PEDESTRIAN ARTERIAL AND FREEWAY CROSSING BEHAVIOUR IN CAPE TOWN: OBSERVATIONS AND IMPLICATIONS

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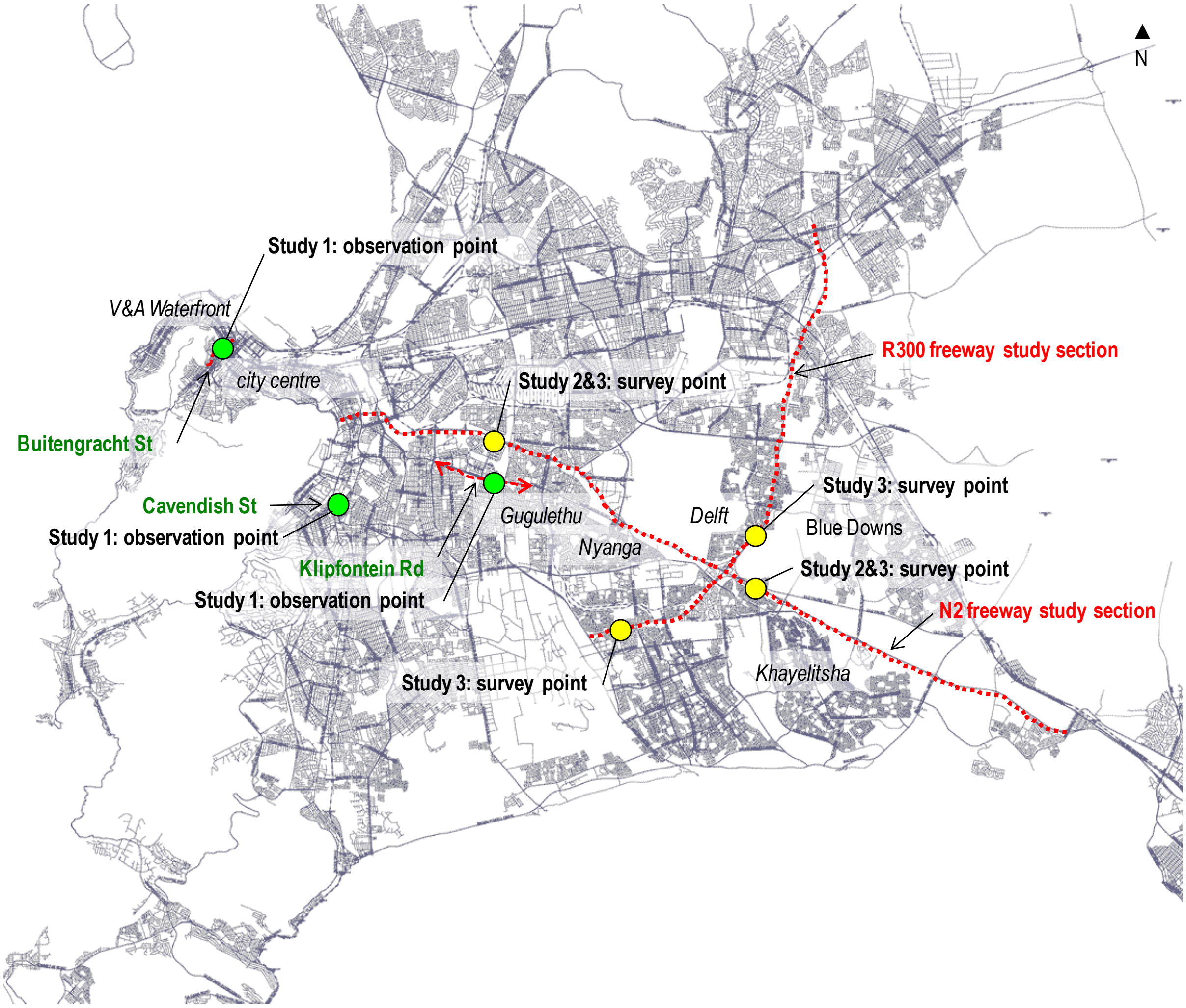
ABSTRACT

This paper reports on a series of small indicative studies, undertaken between 2004 and 2008, that observed pedestrian crossing behaviour on selected arterials and freeways in Cape Town, using a variety of methods. The starting hypothesis for these studies was that the plotted distance of observed unassisted pedestrian crossing points from the nearest crossing facility would follow an S-shaped curve. Closer to the crossing facility, fewer unassisted pedestrian crossings were expected than further away, where detour refusal rates were anticipated to be higher. It was posited that the start of the S-curve would differ in accordance with variations in perceived vehicle collision risk. Thus it was anticipated that the S-curve of a freeway would start further from the crossing facility than the S-curve of an arterial. It was believed that understanding the characteristics of this curve, and how it differed across road classes, would add valuable insights into the spacing between crossing facilities required to reduce unassisted and illegal pedestrian crossing behaviour. The paper describes the findings of three studies. The first observed pedestrian crossing points on two arterials using manual counts and measurements (n=4,518 crossings). The second study identified crossing points along the entire intra-city length of two freeways using informal footpath recognition from aerial photographs (n=305 crossing points), as well as undertaking an intercept survey of pedestrians crossing at-grade (n=100 pedestrians). The third study observed pedestrian crossing points on selected sections of the same two freeways, and undertook an intercept survey of pedestrians crossing both at-grade, and on grade-separated crossing facilities (n=650 pedestrians). It is reported, *inter alia*, that the hypothesised S-curve was not observed in these studies, and that significant numbers of pedestrians cross unassisted at small distances from crossing facilities. The paper concludes that understanding or estimating pedestrian desire lines and walking trip assignment is more important than understanding detour refusal distances in locating crossing facilities and in attempting to minimise unassisted or illegal crossing patterns.

1. INTRODUCTION

South African city road crash fatality rates are amongst the highest in the world: ranging between 20 and 40 fatalities/100,000 population (Behrens 2005). For the nation as whole, the road crash fatality rate is around 28 fatalities/100,000 population (Botha 2009). In Cape Town, pedestrians account for as much as 60% of road crash fatalities (Behrens 2005). Pedestrians crossing the road without the use of crossing facilities are the greatest cause of fatal crashes: nationally accounting for around 36% of the factors contributing to all fatal crashes (Behrens 2002). Data on the relationship between pedestrian road crash fatalities and road classification are sparse and outdated. Those that are available (CoCT 2004, Ribbons 1990) indicate that, because of the greater speed differential, fatal pedestrian crashes in Cape Town occur mostly on arterials and freeways.

Figure 1. *Locality map of study arterials and freeways, and observation and survey points*



To address the pedestrian safety problem in Cape Town, it is therefore essential that pedestrian crossing behaviour and attitudes, as well as pedestrian-driver interaction, along arterials and freeways are understood. While pedestrian road crossing behaviour has been the subject of extensive research elsewhere (see, for instance, Ishaque and Noland 2008 for a comprehensive review of literature in this field, and Papadimitriou *et al* 2009 for a review of alternative approaches to pedestrian modelling), to date, little research of this nature has been carried out within the Cape Town or South African context. The bulk of the international research has focussed on the walking speed of different types of pedestrians while crossing different types of crossing facilities, in order to better understand crossing delay, gap acceptance and signal phasing requirements, and the reasons for temporal and spatial non-compliance with crossing regulations. Of significance to the research reported upon in this paper, studies of spatial non-compliance (e.g. Chu *et al* 2004, and Sisiopiku and Akin 2003) have found that the extra walking distance required to reach a crossing facility is an important contributing factor in the decision to jaywalk, although the likelihood of spatial non-compliance decreases as traffic volumes increase, which suggests an association between levels of non-compliance and risk. A limitation of this body of research, from the perspective of understanding pedestrian crossing behaviour in Cape Town, is that it focuses largely on compliance with travel control systems at at-grade pedestrian crossing facilities that regulate the location and time of crossing. Little research appears to have been undertaken on illegal at-grade freeway crossing behaviour. As will be demonstrated later in this paper, this behaviour is common in the South African context. A combination of well-developed freeway networks, a high dependence on walking as the primary mode of travel, and poor law enforcement, is posited to result in a relatively larger occurrence of at-grade freeway crossing than would be expected in poorer countries without well-developed freeways networks, and in wealthier countries without the same share of longer distance walking trips and more effective law enforcement.

