Pedestrians avoid busy roads: evidence from video surveys and bus stop data

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Abstract

This paper assesses the influence of motorised traffic on pedestrian mobility in an area in London surrounded by major roads. Pavement and crossing flows obtained by a video survey are analysed in comparison with data on bus stop usage. The flows along the busiest road are lower than it would be expected given the location of the road along the walking routes to bus stops. The propensity to cross the road (overall and informally) correlates negatively with traffic levels, especially in roads with medium traffic speeds. The hypothesis that local residents avoid crossing the road away from designated facilities is also supported by differences in the number of passengers boarding and alighting buses at different stops.

Street mobility and network accessibility:
towards tools for overcoming barriers to walking amongst older people

1. Background and contribution

Motorised traffic inhibits the movement of pedestrians, with potentially far-reaching consequences on the wellbeing of the residents in affected areas. High traffic levels create air pollution and noise, cause delays and detours, and force pedestrians to engage in risky crossing behaviours. The persistence of these effects may lead to the suppression of walking trips (Owen *et al*. 2004), which is associated with lower levels of accessibility to goods and services, physical exercise, and social interaction (Mindell and Karlsen 2012).

There is a growing body of research on the relationships between walking behaviour and the characteristics of the built environment, including road infrastructure and motorised traffic (Talen and Koschinsky 2013). This literature is complemented by surveys or qualitative studies of people's perceptions and attitudes about the presence of roads in their neighbourhoods (Mullan 2003). These two types of methods provide useful guidelines for local governments to improve walkability, but need to be validated with information about the street activity in the areas where policies are implemented. This information is usually obtained by on-the-spot observation or video surveys (May *et al*. 1985).

The effect of roads on people moving about in an area may be assessed by counting the flows of pedestrians walking along and crossing busy roads. The estimated propensity of pedestrians for crossing the road is a simple indicator of the barrier effect of traffic on pedestrians. This approach was used by Hine and Russell (1993, 1996), who suggested the use of "crossing ratios", obtained by taking the number of pedestrians crossing the road as a proportion of the pedestrians walking along a section of the road on both sides of the pavement. The propensity to cross informally, and not in designated crossing facilities, is another useful indicator. For example, Sisiopiku and Akin (2003) proposed a "spatial compliance ratio" to measure the proportion of pedestrians who cross away but within 3m from a formal crossing facility.

This paper adds to these efforts by investigating the role of traffic levels and speeds in explaining discrepancies between observed and expected pedestrian pavement and

crossing flows. The observed flows were calculated from a video survey and the expected flows were obtained by analysing the number of passengers using bus stops and using network analysis to derive the optimal walking routes to those bus stops. The use of this approach is facilitated by the characteristics of the case study area, a neighbourhood with very few destinations for pedestrians other than bus stops.

The rest of the paper is organised as follows. Section 2 introduces the characteristics of traffic, pedestrian infrastructure, and land use in the study area. Sections 3 and 4 present the results of the analysis of pavement flows and crossing ratios respectively. Section 5 concludes the paper and proposes directions for further research.

2. Study area and methods

Woodberry Down is a residential neighbourhood in North London surrounded by two major roads, a large park, a canal, and two water reservoirs (Figure 1). The neighbourhood is split by Seven Sisters Road, a busy six-lane road (Figure 2). The only designated crossing facilities in the 1km section of the road traversing this area are three signalised crossings (at both ends and halfway between them) and an underpass in the western end, which is linked to the Manor House underground station. This western end is particularly problematic, as the pedestrian desire lines to bus stops are interrupted by traffic negotiating a confusing junction of major and minor roads and by buses stopped or U-turning. Unlike in other parts of the road, there is no central reservation which could be used as a pedestrian refuge in this location. There are three other roads in this area: a busy 4-lane road (Green Lanes) and two quieter 2-lane roads (Woodberry Grove and Woodberry Down). The rest of the neighbourhood is accessed by driveways and pedestrian-only passageways.

