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Early child development in England: cross-sectional analysis of ASQ-3 records from the 2-2$\frac{1}{2}$-year universal health visiting review using national administrative data (Community Service Dataset, CSDS)

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Abstract

Introduction
The Ages & Stages Questionnaire 3rd Edition (ASQ-3) is a tool to measure developmental delay for children aged between 1 - 66 months originally developed in the United States. This measure has been collected in England since 2015 as a part of mandated 2-2$\frac{1}{2}$-year health visiting reviews and collated nationally in the Community Services Dataset (CSDS). CSDS is known to be incomplete and to-date there have not been any published analyses of ASQ-3 held within CSDS.

Objectives
This study aimed to a) identify a subset of complete child development data for children aged two in England using ASQ-3 data in CSDS between 2018/19-2020/21; b) use this subset of data to analyse child development age 2-2$\frac{1}{2}$-years in England.

Methods
This study compared counts of ASQ-3 records in CSDS by local authority and financial quarter against national, publicly available Health Visitor Service Delivery Metrics (HVSDM) to identify local authorities with complete ASQ-3 records in CSDS. This study described child development in this subset of the data using both a binary cut-off of whether a child reached expected level of development and the continuous ASQ-3 score.

Results
Among the 226,505 children from 64 local authorities in the sample with complete ASQ-3 data, 86.2% met expected level of development. Children from the most deprived neighbourhoods (82.6%), children recorded as Black (78.9%), and boys (81.7%) were less likely to meet expected level of development.

Conclusions
To fully understand early child development across England, the completeness of ASQ-3 data in the CSDS requires improvement. Second, in order to interpret the national CSDS data on child development, ASQ-3 should be standardised and validated in an English context with attention paid to implementation and subsequent referral and support pathways. Our study provides a minimum estimate of children needing developmental support (13.8%), with many more children likely to be experiencing moderate or mild delay but not identified by the ASQ-3 cut-offs for expected development.

Keywords
child development; early years; ages and stages questionnaire; health visiting; community service dataset

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Introduction

Early child development is associated with longer term educational attainment and economic, social and health outcomes in adulthood [1, 2]. In line with this evidence, the government has also recognised the importance of reducing early childhood inequalities [3–6] and has committed to improving support for babies and toddlers through their 2021 Start for Life agenda [7]. The backbone of services for babies and toddlers is the Healthy Child Programme in England which comprises a universal preventative service for children under five along with targeted support for families with higher need, in order to promote health and wellbeing and reduce inequalities in early childhood [8–11]. The Healthy Child Programme is led by health visitors, specialist community public health nurses who work in partnership with teams of community staff nurses, nursery nurses, health care assistants, and other specialist health professionals [9, 10, 12].

Within the Healthy Child Programme in England, there are five mandated universal health reviews: during the third trimester of pregnancy, when the child is age 10-14 days (new birth visit), 6-8 weeks (6-8-week review), 12 months (one-year review), and 2-2$\frac{1}{2}$-years (2-2$\frac{1}{2}$-year review). Each of these mandated contacts has a schedule of health promotion activities and a review of health and development of the child within their family context [13]. The 2-2$\frac{1}{2}$ year review is the final universal contact between families and the health visiting team before a child starts school at age four: a key part of the 2-2$\frac{1}{2}$ year review is an assessment of child development to identify any additional support that a child may need to be ready for school entry. As part of this assessment, a measure of child development called the Ages & Stages Questionnaire 3rd Edition (ASQ-3; adapted for use in England), is used routinely to collect population level data on early child development for monitoring trends and disparities [14]. The ASQ-3 is a tool originally developed in the United States (USA) and licensed by Brookes [15] in order to screen for developmental delay of young children aged between one month and five years [11].

The World Health Organisation recommends monitoring early child development in primary care settings [16–18]. Universal health checks which include assessment of child development at age 2-3 by primary care staff are also conducted in other countries globally, including Australia, Canada, the United States, and Scandinavia [19]. Similarly, in each of the four UK nations of England, Norther Ireland, Wales and Scotland, each child should receive a universal health and developmental review at age 2-3-years. The measure of child development collected at this review is used as a national indicator of how well young children are developing before school [20–22].

The new (2024) Labour government in Britain has identified child development as a key part of its policy agenda and has committed to a target of 75% of children being 'ready to learn' age 4-5-years by 2028 (currently 67% of children, based on the teacher assessed Early Years Foundation Stage Profile [23]. The measure of child development at age 2-2$\frac{1}{2}$-years is an important measure on the trajectory of being 'ready to learn' at age 4-5-years. In the USA where it was developed, the ASQ-3 has mainly been used for identifying developmental delays especially in medical settings, with the aim of enhancing early detection, appropriate clinical referral, and interventions, whereas in Scandinavian countries, it has often been used to capture child development as an outcome measure in intervention studies [24]. ASQ-3 has also been used to screen for early developmental delays in Europe (e.g. France and Norway) [25, 26], Africa (e.g. South Africa and Zambia) [27], South America (e.g. Uruguay, Chile and Colombia) [28, 29], Asia (e.g. Indonesia and China) [29, 30], and Australia [31]. In the United Kingdom (UK), ASQ-3 is used in many local areas alongside professional judgement to decide which individual children are referred for extra support, in addition to its function in collecting population level data to be collated nationally [32].

In England, there is a publicly available local authority level dataset on health visiting which includes child development age 2-2$\frac{1}{2}$-years (ASQ-3): Health Visitor Service Delivery Metrics (HVSDM), published by the Office for Health Improvement and Disparities with data submitted by local authorities [33–35]. This data reports high usage of ASQ-3 for children aged 2-2$\frac{1}{2}$-years: in 2018/19, 71.4% of children aged 2$\frac{1}{2}$-years had ASQ-3 completed in the correct period and ASQ-3 was used in 90.4% of all 2-2$\frac{1}{2}$ year health and development reviews (figures for 2022/23 are 73.6% and 92.5% respectively) [36]. However, as the HVSDM are aggregate figures at local authority level, they cannot be used to analyse disparities, and they cannot be linked to other administrative data.

An alternative source of data is the Community Services Dataset (CSDS), an individual-level administrative dataset of all community services in England, which should hold complete data on health visiting, including ASQ-3 data for every child in England who has had a 2-2$\frac{1}{2}$-year review. However, the CSDS has high levels of missingness due to the fact that providers remain at different stages of maturity in submitting their data to CSDS, including ASQ-3 data [37]. In our previous analyses of 33 local authorities, only 20-30% of children aged 2-3-years old in 2018/19 had a record of ASQ-3 in CSDS [3]. In this study, we extend this work to identify a subset of CSDS ASQ-3 data in three financial years (between April 2018 and March 2021) that is the most recent and sufficiently complete to carry out research. This study then uses this subset to describe child development at age 2-2$\frac{1}{2}$-years in England (as measured by ASQ-3), by child characteristics.

