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Experiences from Ada George Road in Port Harcourt, Rivers State, on the Impact of Pedestrian Crossing Behaviour on Traffic Flow.

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Abstract Traffic congestion is a significant challenge Port Harcourt faces, particularly at intersections and midblock crossings that lack pedestrian provisions. This has resulted in significant delays on major roads in the city. Despite the construction of new roads, pedestrian crossing facilities were not included, leading to a practical investigation into the impact of pedestrian-vehicle interactions on traffic flow. The study observed pedestrian crossing behaviour at five intersections along Ada George Road in Port Harcourt City, using video capturing to analyze patterns and collect data on traffic flow parameters such as vehicular speeds and pedestrian volume. The Speed Performance Index (SPI) was used to determine congestion levels at the intersections. During the morning and evening peak periods, pedestrian volumes at the intersections in order of occurrence were: Agip (1850 and 2341), Chinda (677 and 1936), Happy Food (390 and 682), Open Door (578 and 1376), and Okilton (1660 and 3752). The study found that the intersections had SPI values ranging from 17.50 to 81.50, which indicated varying traffic states as pedestrian volume increased. The results showed that pedestrian crossing behaviour caused disruptions in traffic flow, leading to mild and severe traffic congestion at different intervals during peak periods.

Keywords Pedestrian Crossing, Congestion, Traffic, Intersection, Midblock Crossing

1. Introduction

Transport planning has always prioritized efficient road use, particularly in urban areas. A well-designed transportation system boosts economic growth and benefits individuals, businesses, and the environment [Afrin & Yodo (2020)., Croce *et al*. (2020)]. Transportation plays a crucial role in the progress of any society, as stated by Mohan *et al.* (2020). However, it faces many challenges, such as traffic congestion and accidents. Traffic congestion has significant social, economic, and environmental effects. With the rise in urbanisation and economic development worldwide, traffic jams have occurred during peak hours, particularly at intersections where complex flow patterns are observed (Otto & Awarri, 2022). Academic studies have shown that developing nations suffer greatly from its economic impact (Kumar & Sing, 2017). In solving traffic problems, vehicles traditionally receive more attention than pedestrians in Nigeria, disregarding safety and comfort. Not considering pedestrians in the design of roads has led to severe traffic congestion in Port Harcourt, according to Otto *et al.* (2023).

Walking is a crucial mode of non-motorized transportation for pedestrians to connect with other transportation networks and neighbouring activity centres. Unfortunately, pedestrians are often the most vulnerable users in a transportation network, receiving the least attention (Asaithambi, *et al.,* 2016). In Port Harcourt and throughout

Nigeria, traffic accidents involving pedestrians have become a significant safety risk due to increasing urbanisation, car ownership, and disregard for traffic laws by drivers and pedestrians. The wide variety of vehicles on the roads, with no lane discipline, causes conflicts between vehicles and pedestrians. Additionally, Port Harcourt's Road designs lack pedestrian-friendly features such as sidewalks, pedestrian crossings, bus stop approaches, bus priority lanes, continuous pedestrian routes, and lanes for slow vehicles like bicycles. Consequently, pedestrians and slow-moving vehicles are exposed to hazardous conditions, while motorized vehicles face clogged roads.

In the bustling city of Port Harcourt, sharing the road between vehicles and pedestrians along Ada George Road can be a challenge. Despite their distinct differences, both modes of transportation vie for the same street and highway space, as shown in Plate 1 below. To address this issue, establishing practical design standards and regulations for all traffic is crucial for effective roadway design. Therefore, the designer needs to comprehensively understand the entire spectrum of traffic to ensure a proper design. This involves knowing the type and volume of vehicles that will use an intersection and the number and behaviour of pedestrians crossing it.

Plate 1: Pedestrian Crossing Pattern at Agip and Open-Door Locations along Ada George Road in Port Harcourt

It is essential to establish highway design standards that prioritize pedestrian traffic. The design and operational tactics should include measures to regulate vehicle speeds, reduce obstructions to pedestrians, minimize conflicts between pedestrians and vehicles, decrease competing attention demands, provide adequate walkway separation, and offer visually appealing designs. These objectives should aim to enhance pedestrian walkway features, including accessibility, directness, continuity, safety, guidance, and aesthetics, over the flow of vehicular traffic. Professionals in the design industry have discovered ways to devise solutions that allow pedestrians and vehicles to interact securely and effectively (Mark & Virkler, 2023).

Pedestrian facilities such as sidewalks, crosswalks, pedestrian signals, road signs, pedestrian overpasses, and bridges are designed to provide a secure and efficient way for people to move around. However, these facilities can also cause accidents, traffic congestion, and a reduced average travel speed. As observed on Ada George Road in Port Harcourt City, these facilities are lacking. Therefore, this study aims to address the gap in research by examining how pedestrian behaviour affects traffic flow on Ada George Road and suggesting solutions that will draw the government's attention to the importance of providing appropriate pedestrian crossing facilities.

The following objectives were carried out to achieve the aim of this study.

i. Determination of the volume of pedestrians crossing.
ii. Determination of the average speed at every 15-minute interval.
iii. Determination of the Speed Performance Index (SPI).

2. Materials and Methods

2.1 Materials

During the field survey for this research, the following equipment was used: a data entry sheet, pen, video camera, and measuring tape.