Figure 1: Woodberry Down
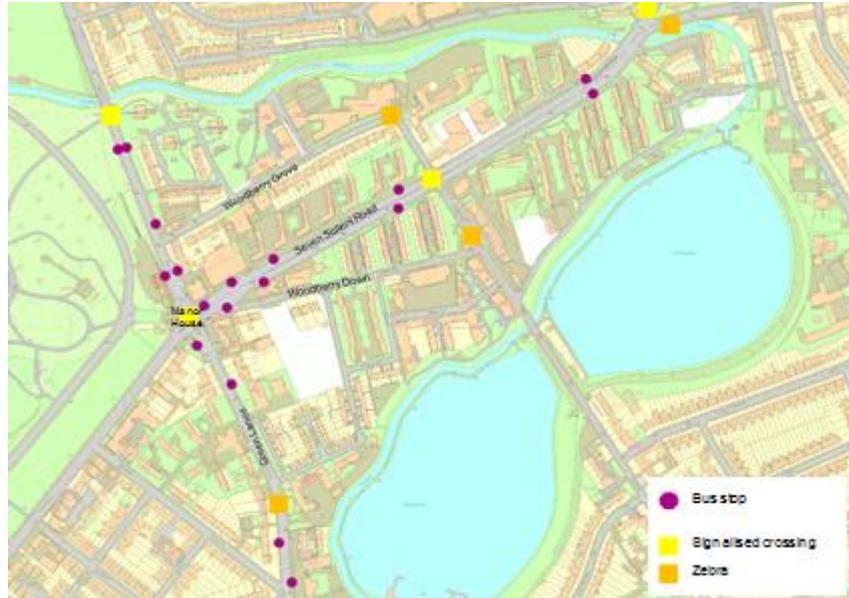
Source of base map: EDINA Digimap Ordnance Survey Service

Figure 2: The four roads of Woodberry Down

The Woodberry Down area is being subject to an extensive regeneration program over the next 20 years. It is hoped that the present study provides evidence on the barrier effect of Seven Sisters Road on local residents and the need to include the improvement of pedestrian environment as a part of the regeneration program.

The area is also an interesting case study because of the role of bus stops as the main destination for pedestrians. The neighbourhood is residential and contains no

supermarkets or long strips of shops like similar areas in London located near an underground station. The only major facility is a health centre, which is located at the south-western extreme of the neighbourhood, beyond walking distance to many residents. Most residents need to walk to the underground station or bus stops to go to work or to access shops and other facilities in surrounding areas. A survey parallel to the present study found that 48% of 100 respondents cross Seven Sisters Road to use public transport most days and a further 27% cross that road 2-3 times a week. Because the walking flows to local destinations other than bus stops are small, the analysis of data on bus stop usage can provide insights on the expected pedestrian flows along the streets leading to those bus stops. The discrepancy between the observed and expected flows may be explained in part by high traffic levels or other negative aspects of roads and motorised traffic.

The use of buses to travel to most of daily destinations can also provide a way to overcome the danger and unpleasant effects of crossing the road. In another initiative parallel to this study, workshops with local residents found that some older residents get on or get off buses one stop before or after the stop that serves their home, in order to cross the road in a safer. Once again, the analysis of bus stop usage data can shed light on the prevalence of this type of behaviour, which would signal the existence of a severe negative effect of road traffic on the local community.

To investigate these questions, a video survey was set up to count road traffic and the number of pedestrians walking along and crossing roads. The survey was done on a weekday (16 September 2014) between 7AM and 10PM. A total of fifteen cameras were installed in the four main roads. The objective was to cover all the formal and informal crossing points in Seven Sisters Road and some locations in the other three roads where crossing facilities were located near informal crossing points serving important pedestrian desire lines. The counts were based on a sample of the footage (from 16 to 30 minutes past every hour) and then extrapolated for the whole survey period. The average road traffic speed in all sections of the road and the average delay for pedestrians in all formal and informal crossing points were also measured, using a sample of the footage. Data on the daily number of people boarding and alighting buses in each stop in the study area was provided by Transport for London.