Method

Data source: Community Service Dataset (CSDS)

This study used individual-level ASQ-3 data and demographic characteristics of the children captured in CSDS [38, 39] for the three financial years between April 2018 and March 2021, which was the most recent data available to this study at the time of analysis. The ASQ-3 data is entered into each local data system by providers of health visiting (health visitors or other members of the health visiting team such as staff nurses or nursery nurses), and then uploaded monthly to the CSDS by local authority or NHS based data teams with other data on community services, where it is collated at a national level [39].

This study used Systematized Nomenclature of Medicine Clinical Terms (SNOMED) codes [40] to extract 2-2$\frac{1}{2}$-year

child development outcomes collected using 24, 27 or 30 month ASQ-3 questionnaires. These questionnaires cover the full age range of 2-2$\frac{1}{2}$-years when the universal health review should occur [15]. This study excluded duplicates by only keeping the latest record for each child. This study also excluded records without demographic information in CSDS. This study described the process of identifying eligible ASQ-3 records in Appendix Figure 1.

This study derived Lower Layer Super Output Area (LSOA) quintiles of deprivation from the Index of Multiple Deprivation (IMD) [41] based on the child's LSOA code. LSOA is a geographic hierarchy which is designed to improve the reporting of small area statistics in England and Wales and generally includes 400 to 1200 households or 1000 to 3000 people [42, 43].

Outcome variable: ASQ-3

Background

ASQ-3 was developed to screen for developmental delay and comprises 21 age-specific questionnaires for children aged between one month and 66 months ($5\frac{1}{2}$ years) [44]. Each questionnaire has 30 questions about the child's development which are grouped into five domains with three response options (yes/sometimes/not yet). This study used 2-2$\frac{1}{2}$-year child development outcomes collected using 24-, 27- or 30-month ASQ-3 questionnaires.

Domains

ASQ-3 covers five key domains of child developmental status in the following areas [15, 45]:

- Communication: babbling, vocalising, listening, and understanding
- Gross Motor: arm, body, and leg movements
- Fine Motor: hand and finger movements
- Problem Solving: learning and playing with toys
- Personal-Social: solitary social play and play with toys and other children.

Example questions of each of these domains can be found in Appendix Table 1.

Scores/Cut-offs

Different cut-offs for each ASQ-3 domains are provided by the ASQ-3 developers that measure whether a child's developmental status is at an expected level, in accordance with the child's age [15]. These cut-offs of 'at or below the cutoff score of 2 standard deviations below the mean' have been determined based on a USA population of 15,138 children aged between one and 66 months. See ASQ-3 technical report for more information on ASQ-3 cut-offs [45]. The score of each domain ranges between 0 and 60, with a possible total score of 300. However, total score is rarely used since each domain has different cut-offs for an 'expected' level of child development [15]. For example, the cut-off score for 27-month fine motor domain is 18.42 whereas it is 28.01 for the gross motor domain. The cut-off score for each domain can be found in Appendix Table 2. Based on the cut-offs for expected development recommended by the developers of ASQ-3, this study created a binary variable indicating whether a child reached expected or above level of development for all five domains [35]. This study used both a binary cut-off variable and a continuous ASQ-3 score variable to describe child development at age 2-2$\frac{1}{2}$-years, stratified by child characteristics.

Creating an analysis dataset with complete ASQ-3 data

We assessed the completeness of ASQ-3 data in CSDS for financial years 2018/19 to 2020/21 at the local authority-quarter level by comparing the number of children with a completed ASQ-3 to the number reported in the aggregate publicly available HVSDM. In previous work, we have found that HVSDM was accurate when compared to locally held data, which supports the use of HVSDM as reference data [3, 46]. We were concerned that the quality of 2020/21 data might have been affected by the impact of the COVID-19 pandemic, but there were as many ASQ-3 records in 2020/21 as in the previous two years. In the analysis dataset, this study included those local authority-quarters where CSDS captured at least 85% of the number of children who had an ASQ-3 completed reported in the HVSDM. See Appendix Figure 2 for more information on methods for creating the analysis dataset.

Results

All counts of individuals from CSDS have been rounded to the nearest 5 to comply with NHS statistical disclosure rules for subnational data [47].

How complete was the CSDS data?

The analysis dataset included 293 local-authority-quarterly data points from 64 local authorities (43.0% of 149 local authorities and 16.4% of a total 1,788 datapoints). This was the subset of data with CSDS where the ASQ-3 data had high agreement with the HVSDM between April 2018 and March 2021. The median number of quarters in the analysis dataset was 4 (out of 12 possible quarters). Some local authorities (n = 9/64, 14.1%) had just 1 complete quality quarter i.e. they contributed only three months of data to the analysis dataset in the three-year study period (Appendix Figure 3).

In all 149 local authorities in England (2018/19-2020/21), there were 3,015,809 children eligible for a child development review, based on age-specific population estimates from the Office for National Statistics (ONS) data. There were 2,994,828 unique children in the whole of CSDS (149 local authorities) for this study's time period who were eligible to have an ASQ-3 measure, based on their age. In other words, CSDS had the size of the denominator we would expect based on ONS data: no evidence that large numbers of eligible children were missing from CSDS. Of the 2,994,828 eligible children in CSDS, 432,910 (14.5%) had a record of an ASQ-3 having taken place (see Appendix Table 3 for full details). Due to missing demographic data for the child, a small proportion of valid ASQ-3 records (2,200, 0.5%, Appendix Figure 1) was excluded. When this study restricted the sample to only those

local authority quarters with highly complete ASQ-3 data, we obtained a final sample of 226,505 children with valid ASQ-3 records living in 64 local authorities who represented 52.3% of the valid ASQ-3 records across the entire CSDS cohort (149 local authorities, 2018/19 - 2020/21). Please see Appendix Figure 1 for flow of records and children into the analysis dataset.

Consequently, this study's final sample of children may be small relative to the estimated total number of children in England who were eligible to receive a child development review. Nevertheless, this study can be confident that our results give a reasonably complete picture of the ASQ-3 results in 64 local authorities at specific points during this study's time period.

Study sample: how comparable was the 'analysis dataset' to the national picture

The local authorities in the analysis dataset were similar to all local authorities in England, based on region and urban/rural status but slightly less deprived (see Appendix Table 4). Appendix Figure 3 and Appendix Table 4 show where in England the 64 local authorities were located: although each region was included, there was under-representation of the South East and East Midlands and over-representation from Yorkshire and the Humber and the North East. Our analysis dataset was not dominated by London local authorities (12 included of a possible 32).

Those children included in the analysis dataset (n = 226,505) were slightly more deprived and less ethnically diverse than all children aged 2 years in England based on 2021 Census data published by the Office for National Statistics (ONS) [48] (Table 1). This study sample contained a higher proportion of children in the most deprived IMD quintile (28.3%) than the national picture (24.8%) and all children aged 2-2$\frac{1}{2}$-years recorded in CSDS (25.9%). There was a higher proportion of children aged 2-2$\frac{1}{2}$-years with White ethnicity in the analysis data set (78.9%) as in England as a whole, based on a comparison with 2021 Census data (71.9%) and all children aged 2-2$\frac{1}{2}$-years recorded in CSDS (70.7%) [48].