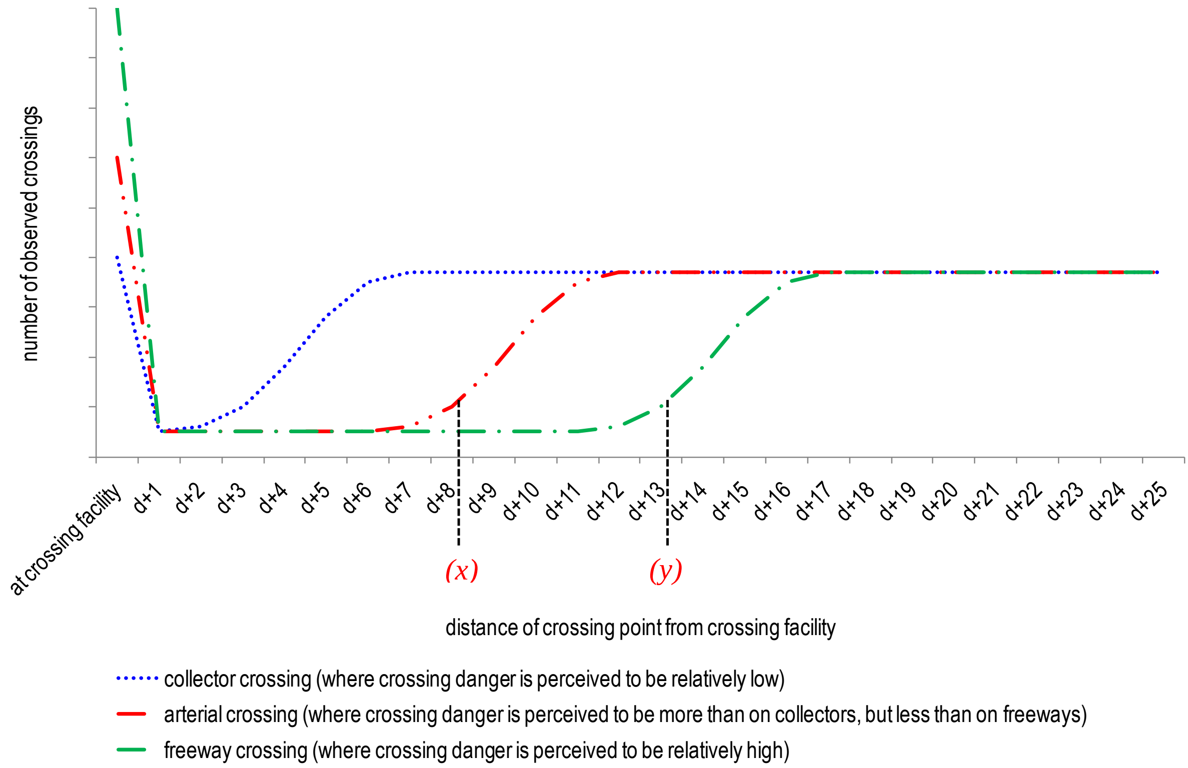
The purpose of this paper is to report upon a series of small indicative studies, undertaken between 2004 and 2008, that observed pedestrian crossing behaviour and collected attitudinal information on selected arterials and freeways in Cape Town, using a variety of methods. The studies were undertaken by students at the University of Cape Town, under the supervision of the author.

The paper is divided into six sections. In the following section the overarching hypothesis that guided the studies is described. In sections three to five, the individual studies are discussed in terms of their research method and key findings. The paper concludes, in the final section, with a synthesis of findings, and a discussion on implications for developing planning and management practices that improve pedestrian safety and for further research needs.

2. OVERARCHING RESEARCH HYPOTHESIS

The starting hypothesis, or supposition, for the three studies undertaken in Cape Town was that the plotted distance of observed unassisted pedestrian crossing points from the nearest crossing facility would follow an S-shaped curve. Closer to the crossing facility, fewer unassisted pedestrian crossings were expected than further away, where detour refusal rates[1] were anticipated to be higher.

Figure 2. *Diagrammatic representation of overarching research hypothesis*



It was posited that the start of the S-curve would differ in accordance with variations in perceived vehicle collision risk and perceptions of the likelihood of severe casualty. Thus it was anticipated that the S-curves of arterials and freeways would start further from the crossing facility than the S-curves of collector routes on which crossing facilities are warranted, and that, in turn, the S-curve of a freeway would start further from the crossing facility than the S-curve of an arterial. Figure 2 illustrates this hypothesis diagrammatically.[2] It was believed that understanding the characteristics of this curve, and how it differed across road classes, would add valuable insights into the spacing between crossing facilities required to reduce unassisted and illegal pedestrian crossing behaviour and thereby improve safety. More specifically, if the distance values of (x) and (y) in figure 2 could be derived from empirical observations, a doubling of this value would present the spacing interval of

[1] The term 'detour refusal rate' is defined in this paper as the proportion of pedestrians crossing a road at a particular point who are unwilling to extend their walking trip distance in order to utilise a pedestrian crossing facility.

[2] For simplification, the figure assumes that the demand for pedestrian crossing is homogeneous along the length of all three classes of road. It should be noted that this demand will of course vary both along the same class of road depending on abutting land use patterns and the socio-economic characteristics of residents, and as well as across different classes of road depending on the travel behaviour patterns and law enforcement characteristics of different city contexts.

crossing facilities, along arterials and freeways respectively, that matched the willingness of pedestrians to detour from their desire line[3] in order to cross at a safer point.

3. STUDY 1: OBSERVED ARTERIAL CROSSING BEHAVIOUR

The first study (Naidoo 2004), undertaken in the spring of 2004, observed pedestrian crossing points on two arterials (Klipfontein Road and Buitengracht Street) and on one major collector (Cavendish Street). The selected section of Klipfontein Road (between the intersection with Vanguard Drive and Hazel Road) is a dual carriageway with three traffic lanes in each direction. A median separates the opposing lanes. Signalised at-grade crossing facilities are provided at the road intersections and in the midblock. Peak hour traffic volumes are in the region of 1,350 veh/hr/dir and the posted speed limit is 70 km/h. The selected section of Buitengracht Street (between the intersection with Coen Steytler Avenue and Hans Strijdom Avenue) is a dual carriageway with five and six traffic lanes in opposing directions. A wide median separates the opposing lanes. Signalised at-grade crossing facilities are provided at the road intersections. Peak hour traffic volumes are in the region of 2,500-3,500 veh/hr/dir and the posted speed limit is 60 km/h. Cavendish Street (between Osborne Road and Vineyard Road) is a dual carriageway with two traffic lanes in each direction. Narrow pedestrian refuge islands separate the opposing lanes. An unsignalised at-grade crossing facility is provided in the midblock. Peak hour traffic volumes are in the region of 1,500 veh/hr/dir and the posted speed limit is 60 km/h.

3.1 Research method

Two methods of crossing observation were utilised. The first method (in the case of Buitengracht Street and Klipfontein Road) took the form of analysis of recorded crime surveillance video footage obtained from the City of Cape Town. Footage from weekday morning and evening peak periods were analysed (15h45-17h45 on Klipfontein Road, and 06h00-07h15 and 16h00-17h45 on Buitengracht Street). Observed pedestrian crossing points were recorded on street plans. In order to estimate the distance of crossing points from crossing facilities accurately, site inspections were conducted in which regularly spaced landmarks were identified and their distance from the nearest crossing facility measured. The limited visual range of the video cameras placed limitations on the length of the road sections observed. The second method (in the case of Cavendish Street) took the form of manual roadside counts and measurements. These observations were conducted on a Saturday morning during the peak shopping period (11h00-12h00). Fieldworkers were stationed between two intersections, and marked observed pedestrian crossing movements on a street plan. The limited visual range of the fieldworkers also placed limitations on the length of the road section observed.

[3] The term ‘pedestrian desire line’ is defined in this paper as the route that pedestrians would prefer to take to get from one location to another in order minimise their travelled path, irrespective of crossing regulations.

