2009 IRF Student Essay Competition

Topic: Road Safety

What low-cost initiatives are available to make roads safer for vulnerable users? Evaluate their effectiveness.

Evaluation of Low-Cost Countermeasures for Pedestrians

by

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1.0 Problem Statement

Fifty-six million walking trips take place each day in the U.S., which represents 7.6 percent of total traveling trips of the country (Nambisan et al., 2007). However, the pedestrian safety isn't optimal in the U.S. According to the National Highway Traffic Safety Administration (NHTSA, 2009), 4,654 pedestrians died in 2007, accounting for 11 percent of total transportation fatalities; and 70,286 pedestrians were injured, which indicates an increase of more than 10,000 injuries compared with 2006. Or equivalently, one pedestrian was injured every 8 minutes and one fatal injury occurred every 113 minutes (Nambisan et al., 2007).

According to the World Health Organization (WHO, 2009), pedestrians have a higher risk of a fatality by 37.7 percent compared to other road users. Especially in developing countries, pedestrian and cyclist traffic volume has grown dramatically, without corresponding facilities for those vulnerable road users.

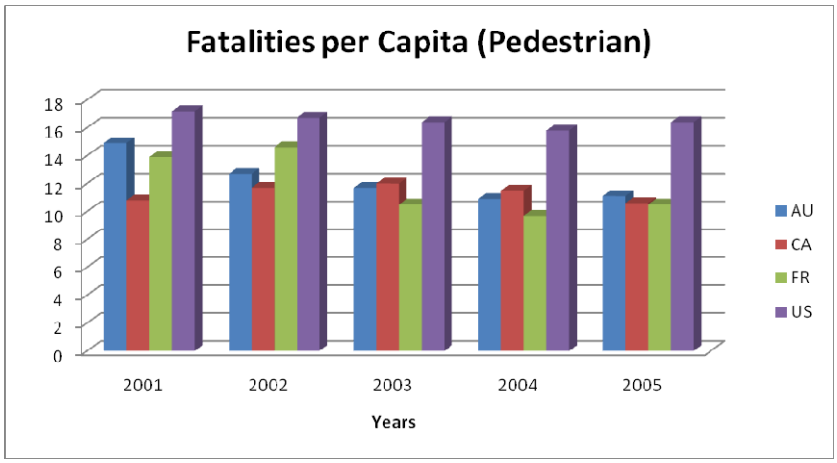

Figure 1. The Fatality per Capita in Australia, Canada, France, and the U.S.

Source: International Transport Statistics Database in WHO, 2009.

Figure 1 shows the pedestrian fatalities per capita in Australia, Canada, France, and the United States from 2001 to 2005. It can be inferred that Australia and France made effective improvements to decrease pedestrian fatality rates, while those rates in the U.S. have remained constant.

2.0 Pedestrian Populations at Risk

2.1 Alcohol Impaired Pedestrians

Nearly half of pedestrian fatalities are attributed to alcohol impairment of drivers or pedestrians (NHTSA, 2009). Alcohol impairment can reduce drivers or pedestrians' cognitive ability, and increase perception and reaction times (FHWA, 2008).

Table 1. Distribution of Traffic Control for Different BAC levels

Traffic Control	0	0.001 to 0.149	0.15	Unknown	Known
No Control	72	85.7	86.2	80.5	75.4
Traffic Signals	22	12.5	9.6	13.8	18.9
Stop Sign	2.8	0	0	1.7	2.1
Give Way Sign	1.7	0	4.2	1.5	1.9
Other	1.1	0	0	0.2	0.8
Total	*99*	*98.2*	*100.0*	*97.7*	*99.1*

Source: Center for Automotive Research. In Hutchinson et al., 2009.

Table 1 shows that 86.2 % of the pedestrians with BAC higher than 0.150 cross roads without any road controls. Therefore, we can presume that alcohol impaired pedestrians are not able to clearly recognize the control devices and behave unpredictably when crossing (Hutchinson et al., 2009).

2.2 Pedestrians with Walking Difficulty

This group of pedestrians includes older pedestrians[1], disabled pedestrians, and pedestrians accompanied by children (TRB, 2006). Older pedestrians are easily trapped in the middle of roads, especially when walking across a high-traffic volume road with short gaps between two successive vehicles. Table 2 shows the distribution of injury severity by age groups, as reported in an article by Clifton et al. (2009). It is observed that older pedestrians experienced the highest fatality rate across all age groups of the pedestrian related crashes of the U.S. in 2007.

Table 2. Severity of injury by age group.

Age	Number	No Injury (%)	Non-fatal injury (%)	Fatality (%)
Child (0-15)	1543	47.6	51.3	1
Adult (16-64)	2643	50.7	47.8	1.5
Older (Over 65)	196	43.4	50	6.6

Source: Clifton et al., 2009.