2.2 Methods

The five busiest intersections along Ada George Road in Port Harcourt City, where pedestrian traffic is hefty, were carefully chosen for the study. The team thoroughly assessed the area to determine the congestion level on various routes and the flow of pedestrian traffic. Data were collected at these intersections at different times throughout the week, focusing on peak hours (7 am to 9 am and 5 pm to 9 pm). Manual and video-capturing methods were used to measure traffic flow, recording the number of pedestrians and the speed of vehicles in all directions. It is worth noting that the roadway used in this study has a design speed of 80 km/hr.

Around the world, pedestrian traffic accidents have become a critical safety concern, especially in developing cities. This is primarily due to the ever-increasing population density, swift urbanisation, and drivers' and pedestrians' violation of traffic laws. The behaviour of pedestrians at road crossings plays a significant role in traffic flow. The Speed Performance Index (SPI) method was adopted to assess pedestrian crossing patterns.

2.2.1 Speed Performance Index (SPI) Assessment

The study area was divided into five locations, each with 30-meter segments that were analyzed. To obtain accurate results, all vehicles travelling on a particular road in northbound and southbound directions were monitored during peak hours (7:00 am to 9:00 am and 5:00 pm to 9:00 pm). The SPI was calculated using Equation 1, and it should be noted that the maximum designed speed for this study was 80 km/hr. The criteria for every traffic state were determined using Table 1.

$$\text{SPI} = \frac{\text{Average vehicle speed}}{\text{Designed maximum speed}} \times 100 \quad (1)$$

A section of the road at each of the five locations along Ada George Road was marked and taken into consideration to get the speed of vehicles using Equation 2. To evaluate the speed of the vehicles at each time interval, the video records were used to record both the distance and time.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} \quad (2)$$

Table 1: Valuation Criteria of Speed Performance Index on a Roadway (Fattah, *et al*., 2021)

SPI	Traffic State	Description of Traffic State
0-2	Heavy Congestion	Low average speed with poor road traffic state
25-50	Mild Congestion	Low average speed with a bit of weak road traffic state
50-75	Smooth Flow	Higher average speed with better road traffic state
75-100	Very Smooth Flow	Higher average speed with good road traffic state

3. Results and Discussions

3.1 Volume of Pedestrian Crossing During the Morning Peak Periods

The volume of pedestrian traffic for the five locations along Ada George Road during the morning peak period is presented in Table 2 and Figure 1 below. The volume of pedestrians at each location was counted at 15-minute intervals for 2 hours (7.00 am – 9.00 am).

Table 2: Volume of Pedestrians Crossing during Morning Peak Periods

Time Intervals	Time (mins)	Agip	Chinda	Happy Food Bakery	Open Door	Okilton Drive
7:00-7:15	15	197	80	43	68	160
7:15-7:30	30	213	92	59	98	180
7:30-7:45	45	240	104	62	112	195
7:45-8:00	60	279	121	54	86	238
8:00-8:15	75	252	85	51	81	231
8:15-8:30	90	234	72	46	46	222
8:30-8:45	105	220	64	39	44	209
8:45-9:00	120	215	59	36	43	183
	Total	**1850**	**677**	**390**	**578**	**1660**

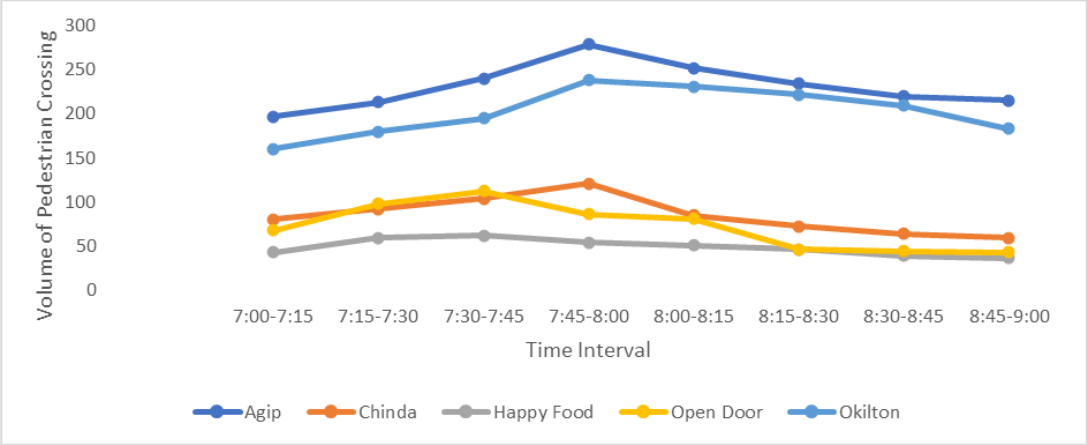

Figure 1: Volume of Pedestrian Crossing at Different Locations during the Morning Peak Period

The field data collected showed that the Agip Intersection has the highest pedestrian volume, followed closely by Okilton Drive during the morning peak period. This was further examined using Figure 1 and Table 1. At the Agip Intersection, there is a gradual increase in the volume of pedestrian traffic up to the first 60 minutes (8:00 am), after which it starts to reduce. The highest number of pedestrians crossing the intersection is between 7:45 am and 8:00 am, the fourth 15-minute interval. This intersection is a significant alighting and take-off point for pedestrians entering different parts of the city. The traffic volume at Agip Intersection is high also because of various business ventures such as the Agip Oil Company, shops and restaurants around the intersection.