Figure 3. *Aerial and streetscape photographs of the observed road sections*

(a) Klipfontein Road

Crossing facilities (Google Earth [13/01/2010])

Crossing pedestrians

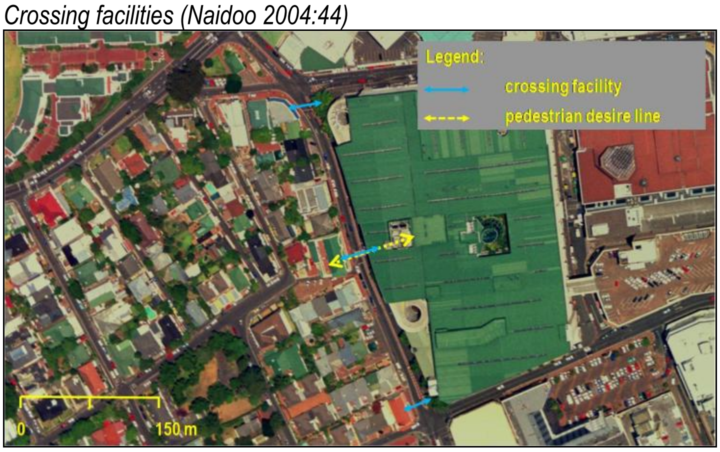
(b) Buitengracht Street

Crossing facilities (Naidoo 2004:33)

Crossing pedestrians (CoCT, date unknown)

(c) Cavendish Street

Crossing facilities (Naidoo 2004:44)

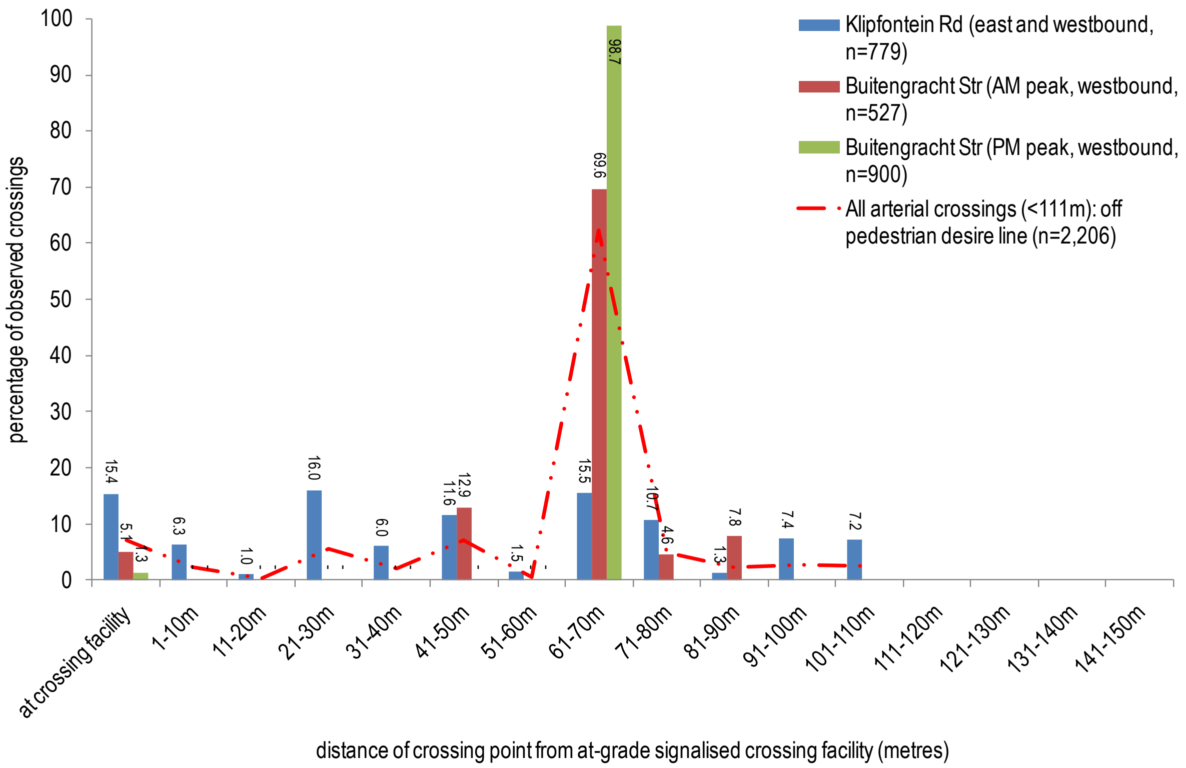


Crossing pedestrians

3.2 Research findings

Of the pedestrians observed crossing the selected section of Klipfontein Road during the two hour observation period, only 15% of crossings were observed to occur at the crossing facility. The remaining 85% of crossings were at other points. Figure 4 illustrates the distribution of crossing points away from the crossing facility.[4] No particular pattern of crossing or pedestrian desire line could be established, and it was found that many pedestrians refused to detour even a short distance to utilise a crossing facility.

Figure 4. *Observed pedestrian crossing distance from at-grade signalised facility, by study arterial: Facility located off pedestrian desire line (percent, n=2,206, Naidoo 2004)*

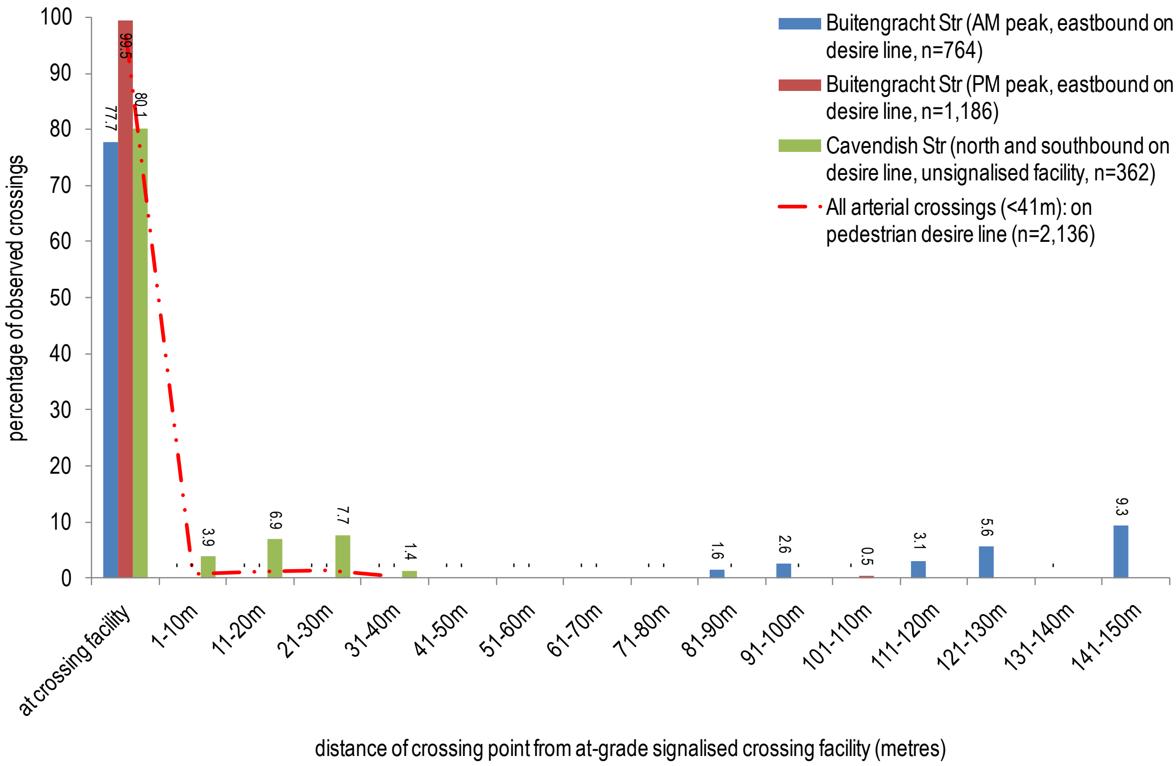


A very different pattern of crossing was observed on Buitengracht Street however. In the case of crossing facilities located away from the dominant pedestrian desire line (associated with workers moving between the central rail station and the Victoria and Alfred Waterfront development), 1-5% of crossings were observed at the crossing facility on the westbound lanes. The remaining 95-99% of crossings was distributed elsewhere, with a high concentration at 61-70 metres from the crossing facility at the point of intersection with the dominant pedestrian desire line. Figure 4 illustrates the distribution of crossings on the westbound lanes. In the case of crossing facilities located on the dominant pedestrian desire line (the eastbound lanes), 78-99% of pedestrians crossings were observed on the crossing facility. Figure 5 illustrates the distribution of crossings on the eastbound lanes. These

4 It should be noted here, and in other similar charts presented later in this paper, that the percentage value of crossings at different points from the crossing facility is determined either by the length of road section analysed or the distance between crossing facilities. Percentage values are used in charts to facilitate visual comparisons between roads where crossing volumes are different. The percentage values provided in charts are, therefore, not of great importance from a relative value perspective.

observations suggest that the use of crossing facilities is closely linked to their location in relation to pedestrian movement desire lines.