Among the 226,505 children in the analysis dataset, 86.2% had a record of expected or above development at age 2-2$\frac{1}{2}$-years based on their ASQ-3 data in CSDS. This was slightly higher than the whole-of-England for the same time period (83.4%: average of 2018/19-2020/21) reported by Public Health England (PHE) in the HVSM [33–35]. The analysis dataset did not include any local authorities where less than 75% of children had a record of expected or above development age 2-2$\frac{1}{2}$-years, which is different to the national picture as reported in the HVSM (see Appendix Table 5).

Child development at age 2-2$\frac{1}{2}$-years in England

This study found that 82.6% of children living in the most deprived neighbourhoods reached expected or above level of development based on their ASQ-3 records in CSDS, compared to 85.0-89.7% of children living in all other neighbourhoods (Table 2).

In the sample, a higher proportion of White (86.8%) and Mixed (86.6%) children reached an expected level of development compared to Asian (80.3%) or Black (78.9%) children. Across all categories of recorded ethnicity, a higher proportion of children living in the less deprived neighbourhoods reached an expected level of development than children of the same ethnicity living in the most deprived neighbourhoods (Appendix Table 6). A higher proportion of girls (90.9%) reached expected level of development compared to boys (81.7%) regardless of ethnicity and deprivation (Table 2). Girls from the least deprived neighbourhoods were more likely to reach expected development (93.5%) when compared to girls from the most deprived neighbourhoods (88.2%) and when compared to boys from both the least deprived (86.0%) and most deprived neighbourhoods (77.2%).

To understand why this tendency for girls to do better than boys regardless of their neighbourhood level deprivation existed, this study explored whether the deprivation level of the local authority in which the child was living as a whole affected the association. To do so, this study categorised children into local authority level IMD quintile groups. However, this study still found this gender gap even when local authority level deprivation was accounted for (see Appendix Table 7).

This gender disparity also existed when this study used ASQ-3 score for each domain of child development (ranges between 0-60) instead of a binary cut-off of expected development (Figure 1). The patterns in Figure 1 were broadly consistent across the three years of the data (i.e. not driven by one year of data; Appendix Figure 4). The gender gap was greatest for the communication and problem-solving domains while it was less clear for the fine motor domain.

The deprivation gradient in child development was also evident when looking at the association between IMD and ASQ-3 at local authority level (Appendix Figure 5), though not as strong as in the individual level analysis. The average proportion of children reaching expected levels of development was similar across the local authorities in the three least deprived quintiles, but variation was greater for the 3$^{\mathrm{rd}}$ and 4$^{\mathrm{th}}$ quintile compared to the local authorities in the least deprived quintile (Appendix Figure 6).

Discussion

Main findings of this study

We found that only 14.5% of children eligible to have had their development measured using ASQ-3 at 2-2$\frac{1}{2}$-years had a record of an ASQ-3 measure in CSDS (2018/19-2020/21). Most of the 85.5% of eligible children 'missing' an ASQ-3 record in CSDS would have actually had a developmental assessment using the ASQ-3 tool, as based on the publicly available HVSDM which shows that 78.6% of 2-2$\frac{1}{2}$-year-olds had an ASQ-3 completed in 2019/20 [34]. A study that investigated reasons for missingness in CSDS concluded that improving automation, commission guidance on contracts and submission processes and dialogue between the CSDS team and local authorities might improve local data submissions.

Despite high missingness in CSDS, this study confirmed that there is a subset of ASQ-3 data in CSDS that is complete enough for analyses of child development aged 2-2$\frac{1}{2}$-years

Table 1: Percentage of children by ethnicity and deprivation in the analysis dataset compared to all children in CSDS and ONS, % (2018/19–2020/21)

Child characteristics	ONS	CSDS	
	Aged 2-years (N = 619,036)	All children aged 2-2½-years (N = 2,264,997)	Children in the analysis dataset (N = 226,505)
Ethnicity			
White	71.9	70.7	78.9
Asian	12.3	11.3	8.0
Mixed	8.0	8.7	7.0
Black	5.2	4.9	2.7
Other	2.7	4.4	3.4
Index of multiple deprivation (IMD) quintiles [a]			
1 Most deprived	24.8	25.9	28.3
2	21.7	21.9	19.2
3	19.2	19.3	18.3
4	17.8	17.2	16.6
5 Least deprived	16.6	15.7	17.6

[a]IMD quintiles were based on the English Indices of Deprivation 2019, as published by the Ministry of Housing, Communities and Local Government [41].
ONS = Office for National Statistics, CSDS = Community Services Dataset.

Table 2: Variation in % children reaching expected level of development by characteristics (95% CI). N = 226,505