3. Pavement flows

The presence of road traffic affects the wellbeing of pedestrians even when they do not wish to cross the road, due to the visual intrusion and intimidation by vehicles and exposure to air pollution and noise. Main roads with large traffic volumes also tend to have a high density of junctions with side streets, interrupting pedestrian circulation and creating obstacles to people with mobility restrictions, if dropped kerbs are not provided. Pedestrians may then choose alternative routes in order to avoid walking along main roads. This hypothesis is tested in this section, which analyses the distribution of flows of pedestrians walking along the pavements in the four roads in the Woodberry Down area. The differences between the observed flows and the flows that would be expected from modelling the optimal pedestrian routes to bus stops are then related to traffic levels or speeds.

Figure 3 shows the daily (8AM-10PM) pedestrian flows in several locations in the four roads. The pavement flows are the sum of pedestrians walking on both directions in each side of the pavement. The sections of Green Lanes and Seven Sisters Road leading to the Manor House junction have by far the highest pedestrian flows. The flows on the eastern pavement of Green Lanes are much higher than the ones on the western pavement, as the former gives access to the North part of the residential neighbourhood and the latter runs along the borders of a large park. The flows on the north pavement of the western section of Seven Sisters Road are also higher than the ones on the south side, which is explained by the flows from people interchanging between buses and the underground.

The most striking result, however, is the relatively low pedestrian flows in the other sections of Seven Sisters Road when comparing with the flows observed in Woodberry Down, despite the fact that Seven Sisters Road has much higher connectivity with other local roads and streets and contains all the stops for longitudinal bus services serving the area.

Note: Rectangle size is proportional to flow value

The hypothesis that pedestrians avoid walking along main roads if there is an alternative route can be tested by looking at the relationship between observed and expected pedestrian flows. In an area such as Woodberry Down, where the main destinations for pedestrians are bus stops, a possible approach to derive the expected pedestrian flows is to collect data on the number of people boarding and alighting buses in each stop and then generate the origins and the walking routes of those people.

The first steps in this method are to estimate the fastest routes from each building in the study area to the nearest bus stop and calculate the service area of each stop (the set of buildings for which that bus stop is the nearest). The estimation of the fastest routes is based on a model of the pedestrian network built on a Geographical Information System. The model includes all the pedestrian pavements along roads, links that are exclusive to pedestrians (such as passageways between buildings and parks) and all formal and informal crossing points. The time to traverse crossings includes the average delay that was observed from the video footage.

The daily number of users of each bus stop is then assigned to the routes ending in that stop proportionately to the total area of the building where they start. The area of each building was calculated from the building area (measured in maps) and the number of floors (identified in field visits). The flows from buildings to bus stops are finally summed up for each link of the pedestrian network.

While information on the number of people entering and exiting Manor House underground station is also available, the walking routes to the station were not used in the analysis to derive the expected pedestrian flows. This is because the station is used by a large number of people living in other neighbourhoods, as the area surrounding Woodberry Down has a low density of tube stations. It is difficult to disaggregate, even theoretically, the total number of users of the station into local and non-local users. In addition, many local users also use buses to access the station, given their location in one of edges of the neighbourhood. Because of the large number of people interchanging from buses to the underground station, the pedestrian pavements adjacent to Manor House station are excluded from this part of the analysis.

A ratio can be calculated between the observed pedestrian flows and the theoretical flows obtained using the methods described above. The analysis of this ratio assumes that flows of non-residents walking in the area and flows of residents to destinations other than bus stops are proportional to the observed flows in all pavements being analysed, and that the differences between the ratio calculated in each pavements reflect only divergences between the fastest routes and people's actual walking routes.

Figure 4 maps the ratio between the observed and expected pedestrian flows along pedestrian pavements and compares this ratio with road traffic levels and speeds. The map shows that the ratio is much lower in Seven Sisters Road than in the two surrounding minor roads. This result suggests that some pedestrians use the minor roads as alternative for longitudinal routes, rather than walking on Seven Sisters Road. This hypothesis is confirmed by the chart, which shows a clear negative relationship between daily traffic levels and the ratio between observed and expected pedestrian flows. The minor roads, which have traffic levels below 10,000 vehicles per day, have observed walking flows 10 times higher than those estimated from the fastest routes to bus stops. In the two main roads, which have traffic levels of up to 30,000 vehicles per day, the ratio between observed and expected flows is much smaller. However, within the set of main roads, the ratio is higher in the sections with higher average speed.