Figure 5. *Observed pedestrian crossing distance from at-grade signalised facility, by study arterial: Facility located on pedestrian desire line (percent, n=2,312, Naidoo 2004)*



To explore the relationship between crossing facility use and pedestrian movement desire lines further, a case was sought where the crossing facility was located at the entrance of a large pedestrian trip attractor with no other entrance along that side of the street. Cavendish Street was selected for this purpose as it is characterised by an unsignalised crossing facility located directly at the entrance of the Cavendish Square shopping centre. Figure 5 illustrates the distribution of crossings on Cavendish Street. Consistent with the findings on eastbound Buitengracht Street lanes, 80% of crossings were observed at the crossing facility.

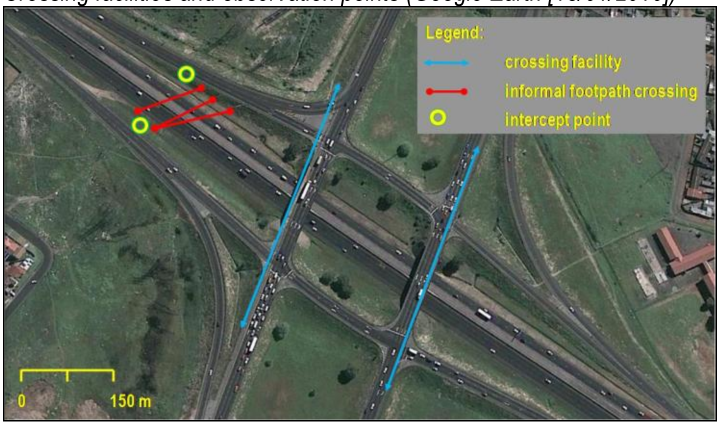
4. STUDY 2: IMPUTED AND SURVEYED FREEWAY CROSSING BEHAVIOUR

The initial intention of the above study was to include observations of both arterial and freeway crossings. The freeway element of the study was, however, abandoned because suitable video footage could be not obtained and roadside observations presented security and visual range problems. The need for freeway crossing observation was, therefore, deferred to a second study (Mngomezulu 2007), undertaken in the spring of 2007, which imputed and surveyed pedestrian crossing behaviour on two freeways (the N2 and the R300). The intra-city length of the N2 freeway extends 38 km east-west, passing by a number of low-income residential neighbourhoods and informal settlements in the south-east of the city (including Gugulethu, Nyanga and Khayelitsha). Opposing traffic lanes are separated by a raised concrete barrier or median. The intra-city length of the R300 freeway extends 22 km north-south, passing by a number of low-income neighbourhoods in the east of the city (including Delft and Blue Downs). Opposing traffic lanes are separated by a median. The maximum posted speed limit on both freeways is 120 km/h.

Figure 6. *Aerial and streetscape photographs of the N2 freeway roadside intercept sites*

(a) Vanguard Drive interchange

Crossing facilities and observation points (Google Earth [13/01/2010])



Crossing pedestrians

(b) Swartklip Interchange

Crossing facilities and observation points (Google Earth [13/01/2010])

Crossing pedestrians (Mngomezulu 2007:26)

4.1 Research method

The method of observation took the form of informal footpath recognition within freeway reserves from aerial photographs taken in 2005 (see figure 1 for the extent of the N2 and R300 study sections), and verification by windshield observation of footpaths and break-throughs in the concrete balustrade fencing separating the freeway reserve from bordering residential neighbourhoods (see inset in figure 6[a]). The distances between footpath crossings and the nearest grade-separated crossing facility (in the form of either a footway on a road bridge, or a footbridge) were measured. In addition, in order to explore the attitudes of pedestrians crossing at-grade, and why crossing facilities were not utilised, an exploratory (n=100) roadside intercept survey was conducted on two selected sections of the N2 freeway (115 m west of the Vanguard Drive footway crossing facility, and 645 m west of first footbridge east of the Swartklip Interchange). The questionnaire included 30 questions relating to the demographics of the respondent, the nature of the trip, reasons for crossing at that point, and attitudes towards crossing safety. Data were collected on weekdays between 14h00 and 18h00. Respondents were intercepted after the at-grade crossing movement.

4.2 Research findings

Aerial photography analysis of the N2 freeway revealed a total of 26 grade-separated crossing facilities (comprised of four footbridges, two subways and 20 footways on road bridges). Distances between crossing facilities vary, with a mean interval of 1,144 m (and standard deviation of 1,101 m). The minimum distance between crossing facilities is 234 m, and the maximum is 4,343 m. A total of 244 informal crossing footpaths were identified and verified. Figure 7 illustrates the distribution of footpath crossing distances from the nearest crossing facility. These findings indicate that, as in the case of arterials, some pedestrians are unwilling to detour even small distances to cross at a facility. The highest concentration of crossing footpaths was observed between 100 m and 300 m from the nearest facility. The decline of crossing footpaths beyond 700 m can be attributed to crossing facility spacings, rather than to any behavioural pattern. The mean interval between crossing footpaths was found to be 123 m, and the minimum and maximum intervals were found to be 10 m and 741 m respectively. The nearest crossing footpath to a crossing facility was found to be 33 m, and the furthest 467 m.

Aerial photography analysis of the R300 freeway revealed a total of 23 grade-separated crossing facilities. Distances between crossing facilities vary, with a mean interval of 961 m (and standard deviation of 609 m). The minimum distance between crossing facilities was 320 m, and the maximum was 3,107 m. A total of 61 informal crossing footpaths were identified and verified. Figure 7 illustrates the distribution of footpath crossing distances from the nearest crossing facility. These findings are broadly consistent with the N2 findings. The highest concentration of crossing footpaths was observed between 100 m and 300 m from the nearest facility. The mean interval between crossing footpaths was found to be 173 m, and the minimum and maximum intervals were found to be nine metres and 948 m respectively. The nearest crossing footpath to a crossing facility was 28 m.[5]

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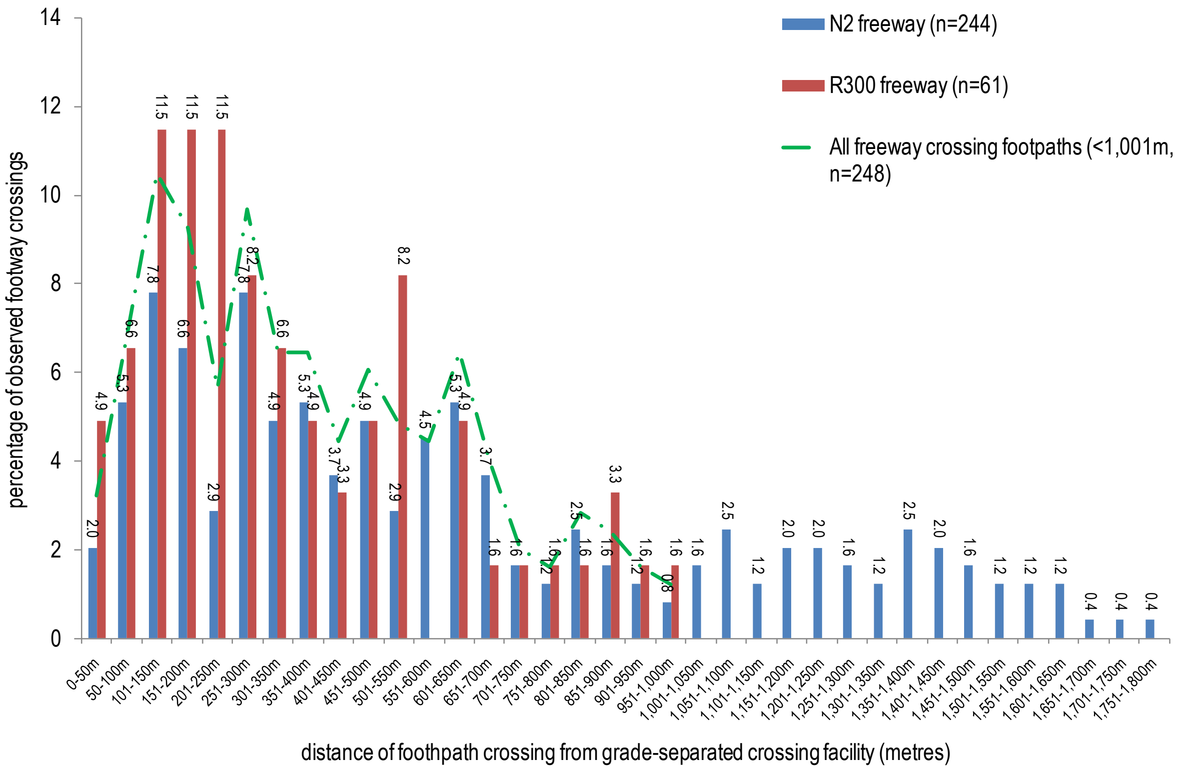
[5] A larger crossing count study on the R300 freeway, involving 23 count locations over two 12 hour periods in November 2007, corroborates that large numbers of pedestrians cross the freeway (9,032/12 hr period), and provides insight into the timing of crossings (finding in the region of 1,600 crossings in the 06h00-07h00 peak hour, and 450 crossing/hour in the off peak) (Erasmus 2008). Of the 9,032 crossings per 12 hour observation period, approximately one-third were illegal (Randall Cable, South African National Road Agency, pers comm, 2009). A complementary (n=117) pedestrian intercept survey provided insight into trip purposes (with social visits, shopping and works trips dominant). A limitation of these data, however, is that they were collected in school vacation time, and therefore omitted school trips.