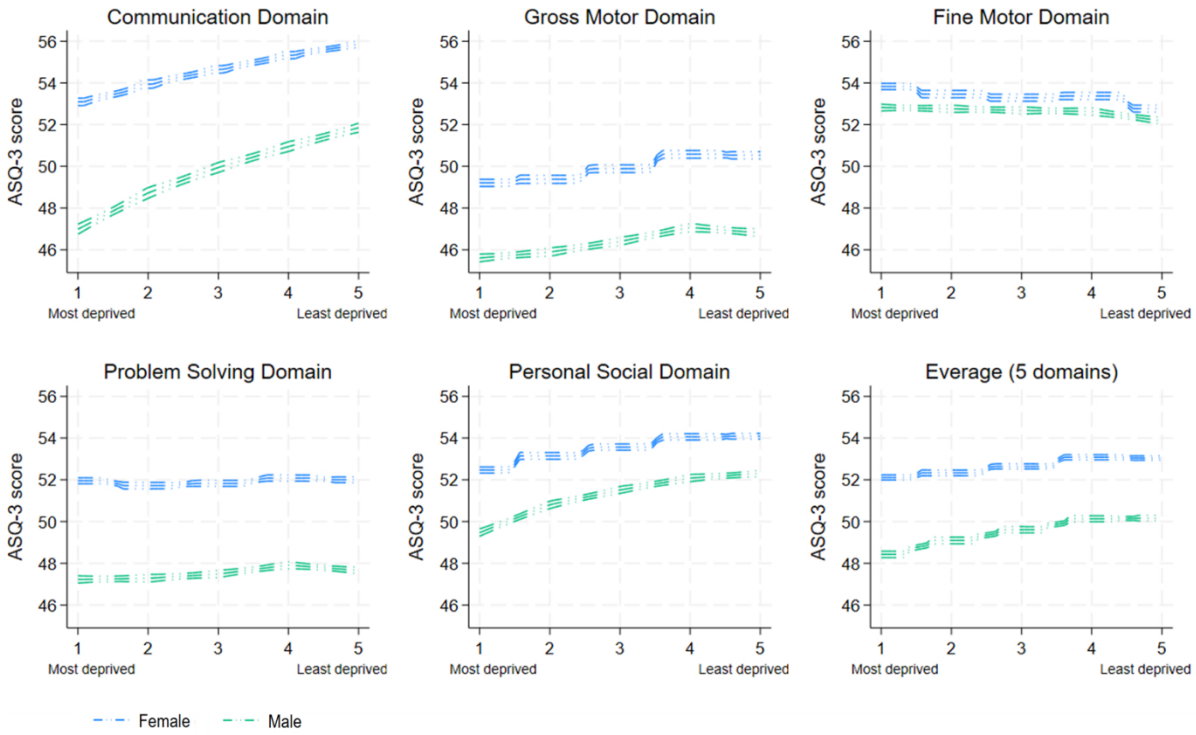
Children reaching expected level of development % (CI)		Index of multiple deprivation (IMD) quintiles		Gender	
		Most deprived % (CI)	Least Deprived % (CI)	Female % (CI)	Male % (CI)
Ethnicity					
White	86.8 (86.6–87.0)	82.9 (82.5–83.3)	90.2 (89.8–90.5)	91.5 (90.3–91.7)	82.4 (82.1–82.6)
Asian	80.3 (79.7–80.9)	79.4 (78.3–80.4)	82.2 (80.2–84.1)	85.8 (85.0–86.6)	75.0 (74.0–75.9)
Mixed	86.6 (86.0–87.2)	83.3 (82.0–84.5)	89.9 (88.7–91.0)	91.1 (90.3–91.7)	82.6 (81.7–83.5)
Black	78.9 (77.8–80.0)	77.3 (75.5–79.1)	82.9 (77.9–87.2)	84.4 (82.9–85.8)	73.5 (71.7–75.2)
Other	83.3 (82.4–84.2)	80.7 (79.1–82.3)	87.2 (84.8–89.4)	88.9 (87.8–90.0)	78.2 (76.8–79.6)
Total	86.1 (86.0–86.3)	82.3 (82.2–82.8)	89.7 (89.4–90.0)	90.8 (90.6–90.9)	81.4 (81.2–81.7)
Gender					
Female	90.9 (90.8–90.9)	88.2 (87.8–88.5)	93.5 (93.2–93.9)		
Male	81.7 (81.5–81.9)	77.2 (76.6–77.7)	86.0 (85.5–86.5)		
Total	86.2 (86.0–86.3)	82.6 (82.2–82.9)	89.7 (89.4–90.0)		
Index of multiple deprivation (IMD) quintiles					
Most deprived	82.6 (82.2–82.8)				
2nd quintile	85.0 (84.7–85.4)				
3rd quintile	87.1 (86.8–87.4)				
4th quintile	88.8 (88.5–89.2)				
Least deprived	89.7 (89.4–90.0)				
Total	86.2 (86.0–86.3)				

CI = confidence interval.

in England: 64 local authorities with 226,505 children in 2018/19 – 2020/21 [49, 50]. However, there are issues with generalisability to the whole of England: the children in the analysis dataset were more deprived and less ethnically diverse than children in the whole of England with slightly higher child development than reported by other sources [48]. Our analysis suggests that the local authorities with the more complete data in CSDS might also be the areas 'doing better' in terms of child development: none of the 22 local authorities with <75% children reaching expected development as reported in the HVSDM met the data completeness criteria for the analysis dataset.

This study found that in the most deprived neighbourhoods in the analysis dataset over 17% of children aged 2-2½-years and especially 22.8% of boys did not meet expected levels of development between April 2018 and March 2021 compared to 13.6% overall. This is similar to figures for

Figure 1: Average 27-month ASQ-3 score by IMD (LSOA quintiles) and gender of the child by domain



Note: The two upper and lower lines surrounding each gender line are the 95% confidence intervals.

Scotland where in 2021/22, 17.9% of young children ages 27-30 months were reported as having a developmental concern at their 27-30-month review, a rise from 14.3% in 2019/20 [20, 51, 52]. Given that this study's analysis dataset under-represents the local areas 'doing worse' in terms of early child development (based on comparison with HVSDM), we provide a minimum estimate of children aged 2-3-years who scored below expected development on the ASQ-3 in the study period. For local authorities with a high concentration of deprived neighbourhoods and large child populations, this will represent a high volume of young children not meeting expected development each year.

The deprivation gradient that this study found in child development aged 2-2$\frac{1}{2}$-years is consistent with findings of previous studies based in England and in other countries [31, 53–55]. For example, a multilevel analysis using the Department for Education Early Years Foundation Stage Profile (EYFSP) data measuring for 17 Early Learning Goals for 653,693 children aged between 4 and 5 years found that children living in income deprived areas were the group with the lowest rates of being School Ready compared to the children from the less income deprived areas [53].

This study found that White children and those with Mixed ethnicity recorded were more likely to reach expected level of development compared to children with other ethnicities recorded. This finding is in line with previous studies that revealed developmental gaps between children with different ethnic backgrounds [1, 53]. A recent study using Millennium Cohort data (children born between 2000 and 2002) also found that in the UK, White children (aged 3) were more likely to achieve higher development scores measured by the Bracken School Readiness test [56] and British Ability Scales II [57, 58] compared to those with other ethnic backgrounds [1].

This study found a striking gender gap in child development as girls were more likely to be assessed as meeting expected level of development compared to boys regardless of ethnicity or neighbourhood deprivation. It is well documented that there are gender differences in early child development [25, 59, 60] and that girls score higher in developmental assessments than boys [1, 31, 61]. This gender disparity persists across different tools for measuring early child development and is evident in studies that used the ASQ-3 [26, 28, 31] and also in studies using The Caregiver-Reported Early Development Instruments (CREDI) [54], Early Development Instrument (EDI) [60], the EYFSP [53] or Early Childhood Development Index (ECDI) [55, 62]. Purdam and colleagues [53] found a similar magnitude of difference between child development in boys and girls as this study did: this study [63] used the EYFSP for 653,693 children (aged 4 and 5 years) in England and found that girls from the most income deprived areas (decile 10) still showed better development than the boys living in less deprived areas (decile 4 to 9).

The gender differences in early child development are also reported internationally: McCoy and colleagues [54] used CREDI [64] to measure the development of 8,022 children (aged under 3) from 17 low-, middle-, and high-income countries finding that the score of girls was on average slightly higher (0.08 standard deviations) than boys.

Studies that used ASQ-3 also found significant gender effects on child development [28, 31]. For example, Veldman and colleagues [31] addressed the risk factors of child development using a sample of 701 pre-schoolers (3 to 5 years) living in low-income and remote communities in Australia and found that being a boy was one of the factors that was associated with a higher odds (odds ratio= 1.78) of children being delayed or at risk of gross motor delay.

