiving P3 vaccination, 208 (25%) had received the third diphtheria and tetanus (D3T3) vaccine; the remaining 674 children had not received any of the third dose primary vaccinations.

The characteristics of the children to their vaccination status were related by comparing the following variables among the five groups of children: i. distribution of families with different numbers of children in the two types of districts; ii. uptake of vaccination at 12 to 14 months; iii. age at which the vaccination was given; iv. proportion of children who received the first dose of pertussis vaccine, but had not had the third dose; v. location at which the children were registered for their vaccination procedures; vi. maternal age when the study child was born; and vii. proportion of children from one-parent families.

Table 2 shows the results with an appropriate statistical test for each of the comparisons. The general pattern shows a strong association between uptake of vaccination and the number of children in the family. The more siblings a child had, the less likelihood of vaccination, including the possibility that he or she would complete the full course of pertussis vaccination. The overall uptake rates for the first dose were 91% for families with only one child, reducing to 78% where there were five or more children in the family (χ² trend=44.1 p<0.001). This downward trend was even more apparent for the third dose, from 86% to 58% (χ² trend=114.1 p<0.001). A similar reduction was noted among the groups when examining children who received the first dose but not the third; the proportions missing the third dose of vaccination were 6%, 9%, 12%, 16% and 26% for the groups respectively (χ² trend=76.7 p<0.001). Children from larger families not only had a lower uptake of vaccination, but were also vaccinated later. The median age in days for the third dose of pertussis was 176, 185, 202, 211 and 228 for the five groups respectively. A comparison of the age of reaching the 90th centile with the first dose showed considerable delays in vaccination for children from larger families.

Family size was related to other factors. Inner city families were more likely to be larger than rural or suburban families, and children from smaller families were more likely to attend the general practitioner (GP) for vaccination procedures. Children with only one-parent were more likely to come from relatively smaller than larger families (see Table 2).

Logistic regression analysis
Table 3 shows the final fitted logistic model, which demonstrates a highly significant overall association between family size and vaccination uptake (χ²=91.2 on two degrees of freedom, p<0.001). A relatively small Pearson goodness-of-fit Chi-square value (74.9) on 60 degrees of freedom depicts a reasonably close fit of the model to the data. In addition to family size, the model showed
that type of district, vaccination location and maternal age were also related to vaccination coverage. The model also identified type of district as an effect modifier.\textsuperscript{10-12}

Table 2 Comparative data of the five groups of children

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>No. of children in family</th>
<th>Two-tailed P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no.</td>
<td>1434 1171 558 232 167</td>
<td></td>
</tr>
<tr>
<td>% uptake for pertussis vaccine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First dose</td>
<td>91.3 89.9 85.5 81.5 78.4</td>
<td>&lt;0.001\textsuperscript{1}</td>
</tr>
<tr>
<td>Third dose</td>
<td>86.1 82.2 75.1 68.1 58.1</td>
<td>&lt;0.001\textsuperscript{1}</td>
</tr>
<tr>
<td>Age (days) at the vaccination</td>
<td></td>
<td>&lt;0.001\textsuperscript{1}</td>
</tr>
<tr>
<td>First dose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50th centile</td>
<td>92 94 95 99 97</td>
<td></td>
</tr>
<tr>
<td>90th centile</td>
<td>110 121 131 141 149</td>
<td></td>
</tr>
<tr>
<td>Third dose</td>
<td>176 185 202 211 228</td>
<td></td>
</tr>
<tr>
<td>50th centile</td>
<td>258 280 302 312 345</td>
<td></td>
</tr>
<tr>
<td>% third dose not given with first dose received</td>
<td>5.7 8.5 12.2 16.4 26.0</td>
<td>&lt;0.001\textsuperscript{1}</td>
</tr>
<tr>
<td>Distribution (%) in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural/suburban districts</td>
<td>42.8 34.8 15.7 5.1 1.7</td>
<td>&lt;0.001\textsuperscript{4}</td>
</tr>
<tr>
<td>Inner city districts</td>
<td>36.6 30.1 15.7 8.5 9.1</td>
<td></td>
</tr>
<tr>
<td>Registered vaccination location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GP clinic</td>
<td>72.8 71.9 72.8 62.8 50.9</td>
<td>&lt;0.001\textsuperscript{4}</td>
</tr>
<tr>
<td>Health clinic</td>
<td>27.2 28.1 27.2 37.2 49.1</td>
<td></td>
</tr>
<tr>
<td>Mean maternal age (SD) in years at birth of the study child</td>
<td>26 (5.4) 28 (4.9) 29 (4.9) 31 (5.0) 33 (4.8)</td>
<td>&lt;0.001\textsuperscript{1}</td>
</tr>
<tr>
<td>% one-parent family</td>
<td>16.9 11.0 8.0 10.7 6.5</td>
<td>&lt;0.001\textsuperscript{1}</td>
</tr>
</tbody>
</table>