Figure 7. *Imputed pedestrian crossing distance from grade-separated facility, by study freeway (n=305, Mngomezulu 2007)*



Analysis of the intercept survey data revealed a disproportionate number of males in the sample (63% males vs. 37% females), and a greater number younger people (40% of respondents were less than 20 years old, and 68% less than 25 years old). Most respondents were learners (34%), followed by workers (30%), unemployed persons (28%) and tertiary education students (8%).

When questioned on why they were crossing at that particular at-grade point, three single or combined most important reasons were given. Table 1 presents these findings, indicating that the most common reason was the desire to walk the shortest route (71%), followed by an equal concern for route distance and crime (17%) and then safety from crime (12%). The latter reason is associated with reports of criminals preying upon pedestrians trapped on footbridges without an escape route. In another question, 72% of respondents said that, for security reasons, they only use a crossing facility when they are not travelling alone.

Table 1. *Intercept survey respondents' stated reason for crossing at-grade, by perceived distance to the nearest crossing facility (percent, n=100, Mngomezulu 2007)*

Reason for crossing at chosen crossing point	Perceived distance to the nearest crossing facility					Total
	0-100m	101-200m	201-300m	301-400m	> 400m	
shortest route	18.0	18.0	8.0	16.0	10.0	70.0
shortest route and safety from crime	3.0	5.0	5.0	1.0	3.0	17.0
safety from crime	3.0	3.0	3.0	1.0	2.0	12.0
Item non-response						1.0
total	24.0	26.0	16.0	18.0	15.0	100.0

When questioned on the three most important factors taken into account when selecting an appropriate crossing location more generally, a different response pattern emerged however. Table 2 presents these findings, indicating that safety from crime assumed greater importance in these responses, and particularly so amongst women. While this was a small sample and the results are therefore only indicative in nature, what is startling is the low or absent concern for traffic safety in the responses provided (with traffic volume and safety combined accounting for just 5% of responses). Nevertheless, 73% of respondents indicated elsewhere in the interview that they use grade-separated crossing facilities either when traffic volumes are high, at night, or in bad weather conditions. Twenty-seven percent of respondents reported that they never use grade-separated crossing facilities.

Table 2. *Intercept survey respondents' stated important factors that influence freeway crossing decisions, by gender (percent, n=100, Mngomezulu 2007)*

Important factors that influence freeway crossing decisions	Females (n=37)	Males (n=63)	All respondents
safety from crime	64.9	52.4	57.0
shortest walking distance	13.5	33.3	26.0
where most people cross	10.8	12.7	12.0
traffic volumes	8.1	1.6	4.0
safety from vehicle collision	2.7	0.0	1.0
total	100	100	100

When questioned on the most important cause of pedestrian crashes on freeways, 80% of respondents indicated this was drunken pedestrians, followed by drunken motorists (15%), and then poor visibility (5%). Most respondents (97%) knew it is illegal to cross a freeway at-grade, and 16% reported that they knew a family member or a friend who had been involved in a pedestrian-vehicle collision.

Table 3. *Intercept survey respondents' stated frequency of grade-separated crossing facility use, by number of years lived in a city (percent, n=100, Mngomezulu 2007)*

Number of years lived in a city	Frequency of grade-separated crossing facility use						Total
	once a day	most days of the week	once or twice a week	once or twice a month	less often	never	
0-5 years (n=24)	0.0	8.3	12.5	20.8	4.2	54.2	100
6-10 years (n=32)	0.0	6.3	28.1	28.1	18.8	18.8	100
11-20 years (n=33)	6.1	3.0	24.2	18.2	27.3	21.2	100
> 20 years (n=11)	9.1	0.0	36.4	18.2	27.3	9.1	100
all respondents	3.0	5.0	24.0	22.0	19.0	27.0	100

Table 3 presents findings with respect to the relationship between grade-separated crossing facility use and the number of years the respondent had lived in a city. These data suggest that more frequent use of crossing facilities might be correlated with greater experience of urban life, and by implication, greater exposure to traffic risks. Amongst respondents who had lived in a city for five years or less, 54% always cross at-grade, compared to 9% of respondents who had lived in a city for greater than 20 years.

5. STUDY 3: OBSERVED AND SURVEYED FREEWAY CROSSING BEHAVIOUR

Given the insights that emerged from the above small-sample intercept survey, a further study was initiated to survey a larger, but nevertheless still indicative, sample of respondents which included both pedestrians who crossed at-grade and on a grade-separated facility. This third study (Gabuza 2008), undertaken in 2008, observed and surveyed pedestrian behaviour on the same two freeways (N2 and R300).

5.1 Research method

The method of observation took the form of a (n=650) roadside intercept survey conducted on four selected sections at 10 intercept points (on the N2 freeway: 370 m west and east of, and at, the Vanguard Drive footway crossing facility, and 645 m west of, and at, the first footbridge east of the Swartklip Interchange; and on the R300 freeway: 200 m south of, and at, the first footbridge north of the Swartklip Interchange, and 900 m west of, and at, the New Eisleben Drive footway crossing facility). These survey points were selected on the basis that they were identified as sites of high pedestrian at-grade crossing in the earlier aerial photograph analysis. The questionnaire included 20 questions relating to the demographics of the respondent, the nature of the trip, reasons for crossing at that point, and attitudes towards crossing safety. Data were collected on weekdays during morning and afternoon peak periods. Respondents were intercepted after the grade-separated or at-grade crossing movement.

Figure 8. *Aerial and streetscape photographs of the N2 and R300 freeway roadside intercept sites*

(a) N2 freeway: Vanguard Drive interchange

Crossing facilities and observation points (Google Earth [13/01/2010])

Crossing pedestrians

(b) N2 freeway: Swartklip Interchange

Crossing facilities and observation points (Google Earth [13/01/2010])

Crossing pedestrians (Gabuza 2008:47)

(c) R300 freeway: Swartklip Interchange

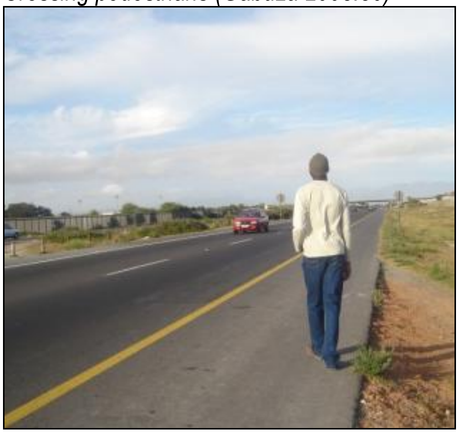
Crossing facilities and observation points (Google Earth [13/01/2010])

Crossing pedestrians (Erasmus 2008)

(d) R300 freeway: New Eisleben Drive

Crossing facilities and observation points (Google Earth [13/01/2010])