Although the proportion of children reaching expected or above at age 2-2$\frac{1}{2}$-year-olds is an indicator of early years health and development in England (included within the Public Health Outcomes Framework) [65], there are challenges in interpreting the ASQ-3 data as a measure of population-level child health to inform policy and service planning. The cut-offs for developmental delay are based on populations of children from the United States [66]. Standardisation within English populations would clarify the most appropriate cut-offs to identify different levels of developmental delay in young children and could inform guidance on appropriate pathways for differing levels of delay [67]. Currently, the pathways following ASQ-3 are not well described and are variable across the country: we don't have a good idea of what support (if any) was offered to the children with lower than expected ASQ-3 score in our analysis dataset [67]. Information about the support triggered by the ASQ-3 in England is an essential part of using the ASQ-3 data on child development age 2-2$\frac{1}{2}$-year for resource allocation and service planning.

Population measures of child development based on ASQ-3 will under-estimate moderate and mild developmental delay: the recent review of short tools to measure child development in high income counties found that ASQ-3 detects severe developmental delay with good to high accuracy but is only moderately able to detect mild developmental delay amongst general populations of children aged 2-2$\frac{1}{2}$-years [67]. The performance of ASQ-3 reflects the difficulty in identifying meaningful developmental delay before the age of four years due to the variability in developmental trajectories of typically developing children [67]. In other words, even the best performing tools only perform moderately in identifying early childhood developmental delay. This means that the children with below expected development in our analysis dataset likely have the more severe end of developmental delay and there will likely be few children who have a low ASQ-3 score but are actually developing typically (assuming the ASQ-3 is implemented as intended by its developers).

A further challenge to interpretation is that the ASQ-3 is implemented differentially across local areas in England, complicating comparisons between areas and over time. In some areas, the ASQ-3 is delivered by fully qualified health visitors who are likely to use professional judgement in combination with the questionnaire to score a child. However, in other places the ASQ-3 may be administered by less experienced or qualified staff in a 'tick-list' way or in other places rely exclusively on parent reports without direct observation of the child by a professional [22, 67]. The differences in implementation will very likely affect which children are scored as below expected development on the ASQ-3 questionnaire.

Finally, it is unclear what the ASQ-3 data in England means in terms of predicting the numbers of children who will be starting school behind their peers and who will be in need of extra help from schools or other services. This is an important challenge given the new (2024) British government's commitment to increasing the proportion of children who are 'ready to learn' at age 4-5-years as measured by the teacher assessment at the end of the first year of school (EYFSP) [23]. Two systematic reviews from the last five years have confirmed that lower ASQ-3 scores are associated with later educational difficulties [68, 69]. However, a study which compared the proportion of lower-than-expected child development by local area using both measures in 2016-17 (ASQ-3 and EYFSP) found only weak correlation [70]. This is supported by the gap between the two measures at national data in the latest available publicly available data: 80.3% of 2-2$\frac{1}{2}$-year-olds reached the expected level of development as measured by ASQ-3 [71], but a much lower proportion of 4-5-year-olds (67.7%) were measured by EYFSP [72] to have a good level of development in 2023/24. We do not know how much the gap between expected child development in children aged 2-3-years and in children aged 4-5-years is attributable to measurement differences between ASQ-3 and EYFSP. For a measure of child development at age 2-3-years to be a helpful indicator of developmental trajectories, to monitor trends and disparities and to estimate policy impact, we need to fully understand how it relates to later universal measures of development.

Strengths and limitations

To our knowledge, this study is the first to use national, administrative, individual-level data in England (CSDS) to identify a sufficiently complete subset of child development (ASQ-3) data. Other researchers who are interested in using ASQ-3 data in CSDS can adopt this approach to develop an ASQ-3 analysis dataset of local authorities and children in England.

Some of the limitations of this study stem from the incompleteness of the CSDS ASQ-3 data itself. Although in theory all 2-2$\frac{1}{2}$-year-olds in England should receive the 2-2$\frac{1}{2}$-year health visiting review using the ASQ-3 questionnaire and the scores should be available in the CSDS dataset, in reality ASQ-3 data in CSDS is highly incomplete. Since the analysis dataset only included 64 local authorities with complete quality, this study cannot be confident about generalising the results to those local authorities and children that are not included in the analysis dataset. Indeed, what this study found is that on average a higher proportion of children in the sample reached the expected level of development than reported elsewhere for England.

Secondly, child demographic information available in CSDS were limited, which hindered an in-depth understanding of child development in different subgroups of children. This study did not have important characteristics known to affect child development (e.g. parental education level) in CSDS and most of the available characteristics had high missingness (e.g. first language – 59.0% and parental occupation – 91.4%). In Cattan et al.'s (2023) study, the effect of ethnicity on child development shrunk for some groups (e.g. the Black-White gap in cognitive development) but did not change for other groups when other covariates (e.g. socio-economic and home learning environment) were included in the model [1].

In CSDS, this study only had the national level child development outcome (ASQ-3) measured when children were at age 2-2$\frac{1}{2}$-years which makes it difficult to address the trajectories of child development. As Peyre et al.'s (2019) study on sex differences in child development during the

preschool period in France found, the gender gap in child development shrunk as children got older. This study cannot address this relationship and other factors' long-term effects on child development using CSDS. Further work should track development in individual children over time by linking CSDS to the National Pupil Database, which will be the case in the extended Education and Child Health Insights from Linked Data (ECHILD) data resource [73] and will also allow investigation by maternal and other child factors such as disability and preterm birth.

Conclusion

This study found that substantial minorities of children in the sample had a CSDS record of below expected development using the ASQ-3 tool. Based on what was known about the accuracy of ASQ-3 from other studies, this substantial minority of children was likely to be truly behind their peers in terms of development. However, there will be many more children with moderate or mild developmental delays not identified by the ASQ-3 cut-off proposed by the developers of the tool and which we used in this study.

Although likely an under-estimate of developmental delay in children (due to only moderate sensitivity of ASQ-3 in general population samples [67] and the under-representation of 'worst performing' local authorities in the analysis dataset), the estimates provide a baseline for looking at the burden and distribution of developmental delay over time in England and how this varies by local area. It can also act as a starting point for local areas to understand whether they have relatively high or low proportions of children who are reaching expected development, taking into account the characteristics of their populations.

Although the national data on child development ages 2-$2\frac{1}{2}$-years in England (CSDS) is incomplete, this study identified a sufficiently complete subset of data to use for analysis. This method can be used by other research teams to develop an 'analysis dataset' within CSDS. To gain a representative national picture we need more complete data in CSDS. It is likely that a whole-country analysis would identify more children below expected development than in our study, as the 'lowest performing' local authorities had incomplete data and were excluded from our analysis.

