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SAFE SYSYTEM COUNTERMEASURES FOR VULNERABLE ROAD USERS IN DHAKA CITY

Md.Rakibul Alam[1] and Md.Mazharul Hoque[2]

[1] Lecturer, Department of Civil Engineering, University of Information Technology and Sciences(UITS), Bangladesh,email:rakibul.buet.bd@gmail.com
[2] Dean and Professor, Faculty of Science and Engineering, UITS, Bangladesh
Former Dean, Faculty of Civil Engineering, BUET, Bangladesh,email:dirarc@gmail.com

ABSTRACT

In Bangladesh, the vulnerable road users (VRUs) such as pedestrians, bicyclists, motor cyclist, pedal rickshaws and users of various informal motorized and non-motorized modes are victims of massive injury due to heterogeneous traffic practice. In most of the cases, vulnerable road users are ignored from the planning of urban road network system. Nearly 65 percent of road traffic fatalities in Bangladesh are attributed to vulnerable road users. The share of vulnerable road users (VRUs) deaths in urban areas, particularly in Dhaka is much more staggering nearly 60 percent in 2014. Transportation by walking is mostly seen in Bangladesh and is highly vulnerable. Cycle rickshaws too cater quite significant proportion of trips (25% to 40%) in cities. Safe system is required to prevent these deaths and serious injuries occurring which has the objective of eliminating deaths and serious injuries, with the guiding principle that everyone, including planners, share responsibility for creating a safe road system. This paper aims to present VRUs crash factors in Dhaka city with a view to ameliorating in-built crash risk factors by implementing affordable road environmental countermeasures. This paper in particular focuses on the potential application of safe system principles for improving safety of VRUs.

Keywords: *Safe system, Vulnerable road user, crash, Dhaka, countermeasure*

1. INTRODUCTION

Road crash is common in every nation of the world.Each year more than 1.2 million people died in road crashes around the world. About 90 percent of fatalities takes place in low and middle incomecountries,and while these countries occupy 82% of entire people of the world(WHO, 2015).More than 50% of injuries of vulnerable road users claim lives in Southeast Asia, Africa and Europe. As a result, road traffic safety becomes a crucial topic in transportation engineering. The number of crash, in which the major victims are pedestrians, bicyclists, motor bicyclists etc., was not possible to be reduced significantly in past years. The vulnerable road users (VRUs), who are pedestrians, bicyclists, cycle rickshaw occupants and motorcyclists, incorporate the biggest portion (around 80%) of urban trip and they are victim of about 80 percent of road crashes in urban zone of Bangladesh (Hoque et al.). Therefore, it is urgent to introduce safe system to ensure the road safety of VRUs in Dhaka city. This paper focuses to present how safe system could be a proper countermeasure to the magnitude of alarming problem considering significant risk factors of crashes in Dhaka city.

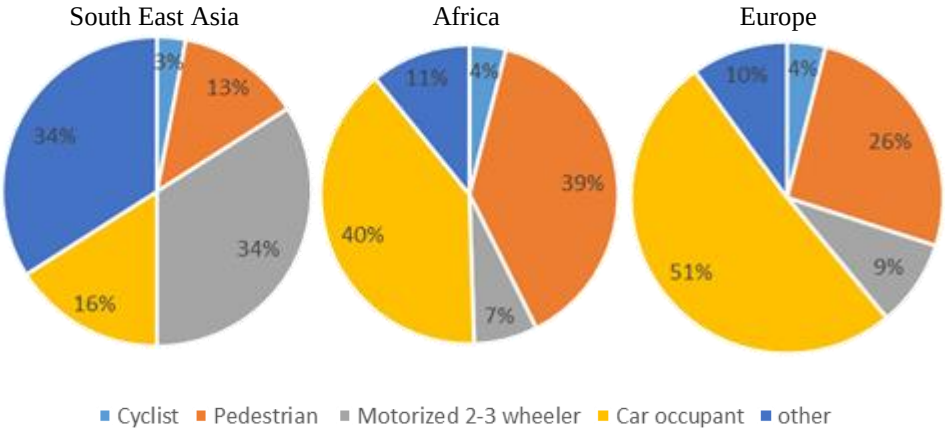

Figure 1: Fatalities of different types of road users around the world (Source: WHO, 2015)

2. SAFE SYSTEM APPROACH

The Safe System concept has the objective of eliminating deaths and serious injuries, with the guiding principle that everyone, including planners, share responsibility for creating a safe road system. Good planning and design sets the foundation for a safe road environment. This approach recognizes that road users inevitably make mistakes that may lead to a crash. In addition, the human body can only withstand certain impact forces before death or serious injury results. Safe system is required to prevent these deaths and serious injuries occurring.

According to the National Road Safety Strategy 2011–2020 (Australian Transport Council 2011),safe system is a road safety approach which holds that people will continue to make mistakes and that roads, vehicles and speeds should be designed to reduce the risk of crashes and to protect people in the event of a crash.