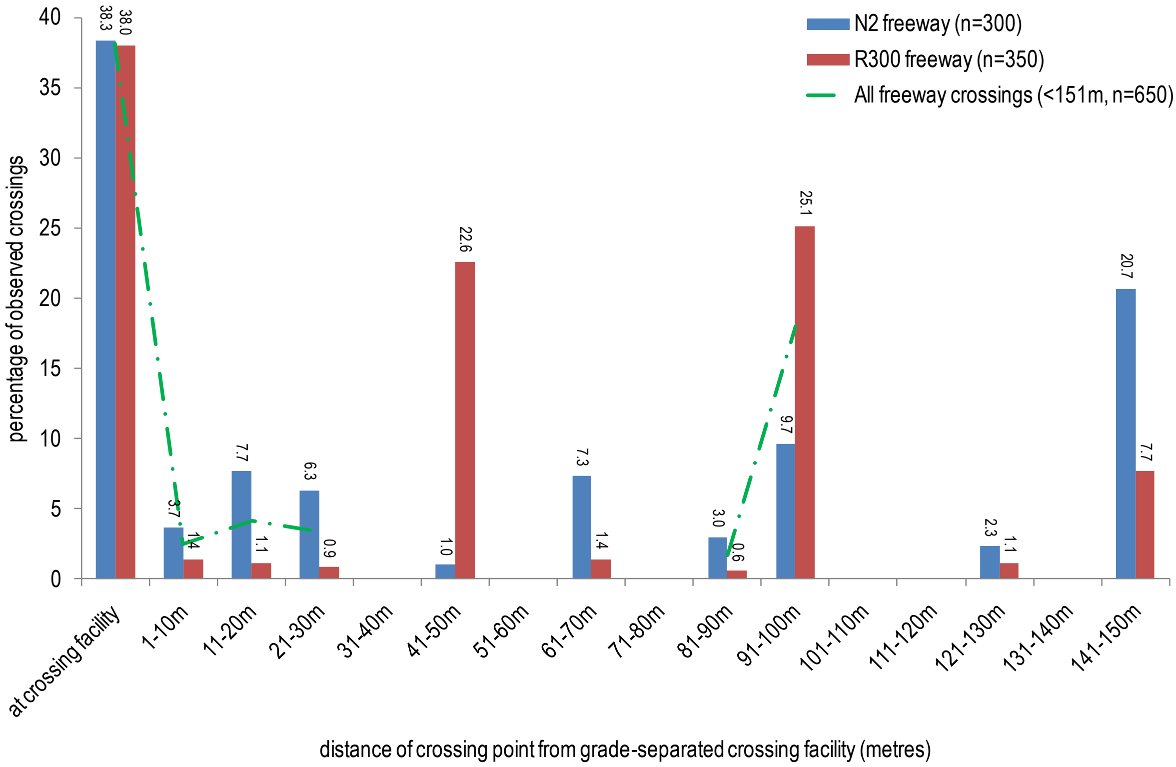
Crossing pedestrians (Gabuza 2008:50)



5.2 Research findings

Of the crossing pedestrians observed on the selected sections of the N2 and R300 freeways, 38% crossed at the crossing facilities, (with the caveat that the length of observed road sections were not exactly equal) thus exhibiting greater use of crossing facilities than that observed in the earlier arterial study (38% vs. 5-15%). The remaining 62% of crossings were at other points, as illustrated in figure 9. As in the arterial study, patterns of crossing away from the facilities are likely to be better explained by the trajectory of pedestrian desire lines, rather than by detour. It was found that despite the greater speed differential and risk associated with freeways, many pedestrians continued to be reluctant to detour even short distances to use a grade-separated facility.

Figure 9. *Pedestrian crossing distance from grade-separated facility, by study freeway (percent, n=650, Gabuza 2008)*



Analysis of the intercept survey data revealed a fairly even spread of respondents across age and gender categories (see table 4). In contrast to the earlier survey, there was a slightly greater proportion of females in the sample (57% males vs. 43% females).

Table 4. *At-grade and grade-separated crossers, by age and gender (percent, n=649, Gabuza 2008)*

Age group	**At-grade crossers (n=401)**						**Grade-separated crossers (n=248)**						**Total**	
	females	%	males	%	sub-total	%	females	%	males	%	sub-total	%		%
<19 yrs (n=136)	41	*6.3*	48	*7.4*	89	*13.7*	16	*2.5*	31	*4.8*	47	*7.2*	136	*21.0*
19-25 yrs (n=94)	22	*3.4*	32	*4.9*	54	*8.3*	17	*2.6*	23	*3.5*	40	*6.2*	94	*14.5*
26-34 yrs (n=117)	40	*6.2*	43	*6.6*	83	*12.8*	17	*2.6*	17	*2.6*	34	*5.2*	117	*18.0*
35-45 yrs (n=199)	35	*5.4*	89	*13.7*	124	*19.1*	49	*7.6*	26	*4.0*	75	*11.6*	199	*30.7*
>45 yrs (n=103)	16	*2.5*	35	*5.4*	51	*7.9*	26	*4.0*	26	*4.0*	52	*8.0*	103	*15.9*
total	154	*23.7*	247	*38.1*	401	*61.8*	125	*19.3*	123	*19.0*	248	*38.2*	649	*100*

When questioned on why they were crossing at that particular at-grade point, three single or combined most important reasons were given. Table 5 presents these findings, indicating that, as in the case of the earlier survey, the most common reason was the desire to walk the shortest route (66%). This was followed by an equal concern for route distance and safety from crime (21%), and then an equal concern for route distance and crossing in the same place as others (14%). Male respondents reported route distance as the main reason more often than females, and appeared less concerned about crossing where others crossed (suggesting less of a concern for security than amongst females).

Table 5. *Intercept survey respondents' stated reason for crossing at-grade, by gender (percent, n=401, Gabuza 2008)*

Reason for crossing at chosen crossing point	**Females** (n=154)	%	**Males** (n=247)	%	**All at-grade crossers**	%
shortest route	92	*59.6*	172	*69.6*	264	*65.8*
shortest route and safety from crime	29	*19.1*	53	*21.5*	83	*20.6*
shortest route and crossing with others	33	*21.3*	22	*8.9*	55	*13.6*
total	154	*100*	247	*100*	401	*100*

When questioned on the most important cause of pedestrian crashes on freeways, 55% of respondents indicated this was drunken pedestrians, followed by drunken motorists (31%), and then poor visibility (15%) (see table 6). Response patterns across the genders were broadly similar, but noticeably different between the at-grade and grade-separated crosser groups. The grade-separated crossers reported greater attribution of collision causes to pedestrian behaviour, than in the case of the at-grade crosser group.

Table 6. *At-grade and grade-separated crossers' perceived causes of pedestrian-vehicle collisions, by gender (percent, n=650, Gabuza 2008)*

Perceived cause of pedestrian-vehicle collisions	**At-grade crossers (n=402)**						**Grade-separated crossers (n=248)**						**Total**	
	females (n=154)	%	males (n=248)	%	sub-total	%	females (n=125)	%	males (n=123)	%	sub-total	%		%
drunken ped.s	62	*40.3*	108	*43.5*	170	*42.3*	90	*72.0*	94	*76.4*	184	*74.2*	354	*54.5*
drunken motorists	72	*46.8*	85	*34.3*	157	*39.1*	25	*20.0*	16	*13.0*	41	*16.5*	198	*30.5*
poor visibility	20	*13.0*	55	*22.2*	75	*18.7*	10	*8.0*	13	*10.6*	23	*9.3*	98	*15.1*
total	154	*100*	248	*100*	402	*100*	125	*100*	123	*100*	248	*100*	650	*100*

Perhaps the most interesting insight derived from the survey concerned the relationship between crossing behaviour and experience of living in a city. Table 7 presents findings with respect to the relationship between grade-separated crossing facility use, and the number of years the respondent had lived in a city[6] and gender. Noticeable differences in behaviour patterns can be observed across gender categories (33% of males used grade-separated crossings compared to 45% of females), and significant differences can be observed across

[6] A large proportion of low-income households living in Cape Town are first generation residents who have migrated from rural districts and small towns in the Eastern Cape (De Swardt *et al* 2005).

categories defined on the basis of experience of city living (90% of respondents who had lived in a city for less than three years crossed at-grade, while 31% of respondents who had lived in a city for more than 15 years crossed at-grade). Of the 401 intercepted respondents who crossed at-grade, 51% had lived in a city for two years or less, whereas amongst respondents who used the grade-separated crossing facility, only 9% had lived in a city for two years or less. The data in the table suggests that time in the city has a relatively smaller impact on the adaption of men's crossing behaviour than women's (42% and 48% of at-grade crossers who had lived in a city for less than three years were female and male respectively, while these proportions were 5% and 26% for at-grade crossers who had lived in a city for greater than 15 years).