3.0 Current Pedestrian Safety Countermeasures

The current countermeasures of improving pedestrian safety can be categorized by the Three Es (Engineering, Enforcement, and Education). Engineering countermeasures include enhancements in the pedestrian facility design, roadway design, traffic calming techniques, and intelligent signals, such as automated pedestrian detection systems and countdown signals.

Law enforcement is one of the most effective measures to improve pedestrian safety. "The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users

[1] The assumed normal walking speed is 3.5 ft/s, while the old or children have a lower speed of 3.0 ft/s.

(SAFETEA_LU)" mandates that the most advanced and effective technologies are identified in the process of planning, design, operation, and management of roadways to improve pedestrian safety (FHWA, 2008). Also, education is crucial to enhance public awareness of pedestrian safety, such as workshops and campaigns. However, the focus of this essay is on engineering solutions and their associated cost-effectiveness. The evaluation of current popular pedestrian safety countermeasures is listed below in Table 3 in terms of their effectiveness and cost.

Table 3. Evaluation of the Cost-Effectiveness of Pedestrian Safety Countermeasures

Description	Effectiveness	Cost
Portable Speed Trailer	High	High
Median Refuge	High	High
Pedestrian Countdown Signals	High	Medium
Advanced Yield Marking	High	Low
In-roadway Knockdown Signs	High	Low
ITS Automatic Pedestrian Detection System	Moderate	Medium
Turning Vehicle Yield to Pedestrian	Moderate	Low
Pedestrian Channelizing	Low	High
High Visibility Crosswalk	Low	Medium
Warning Signs to Motorist	Low	Low

Source: Nambisan. 2009.

4.0 Review of Speed–limiting Countermeasures

This section discusses low-cost countermeasures that limit the speed of vehicles by either traffic signals and signs, or traffic calming techniques. Those countermeasures are applicable on un-signalized roadways with high traffic volume and speeds. The controlled key factors in determining what type of countermeasures to implement include pedestrian volume, vehicle volume, lane width, and pedestrian characteristics, i.e. walking speed and others (Zegger et al., 2004)

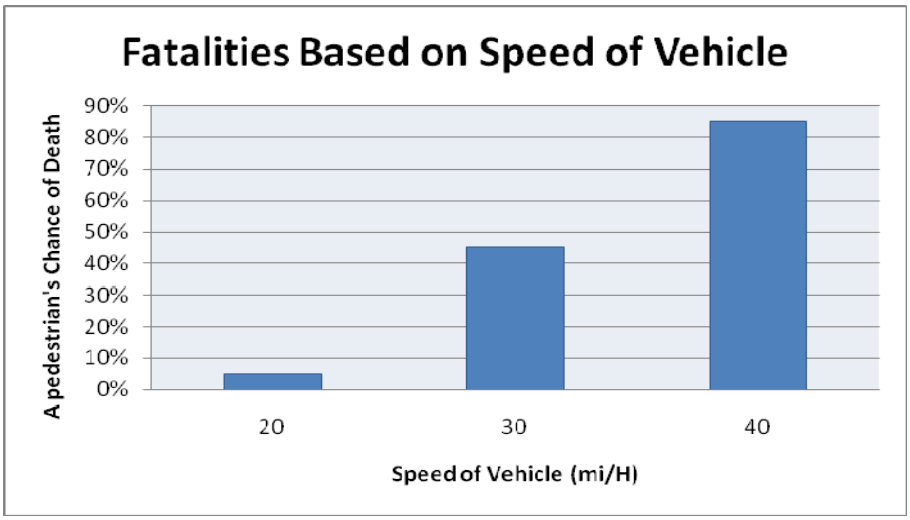

Figure 2. Pedestrian Deaths by Different Impact Speeds.

Source: In Harkey and Zegeer, 2004.

The relationship between the speed of vehicle and the pedestrian injury status was studied by Garder in 2004. He found that the higher the driving speed, the lower the probability that a driver would yield to a pedestrian and the higher the probability of a pedestrian fatality. Figure 2 shows that a pedestrian-related crash with vehicle speed beyond 40 mi/h has an 85 percent chance of being fatal. If the speed is reduced to 20 mi/h, only 5 percent opportunity of the pedestrian crashes involve fatalities (Harkey and Zegeer, 2004).

4.1 Limiting Driving Speed by Traffic Signals and Signs

Limiting speed at intersections and mid-blocks is one of the most effective and low-cost countermeasures to decrease the risks of pedestrian related crashes, as discussed below. Examples of potential low-cost countermeasures include:

- Double Stop Signs
- Yield-to Pedestrian Channelizing Devices (YTPCD)
- Flashing Beacons

For those crashes which happened at stop sign controlled intersections, crashes are usually determined by the compliance of the drivers on the minor roads. One experimental low-cost countermeasure that has been implemented in New Zealand and France is to provide a extra stop sign on the central line of the stop-sign controlled intersections to draw more attention of the drivers to pedestrians (Figure 3). The total crash number has decreased by 30 percent in both New Zealand and France (VHB, 2008). The control device is of low cost and is regulated by the Manual on Uniform Traffic Control Devices (MUTCD).