Due to the challenges of interpretation, data completeness alone will not be enough to maximise the usefulness of England's ASQ-3 data for informing policy and practice. Further research is needed to standardise the universal measure of child development (ASQ-3) in an English population of young children, to investigate how the two universal measures of child development in England (ASQ-3 at 2-$2\frac{1}{2}$-years and EYFSP at 4-5-years) relate to one another and to understand and generate recommendations about intervention and support pathways for children with a spectrum of ASQ-3 scores in England. Some standardisations of implementation would give confidence that ASQ-3 data was comparable between areas and over time.

One further element of consideration should be the gender disparities in early child development that are well documented in the evidence-base, including ruling out gender bias within the measurement tools, as has been done with similar tools in other countries [74].

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Statement on conflicts of interest

The authors declare no conflicts of interest.

Ethics statement

This study has been approved by University College London Institute of Education (UCL IOE) Research Ethics Committee (REC1725).

Data availability statement

Access to the CSDS was approved and provided by NHS England (NIC-393510 and NIC-381972). Health Visiting Service Delivery Metrics data are published by the Office for Health Improvement and Disparities and are openly available: data for 2018/19 [75] can be found at https://www.gov.uk/government/statistics/health-visitor-service-delivery-metrics-2018-to-2019, data for 2019/20 [76] can be found at https://www.gov.uk/government/statistics/health-visitor-service-delivery-metrics-experimental-statistics-2019-to-2020-annual-data and data for 2020/21 [77]) can be found at https://www.gov.uk/government/statistics/health-visitor-service-delivery-metrics-experimental-statistics-annual-data.

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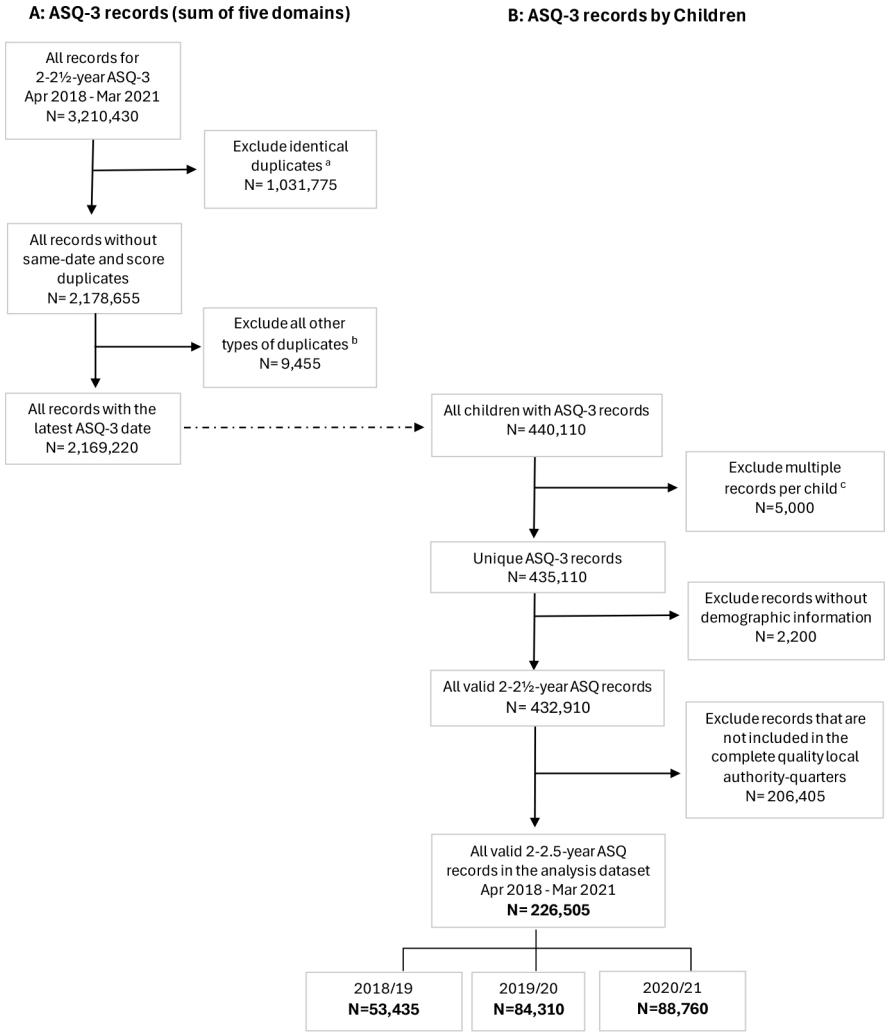
Abbreviations

ASQ-3:	The Ages & Stages Questionnaire 3rd Edition
CSDS:	Community Services Dataset
EYFSP:	The Education Early Years Foundation Stage Profile
HVSDM:	Health Visiting Service Delivery Metrics
IMD:	The Index of Multiple Deprivation
LSOA:	Lower Layer Super Output Area
ONS:	Office for National Statistics

Appendix Figure 1: Flow chart to identify the child development (ASQ-3) records in Community Services Dataset from April 2018 to March 2021 for inclusion in the analysis dataset



Notes: [a] 'identical duplicates' were records for which the ASQ-3 records per child were identical based on ASQ-3 domain, assessment date, and score. [b] Other types of duplicates include: (i) the same score recorded on different dates, (ii) different scores recorded on the same date, and (iii) different scores recorded on different dates. [c] Multiple ASQ-3 records per child in different years or done using different ASQ-3-months questionnaires.

Appendix Table 1: Example questions for each ASQ-3 domain

Domain	Example question
Communication	*'Does your child use all of the words in a sentence (for example, "a," "the," "am," "is," and "are") to make complete sentences, such as "I am going to the park," or "Is there a toy to play with?" or "Are you coming, too?"'*
Gross motor	*'Does your child climb the rungs of a ladder of a playground slide and slide down without help?'*
Fine motor	*'Using child-safe scissors, does your child cut a paper in half on a more or less straight line, making the blades go up and down? (Carefully watch your child's use of scissors for safety reasons.)'*
Problem solving	*'When shown objects and asked, "What color is this?" does your child name five different colors, like red, blue, yellow, orange, black, white, or pink? (Mark "yes" only if your child answers the question correctly using five colors.)'*
Personal-social	*'Does your child wash his hands using soap and water and dry off with a towel without help?'*