Figure 4: Ratio between observed and expected flows
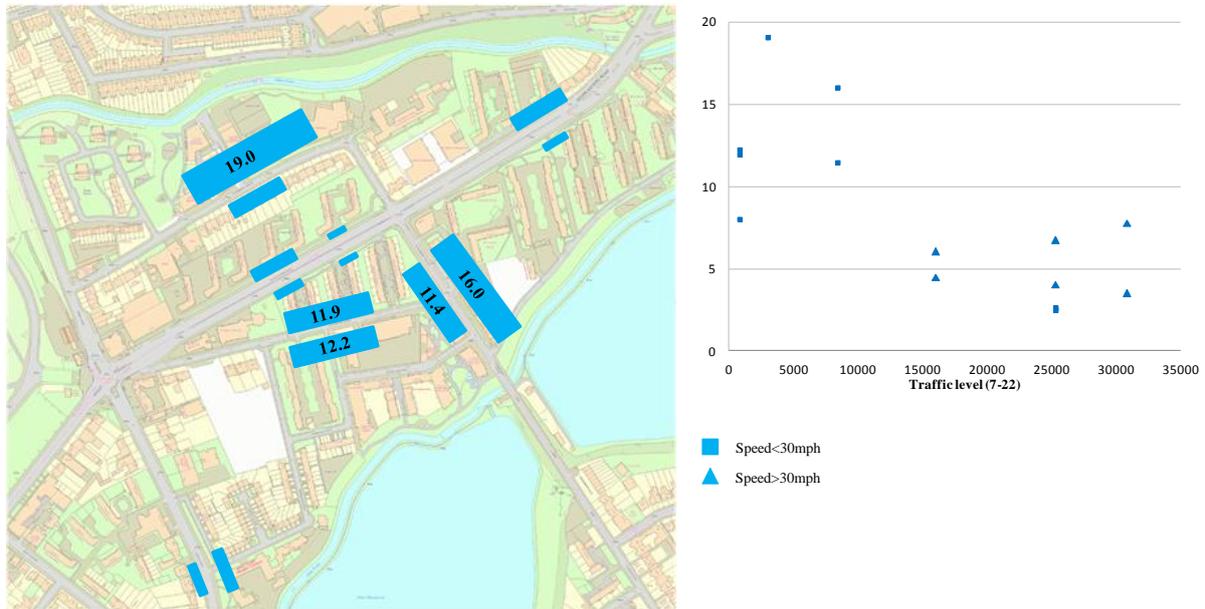
Note: Rectangle size is proportional to ratio. Only the labels of the highest values are shown.

4. Crossing ratios

Large roads represent a barrier to the movement of pedestrians as they interrupt the connectivity of pedestrian pavements. The road may present a physical, absolute, barrier, as in the case of motorways or roads with guard railings separating pavements from the carriageway. However, even when crossing is physically possible, large traffic levels or speeds reduce the opportunities for pedestrians to cross the road safely. It is expected that in roads where this barrier effect exists, the propensity for pedestrians to cross the road is low. The range of different locations where pedestrians cross will also be small, in some cases restricted to designated crossing facilities. These hypotheses are tested in this section by analysing how crossing ratios vary in roads with different number of lanes, traffic levels, and average traffic speeds. Further insights on the hypothesis that people avoid crossing away from designated areas are derived from the study of differences between people boarding and alighting bus at stops.

An indicator of "crossings as a proportion of walking" is defined as the number of pedestrians crossing the road from a given pavement divided by the number of people walking in both directions along that pavement. Each road section has two crossing

ratios, calculated in each of the two pavements. The ratio was not calculated for signalised crossings in 4-way junctions, as it is theoretically difficult to identify a suitable denominator, given the multiplicity of pedestrian movements and the fact that pedestrians may cross the road after crossing another road.

An indicator of "crossing as proportion of nearest formal alternative" is defined as the number of pedestrians crossing the road informally (that is, away from crossings facilities) divided by the number of pedestrians crossing the road in the nearest crossing facility (signalised crossing or zebra).