Table 7. *Grade-separated crossing facility use, by number of years lived in a city and gender (count and percent, n=649, Gabuza 2008)*

Gender	**Number of years lived in a city**								**Sub-total**		**Total**
	1-2 yrs		3-6 yrs		7-15 yrs		>15 yrs				
	AGC	GSC	AGC	GSC	AGC	GSC	AGC	GSC	AGC	GSC	
females	96	8	28	18	20	29	10	70	154	125	279
%	*42.1*	*3.5*	*27.7*	*17.8*	*15.9*	*23.0*	*5.2*	*36.1*	*55.2*	*44.8*	*100*
males	110	14	34	21	52	25	51	63	247	123	370
%	*48.2*	*6.1*	*33.7*	*20.8*	*41.3*	*19.8*	*26.3*	*32.5*	*66.8*	*33.2*	*100*
sub-total	206	22	62	39	72	54	61	133	401	248	649
%	*90.4*	*9.6*	*61.4*	*38.6*	*57.1*	*42.9*	*31.4*	*68.6*	*61.8*	*38.2*	*100*
total		228		101		126		194		649	
%		*100*		*100*		*100*		*100*		*100*	

Note: AGC = at-grade crossers; GSC = grade-separated crossers

Differentiating the effect of time in a city and age on the use of crossing facilities, and their relative strength, is difficult in a small sample survey of this nature. Table 8 presents a cross-tabulation of these two variables, and it is apparent that both age and time in a city are inversely related to the likelihood of at-grade crossing. It was noted above that 90% of the 228 respondents who had lived in a city for less than three years crossed at-grade. Of the 136 respondents younger than 19 years, 65% crossed at-grade, while of the 103 respondents older than 45 years, 50% crossed at-grade. Clearly then experience of traffic safety risks, whether it is gained from living in a city or through maturing with age, is of importance in adapting non-compliant crossing behaviour.

Table 8. *Grade-separated crossing facility use, by number of years lived in a city and age group (count and percent, n=649, Gabuza 2008)*

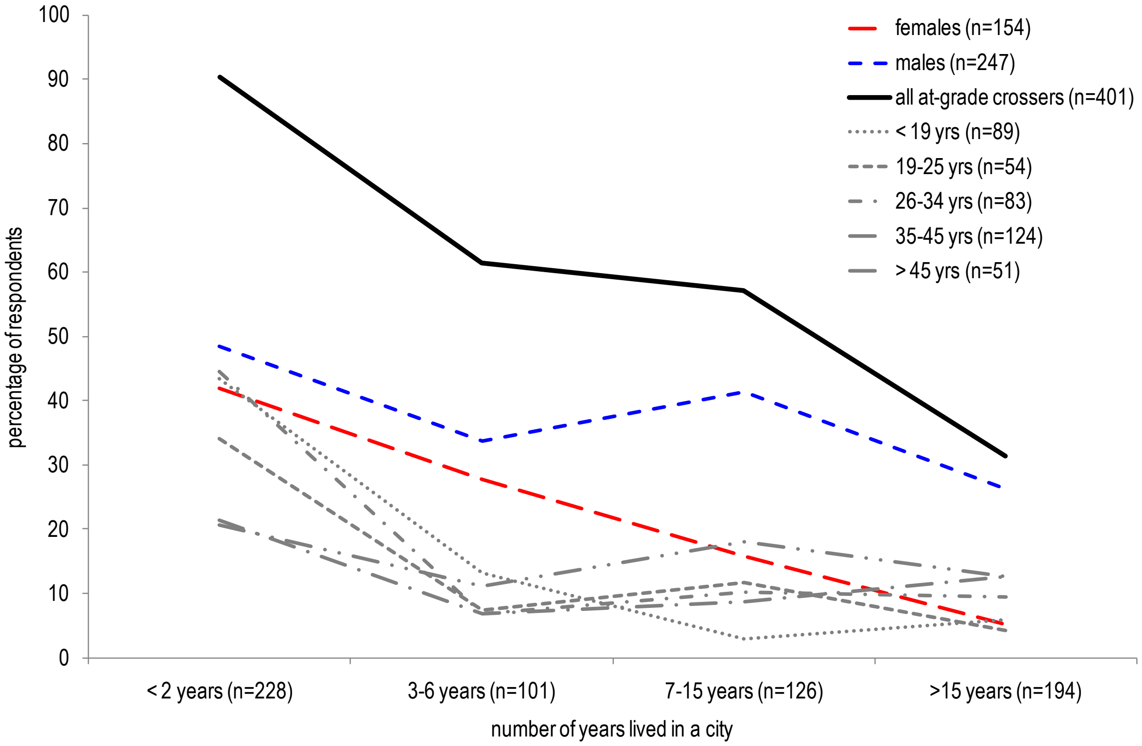
Age group	Number of years lived in a city								Sub-total		Total
	1-2 yrs		3-6 yrs		7-15 yrs		>15 yrs				
	AGC	GSC	AGC	GSC	AGC	GSC	AGC	GSC	AGC	GSC	
<19 yrs	59	14	18	14	4	8	8	11	89	47	136
%	*25.9*	*6.1*	*17.8*	*13.9*	*3.2*	*6.3*	*4.1*	*5.7*	*65.4*	*34.6*	*100*
19-25 yrs	32	1	7	4	11	8	4	27	54	40	94
%	*14.0*	*0.4*	*6.9*	*4.0*	*8.7*	*6.3*	*2.1*	*13.9*	*57.4*	*42.6*	*100*
26-34 yrs	52	1	8	5	12	5	11	23	83	34	117
%	*22.8*	*0.4*	*7.9*	*5.0*	*9.5*	*4.0*	*5.7*	*11.9*	*70.9*	*29.1*	*100*
35-45 yrs	41	6	22	10	36	20	25	39	124	75	199
%	*18.0*	*2.6*	*21.8*	*9.9*	*28.6*	*15.9*	*12.9*	*20.1*	*62.3*	*37.7*	*100*
>45 yrs	22	0	7	6	9	13	13	33	51	52	103
%	*9.6*	*0.0*	*6.9*	*5.9*	*7.1*	*10.3*	*6.7*	*17.0*	*49.5*	*50.5*	*100*
sub-total	206	22	62	39	72	54	61	133	401	248	649
%	*90.4*	*9.6*	*61.4*	*38.6*	*57.1*	*42.9*	*31.4*	*68.6*	*61.8*	*38.2*	*100*
total		228		101		126		194		649	
%		*100*		*100*		*100*		*100*		*100*	

Note: AGC = at-grade crossers; GSC = grade-separated crossers

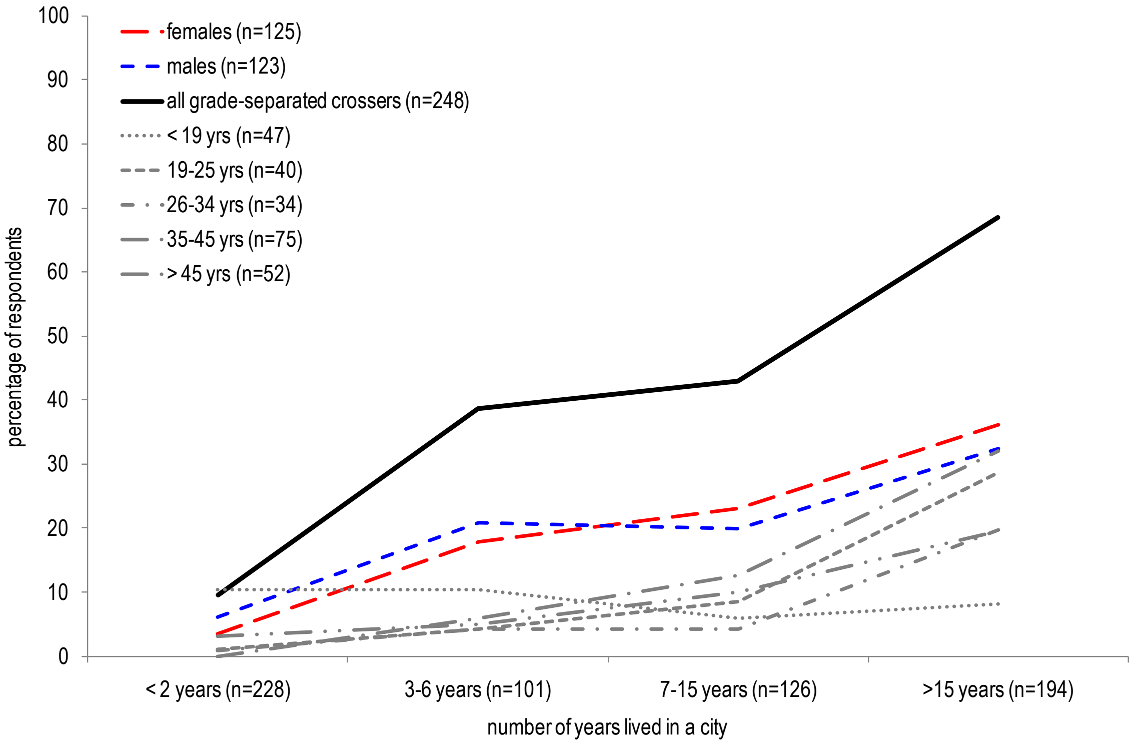
Figure 10(a-b) illustrates relationships between crossing behaviour and the demographic variations presented in tables 7 and 8. The plot of grade-separated crossers aged less than 19 years in figure 10(b) clearly illustrates that confounding effect of age and time in a city with respect to understanding impact on spatial non-compliance.