Closely following in traffic volume is Okliton Drive. There are a lot of residential settlements around this particular intersection, which leads to the heavy flow of pedestrians as they come out from these areas to engage in their daily activities. The optimum number of pedestrian crossings at Okilton Drive is between 7:45 am and 8:00 am, the fourth 15-minute interval. Similar to that of Agip Intersection.

At Open Door, Chinda, and Happy Food Bakery, it was observed that most houses are tilted towards the Ikwerre Road axis, making more pedestrians use it as a quicker route. Due to this, few pedestrians residing around these locations use the Ada George route, which in turn causes a low traffic count while getting results, as explained in Figure 1 above. The optimum volume of pedestrian crossing at Chinda is between 7:45 am and 8:00 am from Figure 1, while for Open Door and Happy Food Bakery, it is between 7:30 am and 7:45 am.

3.2 Volume of Pedestrian Crossing During the Evening Peak Periods

Table 3 and Figure 2 present the volume of pedestrian traffic for five locations along Ada George Road during the evening peak period. The pedestrian count for each location was recorded at 15-minute intervals of 4 hours, from 5:00 pm to 9:00 pm.

Table 3: Volume of Pedestrians Crossing during Evening Peak Periods

Time Intervals	Time (mins)	Agip	Chinda	Happy Food Bakery	Open Door	Okilton Drive
5:00-5:15	15	112	67	30	60	180
5:15-5:30	30	128	83	80	81	195
5:30-5:45	45	130	95	72	112	210
5:45-6:00	60	140	100	67	150	233
6:00-6:15	75	175	105	55	142	243
6:15-6:30	90	182	111	53	138	256
6:30-6:45	105	200	150	50	131	268
6:45-7:00	120	194	190	48	105	284
7:00-7:15	135	190	184	44	88	300
7:15-7:30	150	170	170	42	76	330
7:30-7:45	165	165	163	37	65	310
7:45-8:00	180	154	147	32	57	296
8:00-8:15	195	120	125	25	53	250
8:15-8:30	210	103	102	22	46	182
8:30-8:45	225	92	87	15	42	120
8:45-9:00	240	86	57	10	30	95
	Total	**2341**	**1936**	**682**	**1376**	**3752**

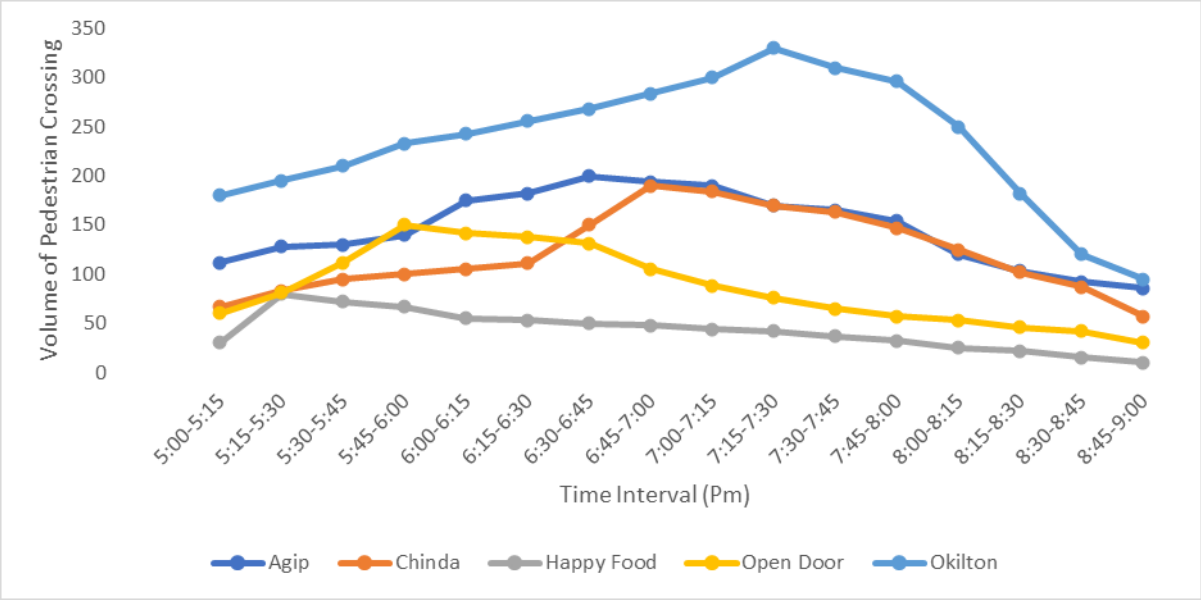

Figure 2: Volume of Pedestrian Crossing at Different Locations during the Evening Peak Period

According to Figure 2 and Table 3, it is clear that Okilton Drive has the highest number of pedestrians. The pedestrian count consistently increases up to the third hour (7:30 pm), after which it gradually decreases. The optimum number of pedestrian crossings at Okilton Drive is between 7:30 pm and 7:45 pm, as pedestrians approaching Okilton Drive face congestion at intersections before Okilton Drive. Additionally, there are many residential settlements around and close to this intersection.