\textsuperscript{1}: Chi-square test for trend; \textsuperscript{4}: Analysis of variance on log transformed data; \textsuperscript{4}: Analysis of variance on original data.

The sign of the regression coefficient, $\beta$, shows the direction of association between vaccination status and that variable. Negative coefficients mean that a child was less likely to be vaccinated. In the absence of internal correlation among the variables, the coefficient $\beta$ equalled the natural logarithm of the odds ratio for the association between vaccination status and any two values of a variable.

For example, for a child born to a teenage mother or aged between 20 and 39 years, ie the odds of being vaccinated for the latter child were 1.4 times the odds for the former child.

However, the inclusion of an interaction term involving family size and the type of resident district showed that the strength of the association between vaccination uptake and the number of children in the family was different in rural and suburban areas compared with inner city areas. In this circumstance, the odds ratio was more difficult to calculate.\textsuperscript{12} Table 4 shows the adjusted odds ratios and 95% larger-sample confidence intervals in the two types of districts. The adjusted odds ratio suggested a stronger association between vaccination uptake and the number of children in the family in rural and suburban areas than in inner city districts. In the former area's one 'unit' increase in the number of children in the family was responsible for a decrease of the odds of being vaccinated by a factor of 1.7 (1/0.59), whereas in inner city the corresponding factor was 1.3.

**Discussion**

Pertussis vaccination uptake was chosen as the main outcome in this study; a vaccination perceived as the most problematic in this country. It is also one of the preventable diseases in the primary immunisation programme that British children are most likely to meet.\textsuperscript{13}

The findings from this study clearly demonstrate that children from larger-sized families are poorly vaccinated compared with those from smaller families. Children in larger families not only had a lower overall uptake of vaccinations, but also started their vaccinations later. Those children from larger families who started vaccination were less likely to have completed the course eight to 10 months after the due time compared with children from smaller families. This finding, among other factors, helps to explain the overall disappointing uptake rate of vaccinations in some areas, especially in inner cities, where a higher proportion of larger-sized families has been noted compared with rural and suburban areas (see Table 2).

Table 3 Logistic regression model for vaccination status

<table>
<thead>
<tr>
<th>Variable</th>
<th>Regression coefficient ($\beta$)</th>
<th>Standard error of $\beta$</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.965</td>
<td>0.153</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>No. of children in family (1-5)</td>
<td>-0.527</td>
<td>0.061</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Type of district (City v. R/S)</td>
<td>-1.026</td>
<td>0.216</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Vaccination location (GP v. HC)</td>
<td>-0.370</td>
<td>0.116</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Maternal age (&lt;20 v. 20-39)</td>
<td>-0.362</td>
<td>0.168</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Interaction between family size and type of district</td>
<td>0.298</td>
<td>0.080</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

R/S: Rural and suburban districts; City: Inner city districts; GP: General practices; HC: Child health clinics.