Figure 5: Crossing ratios
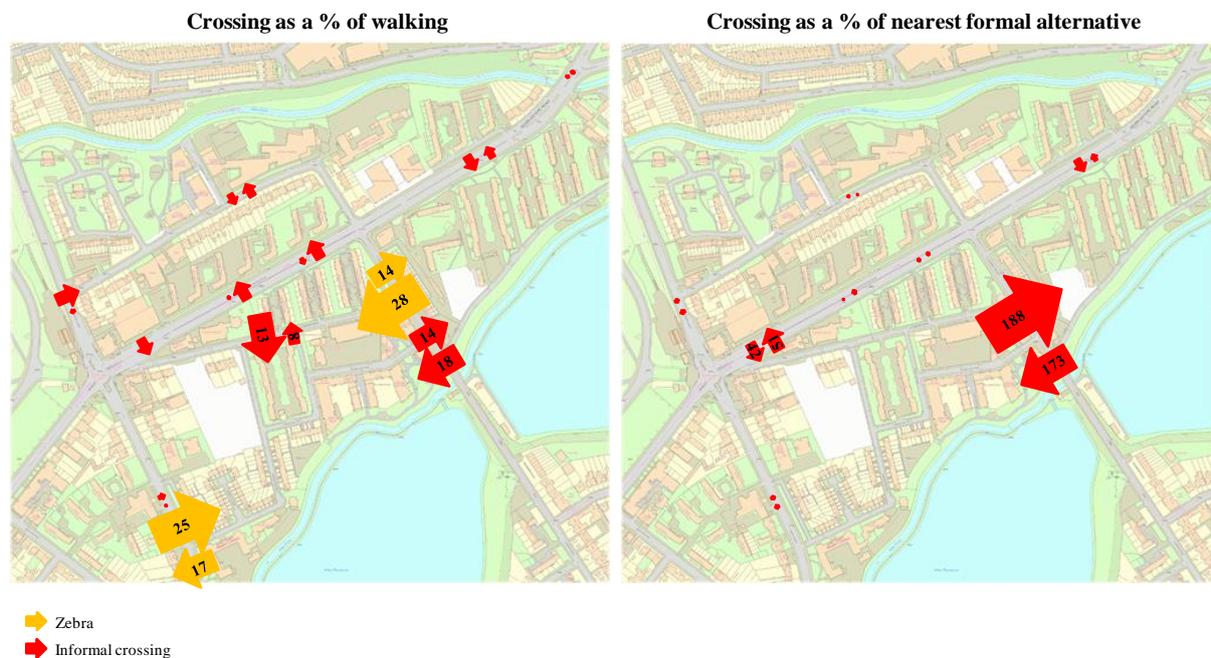
Note: Rectangle size is proportional to ratio. Only the labels of the highest values are shown.