Agip intersection follows Okilton Drive in terms of traffic volume. This intersection is a significant alighting and take-off point for pedestrians and road users from various parts of the city. There are also many shops and restaurants in the area, which causes many pedestrians to come out as the day ends. The optimum volume of pedestrian crossings at Agip intersection is between 6:45 and 7:15 pm, the second hour.

Chinda is a busy area for pedestrians, especially during the peak hours of 7:00 pm to 7:15 pm. This is due to the flow of people coming from the Agip intersection, where some pedestrians get off as their final destination. In addition, Open Door has a variety of shops, schools, and vehicles, which adds to the foot traffic in the area.

3.3 Effect of Pedestrian Crossing on Vehicular Speed during Morning Peak Period

Table 4 presents vehicular speed variation at five intersections during the morning peak. Also, Figure 3 presents vehicular speed and pedestrian volume variations for the Agip location. The behaviour follows the same pattern for all five locations.

Table 4: Average Speeds During Morning Peak Period due to Pedestrian Crossing Volume

TIME INTERVAL (am)	AGIP		HAPPY FOOD		CHINDA		OPEN DOOR		OKILTON	
	Vol. of Pedestrians	Speed (Km/hr)	Vol. of Pedestrians	Speed (Km/hr)	Vol. of Pedestrians	Speed (Km/hr)	Vol. of Pedestrians	Speed (Km/hr)	Vol. of Pedestrians	Speed (Km/hr)
7:00-7:15	197	30	43	65	80	50	68	60	160	40
7:15-7:30	213	25	59	58	92	45	98	50	180	35
7:30-7:45	240	20	62	50	104	30	112	40	195	25
7:45-8:00	279	10	54	55	121	25	86	30	238	17
8:00-8:15	252	11	51	58	85	40	81	45	231	20
8:15-8:30	234	13	46	60	72	55	46	65	222	22
8:30-8:45	220	16	39	65	64	60	44	70	209	27
8:45-9:00	215	18	36	70	59	70	43	75	183	30

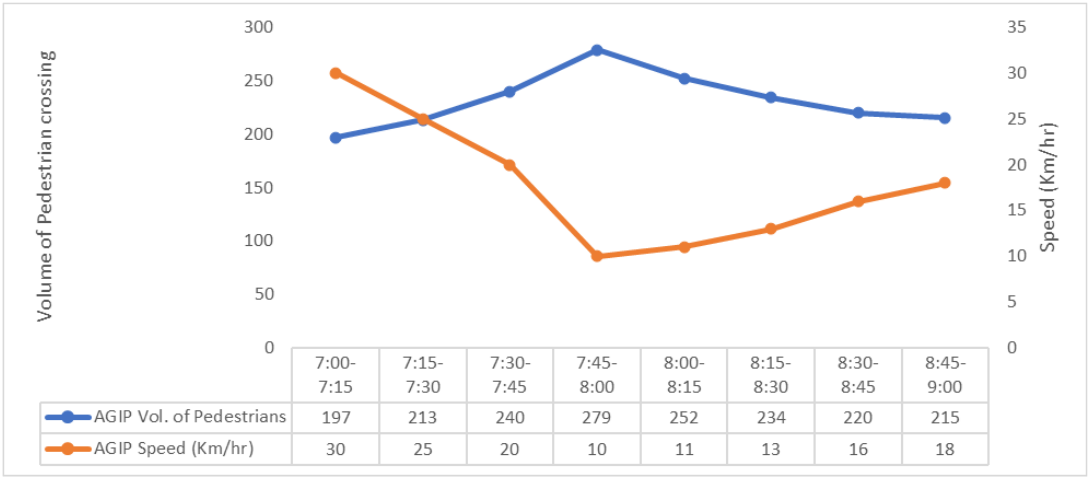

Figure 3: Effect of Pedestrian Volume on Speed at the Agip Location (Morning)

As shown in Figure 3 and Table 3, the speed of vehicles decreases as the volume of pedestrian crossing increases. At Agip intersection, during the peak 15-minute interval (7:45-8:00 am) with a volume of 279 pedestrians crossing, the vehicular speed drops by 17%. Similarly, at the Okilton intersection, with 238 pedestrians crossing during the peak, the vehicular speed dropped by 13%. At the Chinda intersection, the vehicular speed also drops by 17% during the peak 15-minute interval (7:45-8:00 am) due to the close walking distance between Chinda and Agip. Open-door intersections experience a 17% reduction in speed during the peak 15-minute interval (7:30-7:45 am) with a volume of 112 pedestrians crossing. Finally, Happy Food Bakery has the lowest volume of pedestrians crossing during the peak 15-minute interval (7:30-7:45 am) with a volume of 62 pedestrians crossing, and the vehicular speed drops by 11%.

In all the intersections, the vehicular speed tends to decrease as the volume of pedestrians increases and vice versa with respect to time. This observation supports Fattah et al., (2021). This variation in pedestrian crossing and vehicular speed is due to the activities around these locations. Agip intersection is a significant alighting and take-off point for pedestrians entering different parts of the city. This has caused it to have a high volume of pedestrians, followed by Okilton, Chinda, Open Door, and Happy Food.