Figure 3. Supplementary Stop Signs are Provided to Draw More Attentions of Drives.

Source: Vanasse Hangen Brustlin, Inc., 2008.

The Yield-to Pedestrian Channelizing Device (YTPCD) is getting more and more popular nowadays as an effective low-cost countermeasure to increase yielding actions toward pedestrians and provide pedestrians with a secure feeling of being protected by laws. It is a sign attached to a rubber board that reads “State Law Yield To Pedestrian Within Crosswalk”. The sign is placed on the centerline, where it is more visible to drivers. The pre-deployment of the device in Pennsylvania showed that the device successfully increased the number of drivers yielding to pedestrians at different locations, including urban, rural and college town areas. It also has the potential to affect the behavior of drivers at other

neighboring intersections due to an increase in driver's awareness of pedestrians (Strong and Bachman, 2008). The cost of a sign is around $200, while the estimated effectiveness ranges from 82 to 91 percent (Zegger, et al., 2004).

Another cost-effective countermeasure is the use of a traffic signal of flashing beacons at pedestrian crossings installed either overhead or on side streets. There are various control methods of the signal cycle, such as continuous flashing, pedestrian activated mode, or passive detection system. Site studies showed that it increased vehicles' yielding rate to pedestrians by 58 percent on average (TRB, 2006).

4.2 Limiting Vehicle Speed by Traffic Calming Measures

Examples of potential low-cost countermeasures to improve the walking environment include:

- Refuge Island and Danish Offsets
- Pavement Design

Danish offsets are usually installed with a median refuge island. They can improve pedestrian safety especially for older, mobility disabled pedestrians and children, who have a relatively slower walking speed and can be easily trapped in the middle of the road. The refuge island allows pedestrians to stop in the middle of roads and then continue their crossing (See Figure 4). A Danish offset assists pedestrians to view the direction of upcoming vehicles and is effective in reducing pedestrian risk in high volume traffic. Both countermeasures are relatively inexpensive and have shown a great improvement in increasing vehicle yielding and decreasing the number of trapped pedestrians in the middle

of roadways. They are mostly applicable to wide roadways (i.e., more than two-lanes per direction) (Nambisan et al., 2007).

Figure 4. Examples of Median Refuge and Danish Offset

Source: Nambisan et al., 2007.

Pavement designs also have a traffic calming effect to enhance pedestrian safety. The lane width can be narrower near the crossing intersections, which can make drivers lower their speed and be cautious of the pedestrians near crossings. Also, the advanced stop line is wildly used in the United Kingdom and is proven to be highly cost-effective. This kind of measure is similar to the traditional stop lines, but moved further back by 15 to 30 ft to provide a buffering zone between pedestrians and vehicles (See Figure 5). It can be low-cost (advanced stop lines can be marked when traditional stop lines are repainted) and effective if the lines are marked close to the intersection (ATKINS, 2005).

Figure 5. The Layout of Advanced Stop Line in England.
Sources: ATKINS, 2005.

5.0 Cost Evaluation and Recommendation

Different pedestrian safety countermeasures are applicable to different roadway environments (traffic volume, pedestrian volume and roadway characteristics) and target pedestrian populations. The individual or combination of different measures can be used to enhance the pedestrian safety according to the safety problems or concerns. Table 4 shows the cost estimation and applicable scope of recommended countermeasures

Table 4. Summary of Speed-limiting Countermeasures

Type of Countermeasures	Countermeasures:	Cost Estimation ($)	Applicable Scope
Signals and Signs:	Double Stop Signs	50 - 150	Intersection with no signal control
	YTPCD	50-100	Low speed street or Highway
	Flashing Beacons	20,000 – 40,000	High volume, Low speed street
Traffic Calming Measures:	Danish Off sets	Cost Effective[1]	Lane width > 38 ft
	Median Refuge Land	500 - 1000 per meter	Lane width > 38 ft
	Advanced Stop line	Low Cost	Urban intersections
	Pavement Narrowing Design	Cost Various[2]	Two lanes roadway or minor roads

In summary, the most cost-effective measures to enhance the safety of the low cognitive ability alcohol impaired pedestrians are those that limiting driving speeds, such as double stop signs and YTPCD calming devices. Moreover, it was shown that the elderly and disabled pedestrians are also in a higher risk for a fatal pedestrian crash. Danish offsets and median refuge islands can provide a protection area to those pedestrians that are more likely to get trapped in high volume traffic.

The planners and engineers have the responsibility to create a comfortable and safe walking circumstance. The cost-effective evaluation and analysis can assist professional

[1] It depends on the cost of raw materials and labor cost.
[2] The initial expense can be included in the initial investment, if the design is complete before the construction begins.

engineers and transportation agencies to identify the most appropriate countermeasure or countermeasures at the site in a bid to enhance both mobility and safety of the road's most vulnerable user, the pedestrian.

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