Figure 5 maps the two crossing ratios. The highest proportions of crossing flows a proportion of walking occur in the zebra crossing in Green Lanes and in both the zebra and the informal crossing point in the southern section of Woodberry Grove. The crossing ratios reach almost a very high value (28%) in one direction of the zebra crossing in this section. The ratios in Seven Sisters Road are very low comparing with those obtained in the roads mentioned above.
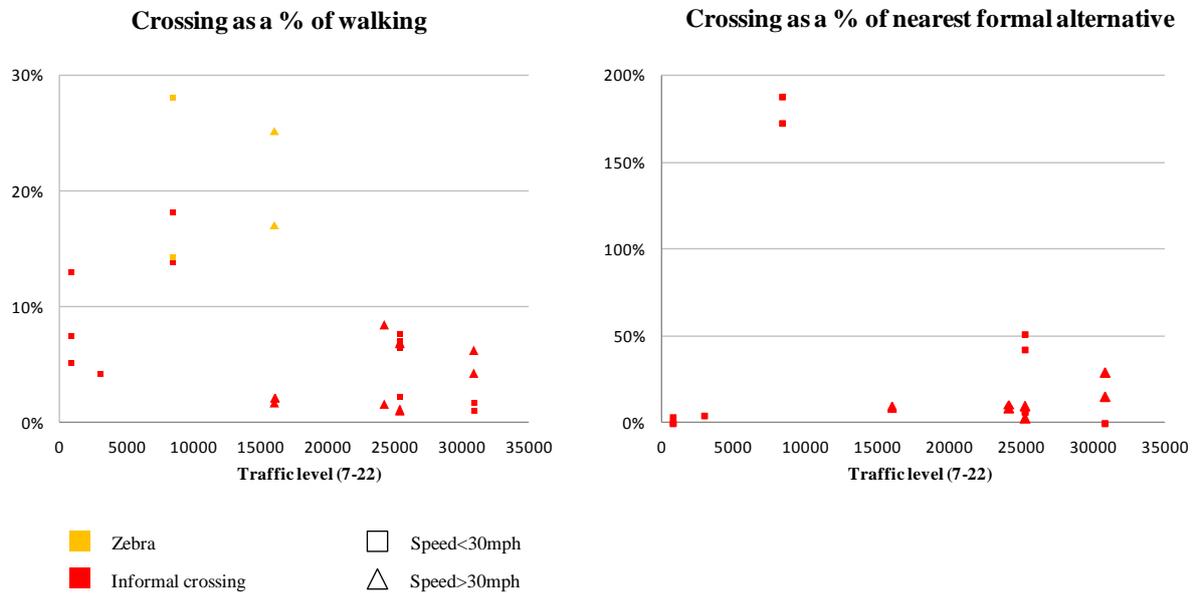
The highest proportions of informal crossing flows are again found in the southern section of Woodberry Grove, with values above 100% in both directions and far above all the other crossing points in the area. The second highest values (42% and 51%) and found in the most dangerous section of Seven Sisters Road for pedestrians, near Manor House junction, despite the proximity of a signalised crossing. The presence of several bus stops away from the signalised crossing, and the delay and detour to access this crossing may explain this result. The proportion of informal crossings in the Southern section of Green Lanes is very small. The informal crossing point in this section is an alternative to the use of a nearby zebra to access the health centre. It would be expected that the relatively large proportion of pedestrians with health problems would lead to a low proportion of risky crossing behaviours. In fact, it was calculated that the proportion of people using the zebra crossing who have a mobility restriction (14%) is much higher than in any other pavement or crossing in this area (usually in the interval 0-5%)

Figure 6 show how the crossing ratios relate to traffic conditions. The figure confirms that the highest ratios of crossings per walking flow are found in zebra crossings, rather than informal crossing points. There is also a visible negative relationship between those ratios and daily road traffic levels. The ratios in roads where the traffic is higher than 20,000 vehicles are always below 10%. Roads with higher average speeds (above 30 mph) also tend to be associated with lower crossing ratios.

The same negative association between road traffic levels and crossing ratios is also visible in the case of crossing as a proportion of the nearest formal alternative, although in this case there are two clear outliers, which correspond to the crossing point in Woodberry Grove identified above. Again, there is some evidence that roads with higher traffic speeds are associated with lower crossing ratios.

Figure 6: Crossing ratios vs. traffic levels

Crossing as a % of walking

Crossing as a % of nearest formal alternative

Legend:
- Zebra (yellow)
- Informal crossing (red)
- Speed<30mph (open square)
- Speed>30mph (triangle)

The hypothesis that crossing ratios in main roads are negatively associated with traffic levels is confirmed using more detailed data on both variables. Table 1 shows the Pearson correlations between crossing ratios and traffic levels calculated hourly in all locations. A small number of outliers (corresponding to cases where hourly walking flows are very low) were excluded from the analysis.