3.4 Effect of Pedestrian Crossing on Vehicular Speed during Evening Peak Period

The average vehicle speed during the evening peak period for the five intersections is described in Table 5 while Figure 4 present the variation in speed and volume of pedestrian crossing at Agip location.

Table 5: Average Speeds During Evening Peak Period due to Pedestrian Crossing Volume

Time Interval (am)	AGIP		HAPPY FOOD		CHINDA		OPEN DOOR		OKILTON	
	Vol. of Pedestrians	Speed (Km/hr)	Vol. of Pedestrians	Speed (Km/hr)	Vol. of Pedestrians	Speed (Km/hr)	Vol. of Pedestrians	Speed (Km/hr)	Vol. of Pedestrians	Speed (Km/hr)
5:00-5:15	112	40	30	30	67	45	60	38	180	30
5:15-5:30	128	35	80	25	83	37	81	35	195	27
5:30-5:45	130	32	72	27	95	33	112	33	210	25
5:45-6:00	140	29	67	30	100	30	150	29	233	23
6:00-6:15	175	20	55	32	105	28	142	27	243	20
6:15-6:30	182	18	53	35	111	25	138	30	256	18
6:30-6:45	200	15	50	40	150	23	131	33	268	17
6:45-7:00	194	17	48	42	190	17	105	36	284	15
7:00-7:15	190	16	44	48	184	20	88	38	300	13
7:15-7:30	170	18	42	51	170	22	76	41	330	11
7:30-7:45	165	17	37	52	163	26	65	44	310	10
7:45-8:00	154	14	32	52	147	29	57	47	296	14
8:00-8:15	120	16	25	52	125	32	53	49	250	16
8:15-8:30	103	20	22	55	102	35	46	53	182	19
8:30-8:45	92	22	15	60	87	39	42	55	120	25
8:45-9:00	86	25	10	65	57	43	30	58	95	27

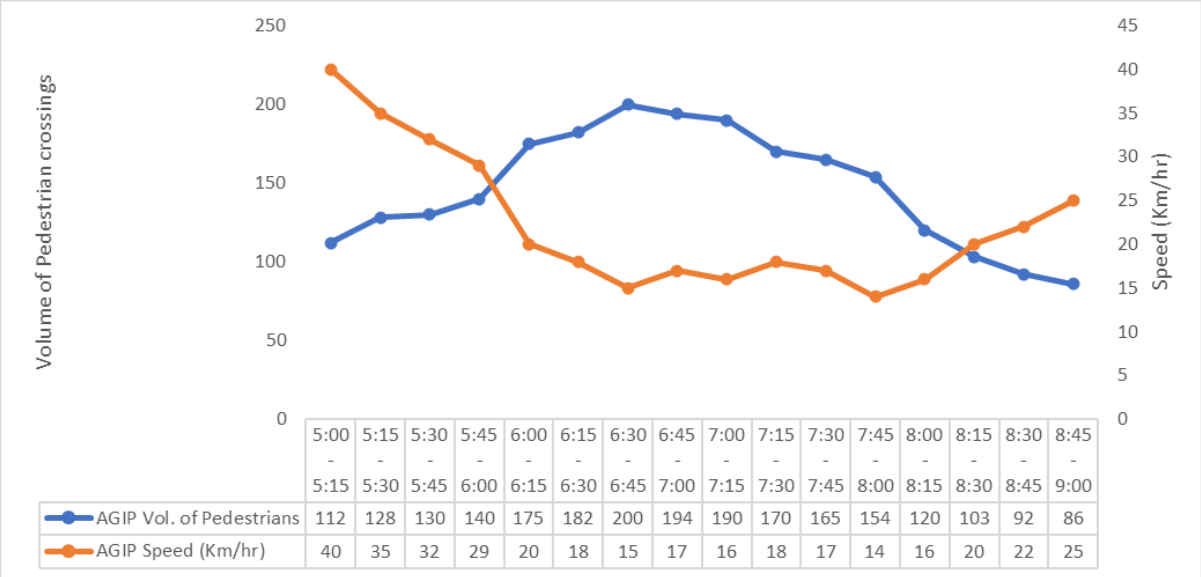

Figure 4: Effect of Pedestrian Volume on Speed at the Agip Location (Evening)

According to the data presented in Table 4, the intersection with the highest volume of pedestrians is Okilton Drive. During peak pedestrian crossing times, which occur between 7:30 pm and 7:45 pm and involve 330 pedestrians, the vehicular speed drops by 10%. This is due to the high number of residents arriving home from various destinations in the area.

The second highest volume of pedestrians is at Agip intersection, where the vehicular speed drops by 12.5% during peak pedestrian crossing times between 6:45 pm-7:00 pm, involving 200 pedestrians.

The third highest volume of pedestrians is at the Chinda intersection, where the vehicular speed drops by 17.8% during peak pedestrian crossing times between 7:00 pm and 7:15 pm, involving 190 pedestrians.

The fourth highest volume of pedestrians is at the Open-Door intersection, where the vehicular speed drops by 6.9% during peak pedestrian crossing times between 6:00 pm and 6:15 pm, involving 150 pedestrians.