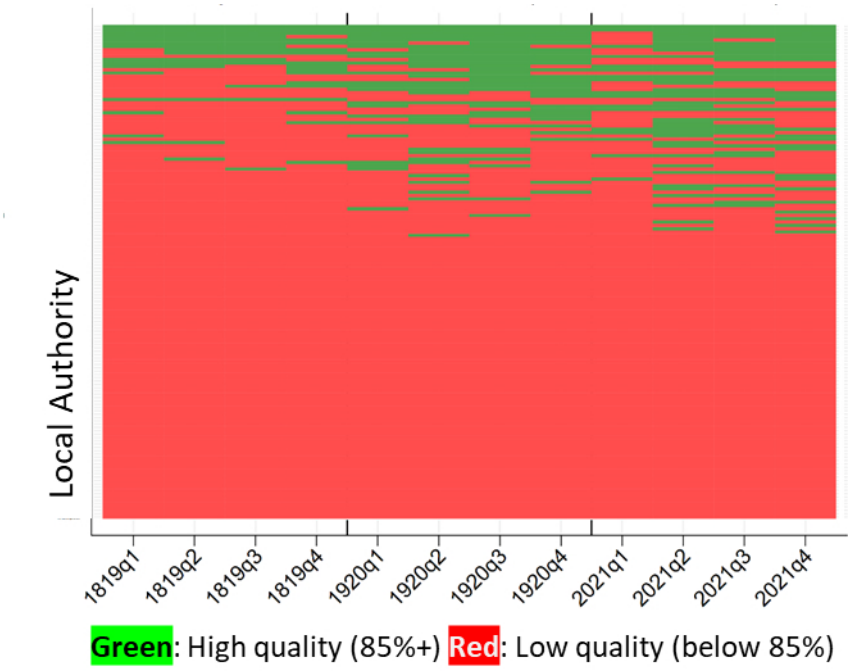
Note: Example questions are copied from 48-month ASQ-3 sample questionnaire [15] which is available from Ages and Stages Questionnaire webpage [78].

Appendix Table 2: Cut-off scores for each ASQ-3 domain

Domain	24 month	27 month	30 month
Communication	25.17	24.02	33.30
Gross Motor	38.07	28.01	36.14
Fine Motor	35.16	18.42	19.25
Problem Solving	29.78	27.62	27.08
Personal-Social	31.54	25.31	32.01

Source: Ages & stages questionnaires 3rd Edition (ASQ-3) [15].

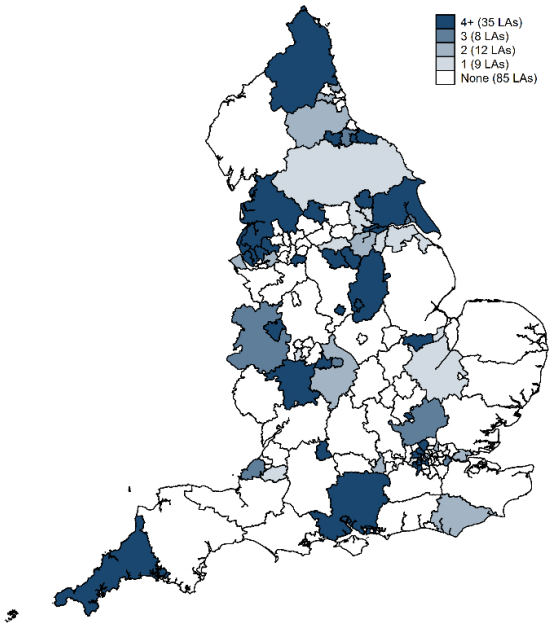
Appendix Figure 2: Completeness of CSDS ASQ-3 (2018/19 – 2020/21)



As there are 149 local authorities in England (health visiting in City of London is delivered by Hackney and in the Isles of Scilly it is delivered by Cornwall), this study had reference data for 1,788 local authority-quarters (12 quarters x 149 local authorities).

In our previous studies, this study has used a +/-15% margin to identify completed CSDS data for health visiting contacts [3, 38, 46, 79] based on the observed difference between counts of mandated contacts recorded in HVSDM and local health visiting activity data. However, in this study it was assumed that if a child had plausible scores across all five domains of ASQ-3 in the CSDS data that this was likely to accurately reflect that ASQ-3 has been administered and this study therefore included local authority quarters of data where ASQ-3 records in CSDS exceeded numbers in the reference data (85%+). Where there were more ASQ-3 records in CSDS than the HVSDM for a given local authority quarter, this study included that local authority quarter of data (no upper limit).

Appendix Figure 3: Total N of quarters included in the analysis dataset (2018/19–2020/21)

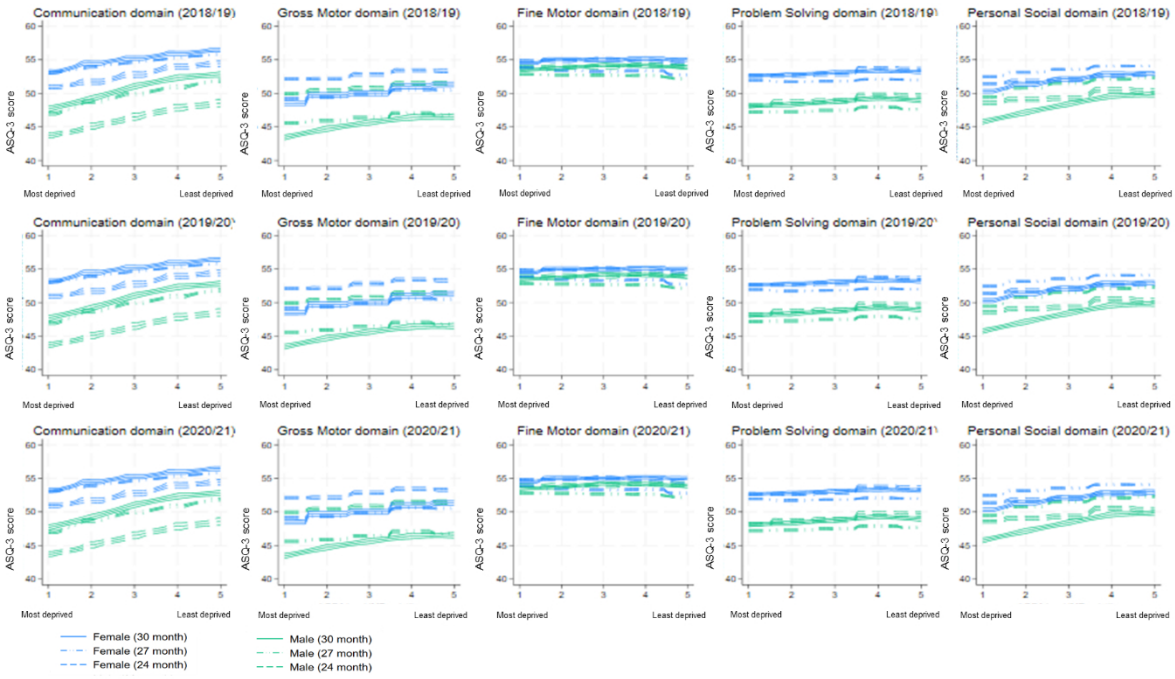


Appendix Table 3: Number and percentage of children eligible for the 2-2$\frac{1}{2}$-years review using the ASQ-3 in CSDS compared to ONS Data (2018/19–2020/21)

All children aged 2-2$\frac{1}{2}$-years	**Aged 2-2$\frac{1}{2}$-years with ASQ-3 record**	
ONS[a]	**CSDS**	
N	**N (%)[b]**	**N (%)[c]**
3,015,809	2,994,828 (99.3)	432,910 (14.5)

[a]Since the ONS data only provides ages in years, this study created the 2-2$\frac{1}{2}$ years age group by adding the number of 2-year-olds with 50% of 3-year-olds. [b]Denominator is ONS all children aged 2-2$\frac{1}{2}$-years [c] Denominator is CSDS all children aged 2-2$\frac{1}{2}$-years.