Table 1: Pearson correlations between hourly crossing ratios and traffic levels

Facility	Speed	Road	% walking		% formal	
			n	correl.	n	correl.
Zebra	All		57	-0.321**		
	<30	Woodberry Grove	27	-0.163		
	>30	Green Lanes	25	-0.242		
Informal crossing	All		290	-0.261***	237	-0.308***
	<30	All	170	-0.243***	118	-0.230**
		Seven Sisters Road	90	-0.276***	60	-0.147
		W.Down/ W.Grove	87	0.552***	57	0.641***
	>30	All	113	0.141	116	-0.044
		Seven Sisters Road	60	-0.018	60	-0.008
		Green Lanes	57	0.149	59	0.000

Significance levels: ***: 1%, **: 5%

The correlation between traffic levels and crossing as a proportion of walking in zebra crossings is negative and significant at the 5% level. The values found in subsets of roads with different average speeds are also negative but not significant at the 10%

level. Both ratios are negatively and significantly associated at the 1% level with traffic levels in informal crossings. This is also valid for the sections of Seven Sisters Road with lower speeds, in the case of the ratio of crossing as a proportion of walking. In smaller roads with small speeds, the correlations are positive. In sections of the main roads with higher speeds, the correlations are insignificant. Overall, the strongest evidence of a negative impact of traffic levels on crossing ratios is found on the sections of the main road with lower speeds.

Bus stop data can be used once again to derive conclusions on pedestrian behaviour in reaction to the presence of road traffic. People may use bus stops at different locations in the two legs of the daily return trip, instead of using a pair of bus stops opposite each other. By doing so, they will be able to cross the road in a safer location. If a substantial number of residents adopt their behaviour, and if the service areas of each bus stops are not equally balanced among both sides of the road (due to different population densities or patterns of land use), then we would expect a gap between the daily number of people boarding and alighting buses in the pairs of stops located in informal crossing points, and in the pairs of stops near designated crossing facilities.

This hypothesis is studied for the case of three pairs of stops in Seven Sisters Road (Figure 7). Only the residents in the service area of these three pairs of stops are included in the analysis. Residents living in the service area of the pair of stops A can avoid crossing the road informally by using the bus stop in A that is on their side of the road in one of the trip legs and then use the bus stop in B that is on the opposite side. Residents living in the service area of stops C can adopt a similar behaviour.

If this hypothesis holds, then the absolute difference between the number of boarders and alightings in the pair of stops B would be similar to the number of residents who would theoretically use stops A and C but who would use stops B if they started avoid crossing the road informally at points A or C. This number can be estimated by comparing the fastest routes from residences to the nearest bus stops on the two sides of the road and the fastest routes that do not use informal crossings. These latter routes are obtained by removing from the pedestrian network model all informal crossings and the central reservation running along some sections of the road. The data on bus stop users was then reassigned to the revised set of routes. The flows in routes ending in each bus

stop were finally aggregated, and compared with the flows that were obtained in the case where residents do not avoid informal locations.

The chart of the right side of Figure 7 shows that the theoretical number of additional users of the pair of bus stops B when residents avoid informal crossings is close to the observed absolute difference between the number of people boarding and alighting buses in that stop. Most of the additional users are residents who previously used stops C. The decrease in the number of users of stops C is only slightly smaller, in absolute value, than the observed difference in number of boardings and alightings in those stops. The only case where the hypothesis studied does not seem to hold is in point A, as the decrease in users of the stops at that point is very small, but the absolute difference between boardings and alightings is very high. This could be due to the proximity of point A to Manor House junction, and the effect of flows of residents and non-residents interchanging from buses to the underground station. Overall, the analysis of bus boardings and alightings suggests that some residents in Woodberry Down avoid crossing in places without crossing facilities by adjusting the origins or destinations of their bus trips.