Lastly, the intersection with the fifth highest volume of pedestrians is Happy Food Bakery, where the vehicular speed drops by 20% during peak pedestrian crossing times between 5:30 pm and 5:45 pm, involving 80 pedestrians.

It is important to note that the volume of pedestrians crossing at each intersection significantly impacts vehicular speed, causing it to either increase or decrease. The observation supports the study by Fattah, *et al.*, (2021).

3.5 Speed Performance Index (SPI) during the Morning Peak Period

Table 6 and Figure 5 analyze the speed performance index during the morning peak.

Table 6: SPI Variation during the Morning Peak Period

Time Interval (am)	AGIP		HAPPY FOOD		CHINDA		OPEN DOOR		OKILTON	
	Speed (Km/hr)	SPI	Speed (Km/hr)	SPI	Speed (Km/hr)	SPI	Speed (Km/hr)	SPI	Speed (Km/hr)	SPI
7:00-7:15	30	37.50	65	81.25	50	62.50	60	75.00	40	50.00
7:15-7:30	25	31.25	58	72.50	45	56.25	50	62.50	35	43.75
7:30-7:45	20	25.00	50	62.50	30	37.50	40	50.00	25	31.25
7:45-8:00	10	12.50	55	68.75	25	31.25	30	37.50	17	21.25
8:00-8:15	11	13.75	58	72.50	40	50.00	45	56.25	20	25.00
8:15-8:30	13	16.25	60	75.00	55	68.75	65	81.25	22	27.50
8:30-8:45	16	20.00	65	81.25	60	75.00	70	87.50	27	33.75
8:45-9:00	18	22.50	70	87.50	70	87.50	75	93.75	30	37.50

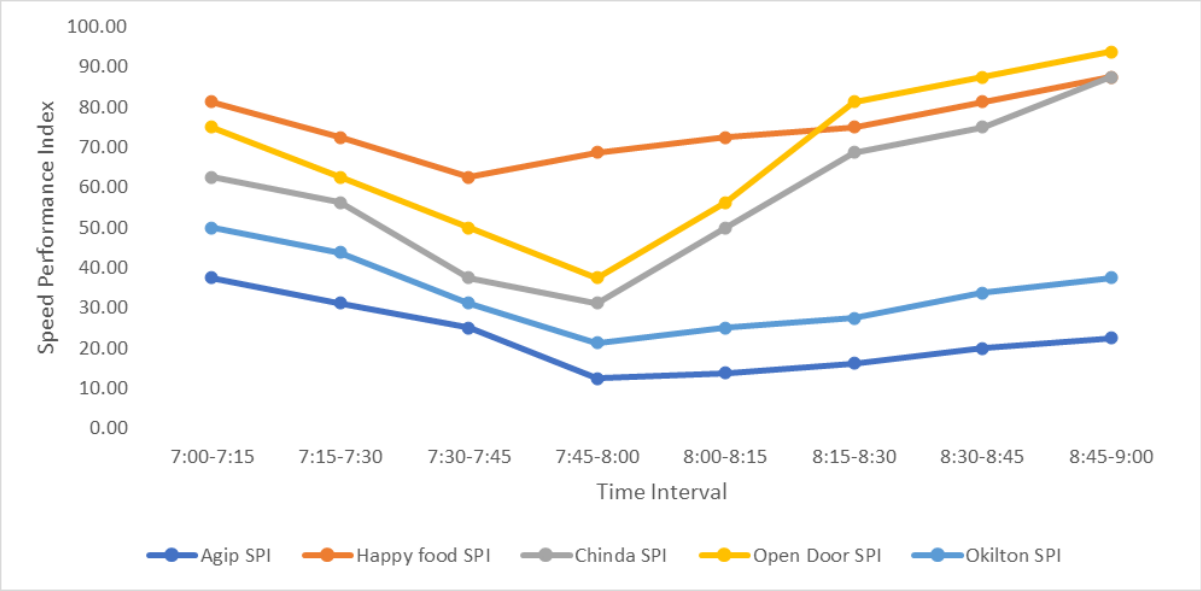

Figure 5: Variation of Speed Performance Index during the Morning Peak Period

During the morning peak hour, the efficiency of vehicle speed at five intersections - Agip, Chinda, Happy Food, Open Door and Okilton Drive - is typically measured using the SPI. The SPI values obtained for each intersection using Table 1 are illustrated in Figure 5 and Table 6.

At Agip intersection, there is mild congestion from 7:00 am to 7:15 am with an SPI value of 37.5 (SPI range of 25-50, indicating a lower average speed). Heavy congestion is from 7:45 am to 8:00 am with an SPI value of 12.5 (SPI range of 0-25, indicating a low average speed with poor road traffic state).

At Chinda intersection, the SPI values show a very smooth flow in traffic from 8:45 am to 9:00 am with an SPI value of 87.5 (SPI range of 75-100, indicating a high average speed with good road traffic state) and mild congestion from 7:45 am to 8:00 am with an SPI value of 37.5 (SPI range of 25-50, indicating a lower average speed).

At Happy Food bakery, there is a smooth flow from 7:30 am to 7:45 am with an SPI value of 62.5 (SPI range of 50-75, indicating a higher average speed with better road traffic state) and a very smooth flow from 8:45 am to 9:00 am with an SPI value of 87.5 (SPI range of 75-100, indicating a high average speed with good traffic state).