Appendix Figure 4: Average ASQ-3 score by Index of Multiple Deprivation (quintiles) and gender of the child by ASQ-3 domain and financial year



Appendix Table 4: Characteristics of local authorities included in the analysis dataset compared to all local authorities in England

Local Authority Characteristics	149 local authorities in England N (%)	64 local authorities included in the analysis dataset N (%)	P value comparing local authorities included with those not included in the analysis CSDS dataset
Region			
East Midlands	9 (6.0)	2 (3.1)	0.12
East of England	12 (8.1)	5 (7.8)	
London	32 (21.5)	12 (18.8)	
North East	12 (8.1)	8 (12.5)	
North West	23 (15.4)	9 (14.1)	
South East	18 (12.1)	5 (7.8)	
South West	14 (9.4)	5 (7.8)	
West Midlands	14 (9.4)	7 (10.9)	
Yorkshire and The Humber	15 (10.1)	11 (17.2)	
Geographical area classification[a]			
Predominantly Rural	20 (13.4)	7 (10.9)	0.74
Predominantly Urban	108 (72.5)	48 (75.0)	
Urban with significant rural	21 (14.1)	9 (14.1)	
Income deprivation affecting children index (IDACI) quintiles [b]			
Most deprived	29 (19.5)	7 (10.9)	0.02
2	30 (20.1)	18 (28.1)	
3	30 (20.1)	17 (26.6)	
4	30 (20.1)	10 (15.6)	
Least deprived	30 (20.1)	12 (18.8)	
Index of multiple deprivation (IMD) quintiles[b]			
Most deprived	29 (19.5)	7 (10.9)	0.05
2	30 (20.1)	17 (26.6)	
3	30 (20.1)	17 (26.6)	
4	30 (20.1)	12 (18.8)	
Least deprived	30 (20.1)	11 (17.2)	

Note: There are a total of 149 local authorities in the analysis as City of London is combined with Hackney and Isles of Scilly is combined with Cornwall. [a]Geographical area type was categorised using the Office for National Statistics (ONS) Rural Urban Classification lookup table for local authority areas [80]. [b]IDACI and IMD quintiles were based on the English Indices of Deprivation 2019, as published by the Ministry of Housing, Communities and Local Government [41].

Appendix Table 5: Comparing the percentage of children reaching the expected level of development in the analysis data to the national data (HVSDM) (2018/19 - 2020/21)

Range (%)	Analysis data N (%)	HVSDM N (%)
Under 75	0 (0.0)	22 (15.7)
75.0-79.9	8 (12.5)	17 (12.1)
80.0-84.9	20 (31.3)	29 (20.7)
85.0-89.9	27 (42.2)	55 (39.3)
90.0-94.9	9 (14.1)	17 (12.1)
Average	64 (86.2)	140 (83.4)

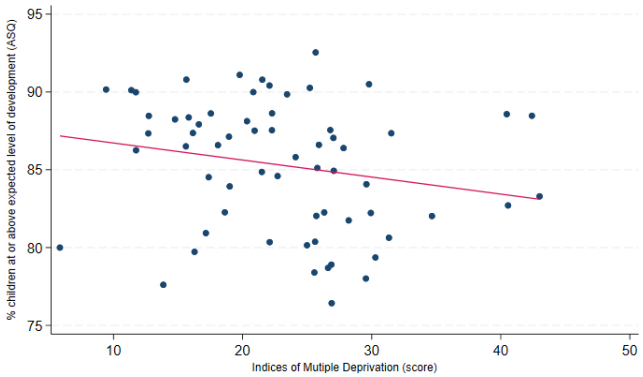
Appendix Table 6: Percentage of children reaching expected level of development by deprivation and ethnicity; % (95% Confidence interval [CI])

	Most deprived % (CI)	2nd quintile % (CI)	3rd quintile % (CI)	4th quintile % (CI)	Least deprived % (CI)	Total % (CI)
White	82.9 (82.5–83.3)	85.9 (85.5–86.3)	87.8 (87.4–88.2)	89.4 (89.0–89.8)	90.2 (89.8–90.5)	86.8 (86.6–87.0)
Asian	79.4 (78.3–80.4)	80.5 (79.2–81.8)	79.9 (78.3–81.4)	81.5 (79.5–83.4)	82.2 (80.2–84.1)	80.3 (79.7–80.9)
Mixed	83.3 (82.0–84.5)	84.6 (83.1–86.0)	87.3 (86.0–88.6)	89.1 (87.8–90.4)	89.9 (88.7–91.0)	86.6 (86.0–87.2)
Black	77.3 (75.5–79.1)	79.3 (77.0–81.5)	81.1 (78.3–83.7)	79.3 (75.3–82.8)	82.9 (77.9–87.2)	78.9 (77.8–80.0)
Other	80.7 (79.1–82.3)	82.9 (80.8–84.9)	83.4 (81.1–85.6)	87.5 (85.0–89.7)	87.2 (84.8–89.4)	83.3 (82.4–84.2)
Total	82.5 (82.2–82.8)	85.0 (84.7–85.4)	87.1 (86.8–87.4)	88.8 (88.5–89.2)	89.7 (89.4–90.0)	86.1 (86.0–86.3)

Appendix Table 7: Percentage of children reaching expected level of development by local authority-level and LSOA-level Index of Multiple Deprivation (IMD) and gender; % (95% Confidence interval [CI])

Local authority level IMD	LSOA level IMD			
	Most deprived quintile		Least deprived quintile	
	Female % (CI)	Male % (CI)	Female % (CI)	Male % (CI)
Most deprived	89.7 (89.1–90.3)	79.2 (78.4–80.0)	94.1 (91.2–96.3)	86.5 (82.7–89.7)
2nd quintile	86.7 (86.0–87.3)	74.4 (73.6–75.2)	93.4 (92.3–94.3)	84.4 (82.9–85.8)
3rd quintile	89.4 (88.5–90.2)	79.7 (78.6–80.8)	94.4 (93.3–95.3)	89.3 (87.9–90.5)
4th quintile	87.1 (86.0–88.1)	76.0 (74.7–77.3)	92.2 (91.3–93.0)	84.5 (83.4–85.6)
Least deprived	87.5 (85.9–89.0)	77.2 (75.2–79.1)	94.0 (93.5–94.5)	86.3 (85.6–87.0)

Appendix Figure 5: Association between local authority level deprivation (IMD score) and percentage of children meeting or exceeding the expected level of development (ASQ-3)



Appendix Figure 6: Association between local authority level deprivation (IMD quintile) and percentage of children meeting or exceeding the expected level of development (ASQ-3)