Figure 7: Avoidance of informal crossings vs. difference between bus boardings vs. alightings
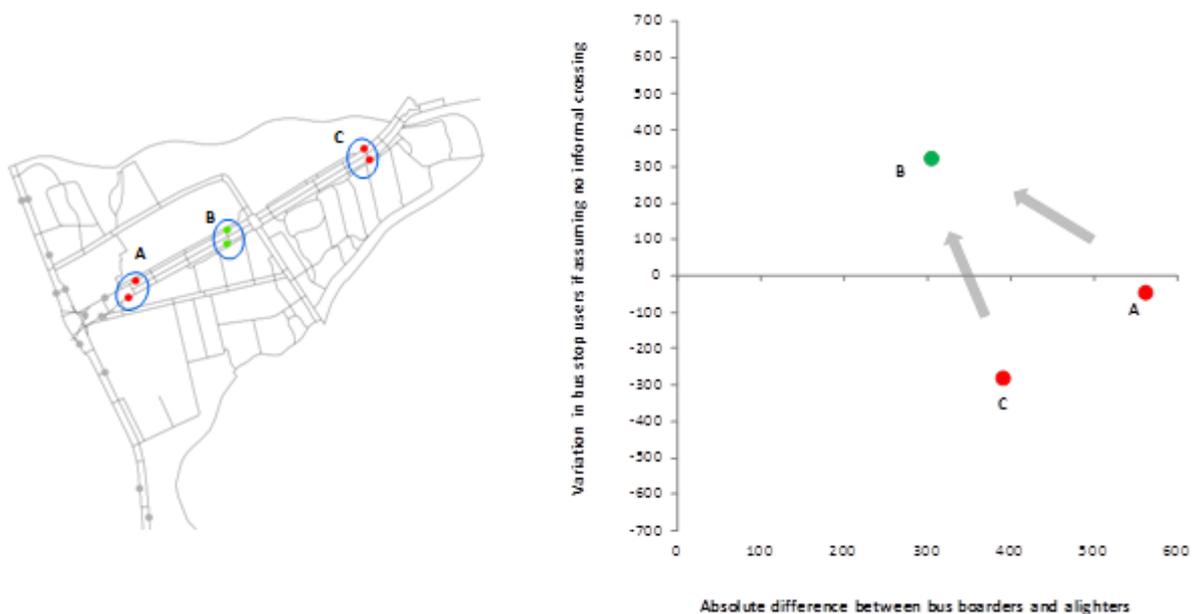
5. Conclusions and further work

This paper analysed the impact of road traffic on pedestrian pavement and crossing flows in a suburban neighbourhood in London. The study adds to the existing literature by using bus stop data to derive conclusions about pedestrian behaviour, including the choice of quiet streets as an alternative to walking along main roads, and accessing bus stops in different locations in the two legs of bus trips to avoid crossing a road in an unsafe location.

The analysis found evidence that suggests that pedestrians tend to avoid the main road running through the neighbourhood (Seven Sisters Road), which has high traffic levels and speeds. The propensity to cross the road is much higher in quieter roads, when comparing both with the number of pedestrians walking along the road and crossing in formal crossing facilities. The propensity to cross tend to decrease with traffic levels, both when considering the daily crossing flows in different crossing points across the study area, and when considering the variations in traffic levels throughout the day in the same location.

Further evidence can be obtained by extracting more detailed information from the video footage, such as aspects of pedestrian behaviour at informal crossings. The analysis can also be extended by comparing sites with different patterns of land use, street layout, and types of crossing facilities.

Acknowledgements

References

Hine, J., and Russell, J. (1993). Traffic barriers and pedestrian crossing behaviour. *Journal of Transport Geography* **1**, 230-239.

Hine, J., and Russell, J. (1996). The impact of traffic on pedestrian behaviour - 2. Assessing the traffic barrier on radial routes. *Traffic Engineering and Control* **37**, 81-85.

May, A. D., Turvey, I. G., and Hopkinson, P. G. (1985) Studies of pedestrian amenity. Working paper 204. Institute of Transport Studies. University of Leeds. Available from http://eprints.whiterose.ac.uk/2347

Mindell, J. S., and Karlsen, S. (2012). Community severance and health: what do we actually know? *Journal of Urban Health* **89**, 232-246.

Mullan, E. (2003) Do you think that your local area is a good place for young people to grow up? The effects of traffic and car parking on young people's views. *Health and Place* **9(4)**, 351–360.

Owen, N., Humpel, N., Lesli, E., Bauman, A., Sallis, J F. (2004). Understanding environment influences on walking – Review and research agenda. *American Journal of Preventive Medicine*, **27(1)**, 67-76.

Sisiopiku, V. P., and Akin, D. (2003). Pedestrian behaviors at and perceptions towards various pedestrian facilities: an examination based on observation and survey data. *Transportation Research F* **6**, 249-274.

Talen, E., and Koschinsky, J. (2013) The walkable neighbourhood: a literature review, International *Journal of Sustainable Land use and Urban Planning* **1(1)**, 42-63.