At the Open-Door intersection, there is mild congestion from 7:45 am to 8:00 am with an SPI value of 37.5 (SPI range of 25-50, indicating a lower average speed with weak road traffic state) and a very smooth flow from 8:45 am to 9:00 am with an SPI value of 93.75 (SPI range of 75-100, indicating a high average speed with good traffic state).

At Okilton Drive, there is heavy congestion from 7:45 am to 8:00 am with an SPI value of 21.25 (SPI range of 0-25, indicating a low average speed with poor road traffic state), and smooth flow from 7:00 am to 7:15 am with an SPI value of 50 (SPI range of 50-75, indicating a higher average speed with better road traffic state).

3.6 Speed Performance Index (SPI) during the Evening Peak Period

Table 7 and Figure 6 analyze the speed performance index during the evening peak.

Table 7: SPI Variation during the Evening Peak Period

Time Interval (pm)	AGIP		HAPPY FOOD		CHINDA		OPEN DOOR		OKILTON	
	Speed (Km/hr)	SPI	Speed (Km/hr)	SPI	Speed (Km/hr)	SPI	Speed (Km/hr)	SPI	Speed (Km/hr)	SPI
5:00-5:15	40	50.00	30	37.50	45	56.25	38	47.50	30	37.50
5:15-5:30	35	43.75	25	31.25	37	46.25	35	43.75	27	33.75
5:30-5:45	32	40.00	27	33.75	33	41.25	33	41.25	25	31.25
5:45-6:00	29	36.25	30	37.50	30	37.50	29	36.25	23	28.75
6:00-6:15	20	25.00	32	40.00	28	35.00	27	33.75	20	25.00
6:15-6:30	18	22.50	35	43.75	25	31.25	30	37.50	18	22.50
6:30-6:45	15	18.75	40	50.00	23	28.75	33	41.25	17	21.25

6:45-7:00	17	21.25	42	52.50	17	21.25	36	45.00	15	18.75
7:00-7:15	16	20.00	48	60.00	20	27.50	38	47.50	13	16.25
7:15-7:30	18	22.50	51	63.75	22	27.50	41	51.25	11	13.75
7:30-7:45	17	21.25	52	65.00	26	32.50	44	55.00	10	12.50
7:45-8:00	14	17.50	52	65.00	29	36.25	47	58.75	14	17.50
8:00-8:15	16	20.00	52	65.00	32	40.00	49	61.25	16	20.00
8:15-8:30	20	25.00	55	68.75	35	43.75	53	66.25	19	23.75
8:30-8:45	22	27.50	60	75.00	39	48.75	55	68.75	25	31.25
8:45-9:00	25	31.25	65	81.25	43	53.75	58	72.50	27	33.75

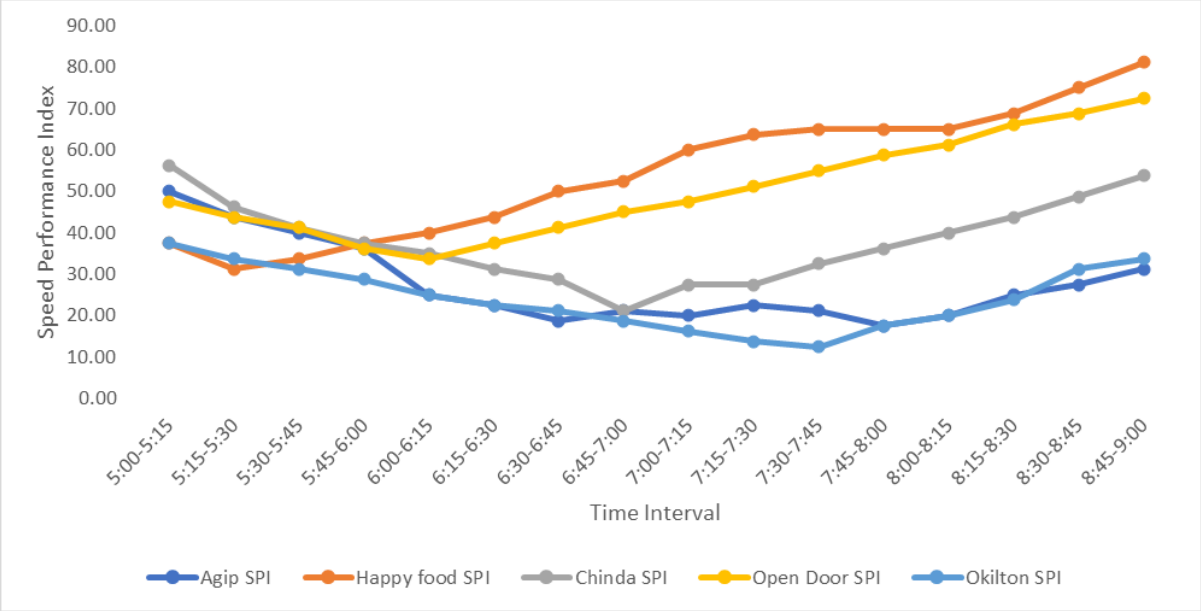

Figure 6: Variation of Speed Performance Index during the Evening Peak Period

Table 7 and Figure 6 explain the SPI values obtained from the traffic survey conducted during the evening peak at five different intersections.