Figure 10. *Grade-separated crossing facility use, by number of years lived in a city, gender and age group (percent, n=649, Gabuza 2008)*

(a) At-grade crossers



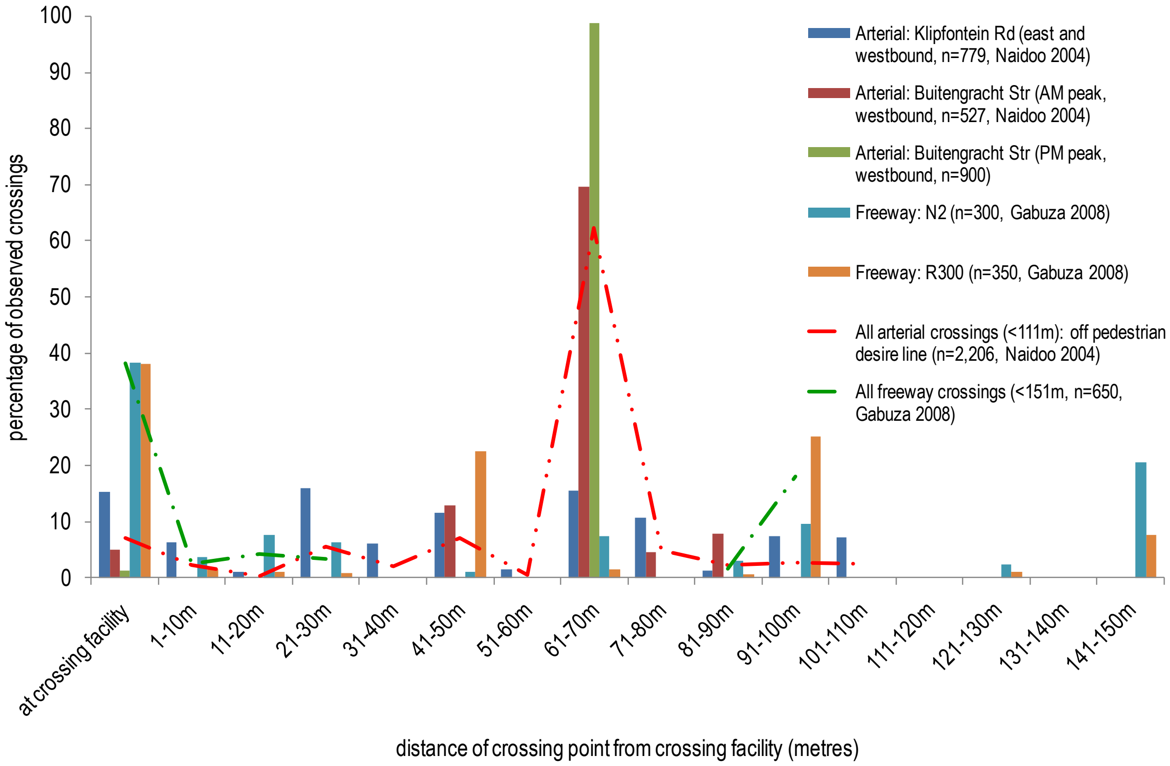
(b) Grade-separated crossers



6. CONCLUSION: SYNTHESIS AND IMPLICATIONS

Reflecting upon the overarching research hypothesis set out in section 2, a synthesis of research findings across the studies (presented in figure 11) indicates that the distribution of points of pedestrian arterial and freeway crossing, in relation to provided crossing facilities, does not follow an S-shaped curve. Significant numbers of pedestrians were observed to cross arterials and freeways unassisted at small distances from crossing facilities. While greater use of freeway crossing facilities was observed relative to arterial crossing facilities, it is posited that patterns of crossing would be better explained by the location of the crossing facilities in relation to dominant pedestrian desire lines. The relatively greater freeway crossing facility use is likely to be associated with, amongst other factors (e.g. the illegality of, and the greater physical difficulty presented by, crossing freeways at-grade), a greater perceived risk associated with the greater speed differential on freeways.

Figure 11. *Synthesis of pedestrian crossing distances from facility, by road type (percent, n=2,856)*



The patterns of pedestrian crossing behaviour reported in this paper are expected to be context specific. Cities where levels of traffic law enforcement and associated compliance levels are higher than in Cape Town, are unlikely to reveal similar unassisted or illegal crossing behaviour. King *et al* (2009), for instance, in their study of signalised crossing facilities in Brisbane reported that illegal crossings accounted for 20% of observed crossings, and Mullen *et al* (1990) reported 25% in a study in the United States. In comparison, the study findings in Cape Town presented in figure 11 suggest that as much as 62% of crossing on freeways, and 93% of crossing on arterials (off desire lines), may be unassisted or illegal.

Even within Cape Town, given findings with respect to the relationship between experience of city living and at-grade freeway crossing, behavioural patterns are likely to vary across different parts of the city on the basis of the different socio-demographic groups they accommodate. Other factors are also likely to play a role in attitudinal and behavioural variation, as found, for instance, by Cho *et al* (2009) with respect to the influence of neighbourhood design on perceptions of safety, and by Rosenbloom *et al* (2004) with respect to religiosity.

What then are the main implications of the findings presented in this paper for the formulation of strategies to improve crossing safety by reducing unassisted and illegal pedestrian crossing behaviour? A first, obvious, implication is that the provision of regularly spaced crossing facilities, on their own, is unlikely to lead to significant changes in pedestrian crossing behaviour. The studies suggest that crossing facilities are more likely to be used if they are located on the pedestrian's desire line. Consequently, understanding or estimating pedestrian desire lines and walking trip assignment is more important than understanding detour refusal distances in locating crossing facilities and in attempting to minimise unassisted or illegal crossing patterns. This necessitates that walking be routinely included in travel behaviour analysis, when in the past it has been omitted, and treated as a travel mode like any other. Trip stage and main mode walking trips need to be analysed in travel surveys, and methods for analysing and predicting walking trip generation, distribution and route choice need to be developed. Regarding route choice analysis and identifying appropriate crossing facility locations, given the role of concerns for personal security in crossing decisions reported in this paper, assumptions that pedestrians simply choose the shortest walking path need to be critically examined in further research, as explored, for instance, by Daarmen *et al* (2005), Japp (2007), Schlossberg *et al* (2007), and Shivute (2007).

A second implication, given the observed relationship between city living and crossing behaviour, is that key to the formulation of any strategy to improve pedestrian safety will be an acceleration of the learning experience and appreciation of traffic risk. This indicates that education and awareness programmes will be important, in parallel with improved enforcement of traffic rules pertaining to pedestrian crossing. For education and awareness campaigns to be most effective, research into variations in attitudes and behaviour across populations segments will be necessary to identify the most appropriate communication medium and targeting of campaigns. In this regard, potential exists to gain useful insights into pedestrian crossing attitudes in the Cape Town context, and how these vary across cultural and socio-demographic groups, through self-reporting surveys (as opposed to pedestrian intercept surveys) amongst selected groups, as applied, for instance, by Granié (2009), Räsänen *et al* (2007), Yagil (2000), and Yang *et al* (2006) elsewhere. Such studies could be conducted at a variety of sites, including the home, which would be more conducive to obtaining richer attitudinal data than is possible in an intercept survey context. A further methodological approach perhaps worth investigating in the Cape Town context is Ajzen's 'theory of planned behaviour',[7] as applied, for instance, by Evans and Norman (1998),

[7] According to the 'theory of planned behaviour' a person's behaviour is determined by his or her 'intention' to perform the behaviour, which is, in turn, a result of his or her 'attitude toward the behaviour', 'subjective norms' and 'perceived behavioural control'. 'Intention' refers to a person's

Holland and Hill (2007), and Zhou *et al* (2009) elsewhere. This approach holds potential in uncovering where education and awareness programmes should be focussed, and their priorities, and may present a useful extension of the research presented in this paper.

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readiness to perform a given behaviour, and it is considered to be the immediate antecedent of behaviour. 'Attitude toward the behaviour' is formed by 'behavioural beliefs' which refer to the perceived likely consequences of the behaviour. 'Subjective norms' are formed by 'normative beliefs' which are beliefs about how other people view the behaviour in question. 'Perceived behavioural control' is formed by 'control beliefs' which refers to the decision-maker's perceived ability to perform a given behaviour. The more favourable the 'attitude toward the behaviour' and the 'subjective norm', and the greater the 'perceived behavioural control', the stronger should the decision-maker's intention be to perform the behaviour in question. (Ajzen 1991)

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