However, the inclusion of an interaction term involving family size and the type of resident district showed that the strength of the association between vaccination uptake and the number of children in the family was different in rural and suburban areas compared with inner city areas. In this circumstance, the odds ratio was more difficult to calculate.\textsuperscript{12} Table 4 shows the adjusted odds ratios and 95% larger-sample confidence intervals in the two types of districts. The adjusted odds ratio suggested a stronger association between vaccination uptake and the number of children in the family in rural and suburban areas than in inner city districts. In the former area's one 'unit' increase in the number of children in the family was responsible for a decrease of the odds of being vaccinated by a factor of 1.7 (1/0.59), whereas in inner city the corresponding factor was 1.3.

**Table 4 Adjusted odds ratio (aOR) of being vaccinated and 95% larger-sample confidence intervals (95% CI) based on the fitted logistic regression model**

<table>
<thead>
<tr>
<th>District</th>
<th>Estimated coefficient s.e. aOR 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of children in family (1-5)</td>
<td></td>
</tr>
<tr>
<td>Rural/suburban</td>
<td>-0.527 0.061 0.59 0.52-0.67</td>
</tr>
<tr>
<td>Inner city</td>
<td>-0.229 0.051 0.80 0.72-0.88</td>
</tr>
</tbody>
</table>

\textsuperscript{1}: Standard error.

Family size is related to ethnic origin. Families headed by persons from ethnic minority groups, especially from Asian countries, often have larger number of dependent children compared with those headed by 'Whites'.\textsuperscript{14} Children living in ethnic minority families tend to be poorly vaccinated.\textsuperscript{9} Unfortunately, this study was unable to relate the ethnic group directly with the number of children in the family and the uptake of vaccination. Ethnic data are not available in the present child health system. However, consideration of ethnic status would be unlikely to explain these findings. Vaccination uptake is affected by many factors,
including vaccination location, maternal age, and district location (see Table 2). Possible reasons for children from larger families missing or being late for their vaccinations include: appointments being missed because of the distractions provided by older siblings; young babies with older siblings catching colds earlier than others children causing postponement of vaccinations because of associated fevers; larger families are often underprivileged, eg by minority origin or lower social class. These factors are usually interrelated. The study data indicated that some parents decided to omit only the pertussis antigen. Omissions of this particular vaccination may be related to the fact that i. some children do have medical conditions which are apparent contraindications to pertussis vaccination; ii. some parents of children feared that their children receiving pertussis might result in medical side effects, particularly neurological problems and; iii. some children may be advised by health professionals not to accept the vaccine because of medical conditions which are not, in fact, contraindications to pertussis vaccine. However, we are not convinced that contra-indications to pertussis vaccination could be a major explanation for the overall lower uptake, as there was a reasonably high uptake rate for the first dose (see Table 2).

Accessible vaccination sessions at more convenient times might enable parents with larger families to attend. Opportunistic vaccinations, ie when children attend the GP practice or hospitals for other reasons, and domestic vaccination by district nurses, health visitors or other community staff, for frequently defaulting families might also improve uptake figures. This study was based on data from a child health computing system and shows that such data can be used for routine assessment, including comprehensive epidemiological evaluation of child health activities. However, there are deficiencies in the present data, especially missing information and the incompleteness of some important variables (eg ethnic group). Because of the critical associations between socio-demographic deprivation and health problems, ie less than optimal development and under utilisation of preventive health care, the collection of such routine data is essential despite the practical difficulties.

Conclusion

Family size appears to be one of the important factors affecting uptake of childhood immunisations; children from larger families are more likely not to receive their due immunisation procedures, compared with their counterparts from smaller families. This is the case in both rural/suburban and inner city areas. Even though child health computing systems were initially developed for facilitating child health record-keeping, scheduling health care services the system data can be used, as a routine database, for continuing and comprehensive epidemiological evaluation of the performance of child health activities to identify defaulters of the services on a population basis.

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