At Agip intersection, the SPI results indicate heavy congestion from 7:45 pm to 8:00 pm with an SPI value of 17.5. The SPI range of 0-25 describes a low average speed with a poor road traffic state. There is also mild congestion from 5:15 pm to 5:30 pm with an SPI value of 43.75. The SPI range of 25-50 describes a lower average speed with a weak road traffic state.

At the Chinda intersection, the SPI results show heavy congestion from 6:45 pm to 7:00 pm with an SPI value of 21.25. The SPI range of 0-25 describes a low average speed with a poor road traffic state. There is a smooth flow from 5:00 pm to 5:15 pm with an SPI value of 56.25. The SPI range of 50-75 describes a higher average speed with a better road traffic state.

The SPI results at the Happy Food intersection illustrate mild congestion from 5:00 pm to 6:45 pm. The SPI range within 25-50 describes a lower average speed with a weak road traffic state. There is a smooth flow from 7:00 pm to 8:45 pm. The SPI range within 50-75 describes a higher average speed with a better road traffic state. The traffic gradually gets to a very smooth flow from 8:45 pm to 9:00 pm. The SPI range within 75-100 describes a high average speed with a good road traffic state.

At the open-door intersection, the results show mild congestion from 6:00 pm to 6:15 pm with an SPI value of 33.75. The SPI range of 25-50 describes a lower average speed with weak road traffic state. There is also a smooth flow from 8:45 pm to 9:00 pm with an SPI value of 72.5. The SPI range of 50-75 describes a higher average speed with a better road traffic state.

At Okilton Drive, the results indicate mild congestion from 5:00 pm to 5:15 pm with an SPI value of 37.5. The SPI range of 25-50 describes a lower average speed with a weak road traffic state. There is also heavy

congestion from 7:30 to 7:45 pm, with an SPI value of 12.5. The SPI range of 0-25 describes the low average speed with a poor road traffic state.

This study has analyzed the effects of pedestrian road crossing behaviour on traffic flow, particularly when the number of pedestrians crossing the road increases. The study found that at times, more than 20 people cross the selected 30-meter stretch of road simultaneously, which forces drivers to slow down their vehicles, causing varying levels of traffic congestion. This study also supports the findings of Fattah *et al.* (2021)

4. Conclusion

The conclusion of this study is based on the set objectives;

i. The morning and evening average pedestrian volume counts for each intersection, in order, are as follows: Agip - 1850 and 2341; Chinda - 677 and 1936; Happy Food - 390 and 682; Open Door - 578 and 1376; Okilton - 1660 and 3752.

ii. During the morning and evening pedestrian volumes, the average speeds of vehicles were recorded for a 15-minute interval. The following speeds were observed: Agip at 10 Km/hr and 15 Km/hr, Chinda at 25 Km/hr and 17 Km/hr, Happy Food Bakery at 50 Km/hr and 40 Km/hr, Open Door at 40 Km/hr and 29 Km/hr, and Okilton at 17 Km/hr and 11 Km/hr.

iii. The traffic flow at various locations during peak hours has been measured using the Speed Performance Index (SPI). At Agip, from 7:15 am to 7:45 am, the SPI is 37.5, indicating mild congestion, which reduces to 12.5 (heavy congestion) from 7:45 am to 8:00 am. In the evening, from 5:15 pm to 7:45 pm, the SPI ranges between 43.75 (mild congestion) to 17.5 (heavy congestion). At Chinda, the SPI is 87.5 (very smooth flow) from 8:45 am to 9:00 am and 37.5 (mild congestion) from 7:30 pm to 7:45 pm. In the evening, from 5:00 pm to 7:00 pm, the SPI ranges between 56.25 (smooth flow) to 21.25 (heavy congestion). At Happy Food, the SPI is 87.5 (very smooth flow) from 8:45 am to 9:00 am and 62.5 (smooth flow) from 7:30 am to 7:45 am. In the evening, from 5:00 pm to 7:00 pm, the SPI ranges between 56.25 (smooth flow) to 21.25 (heavy congestion). At Open Door, the SPI is 93.75 (very smooth flow) from 8:45 am to 9:00 am and 37.5 (mild congestion) from 7:45 am to 8:00 am. In the evening, from 6:00 pm to 9:00 pm, the SPI ranges between 33.75 (mild congestion) to 72.5 (smooth flow). Lastly, at Okilton Drive, the SPI is 50 (smooth flow) from 7:00 am to 7:15 am, which decreases to 21.25 (heavy congestion) from 7:45 am to 8:00 am. In the evening, from 5:00 pm to 7:45 pm, the SPI ranges between 12.5 (heavy congestion) to 37.5 (mild congestion).

5. Recommendations

The study has revealed that pedestrian crossing behaviour affects traffic flow significantly along Ada George Road. Therefore, government should;

- partner with academics and engineers (Nigerian Society of Engineers) in developing design standards that prioritize pedestrian traffic for urban roads in Port Harcourt;
- take pedestrians into account when designing, constructing or improving roads in Port Harcourt;
- should provide designated facilities at high pedestrian volume crossings to improve traffic flow on existing roads;
- develop traffic regulations for pedestrians;
- enforce traffic regulations and penalties for non-compliant pedestrian behaviour.

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