The Safe System comprises five essential components or pillars:

- safe roads and roadsides
- safe speeds
- safe vehicles
- alert and compliant road users (safe road use)
- post-crash care (according to WHO 2011)

Safe roads and road sides that minimize the risk of crashes occurring, and, when crashes do occur, ensure that death or serious injury are minimized. Roads should be predictable, self-explaining and encourage safe travel speeds. Safe speeds that suit the function and environment of the road, so that crash impact forces are managed within human tolerances. All road users should obey limits and drive to conditions. Safe vehicles that incorporate design features and technology that minimize the likelihood of crashes and protect road users (vehicle occupants and other road users, including pedestrians and cyclists) when crashes do occur. Safe road users should be alert, comply with road rules and engage in safe behavior. They are supported through education and information, enforcement of road rules and admittance to the system (e.g. through licensing).

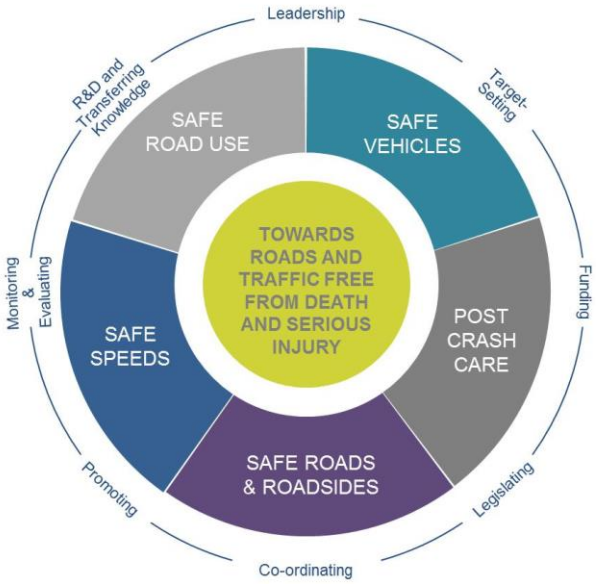

Figure 2: Fundamental elements of Safe system Approach

In order to ensure that safe system elements are considered, or to measure how well a given project (e.g. an intersection, road length, area, treatment type etc.) aligns with safe system principles, a safe system matrix has been produced. The purpose of the matrix is to assess different major vulnerable road users crash considering road users exposure,crash likelihood of it occurring and the severity of the crash should it occur.

Table 1: Safe system assessment matrix for vulnerable road users

	Pedestrian	**Cyclist**	**Motor cyclist**
Road users exposure	AADT; pedestrian numbers; crossing width; length of road segments	AADT; cyclist numbers; pedestrians	AADT; motorcycle numbers; length of road segment
Crash likelihood	Design of facilities; separation; number of conflicting directions; speed	Design of facilities; separation; speed	Design of facilities; separation; speed
Crash severity	Speed	Speed	Speed

3. METHODOLOGY

To find out the situation of vulnerable road users in Dhaka city on the context of their crash problems, some field investigations were performed at various critical areas of intense VRUs movements in Dhaka city. In field investigations photographs, videos and interviews of pedestrian, motor cyclist, pedal cyclist and rickshaw drivers were performed. The historical data from 2001 to 2014 was collected from MAAP (Modular Accident Analysis Program) database of Accident Research Institution (ARI), Bangladesh. From MAAP database, the data was taken in Microsoft excel spread sheet from where different analysis were piled on the research to get risk factors. Moreover, a star rating of iRAP is also executed. Finally, safe system countermeasures are suggested based on crash factors.

4. VRU CRASH DATA ANALYSIS AND RESULTS

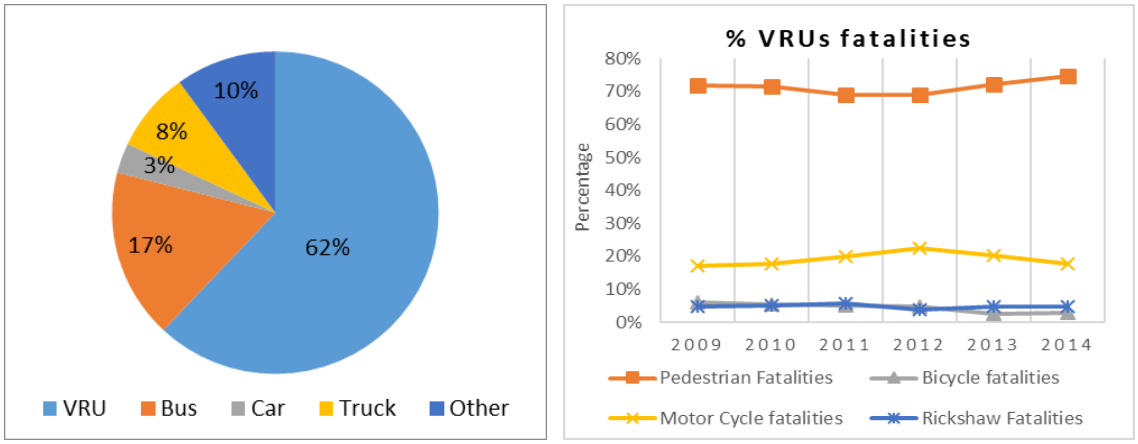

Figure 3: Fatalities of various road users in Bangladesh

Figure 3 shows that the percentage of vulnerable road userfatalities is just above 60% of roadcrash fatalities from 2009 to 2014 in Bangladesh. The right line graph of figure 3depicts percentage of fatalities for each significant member of vulnerable road users. As it is illustrated that in Bangladesh, percentage of pedestrian fatalities (70%) is predominantly higher than rest of the VRUs while motorcyclists about 20%.

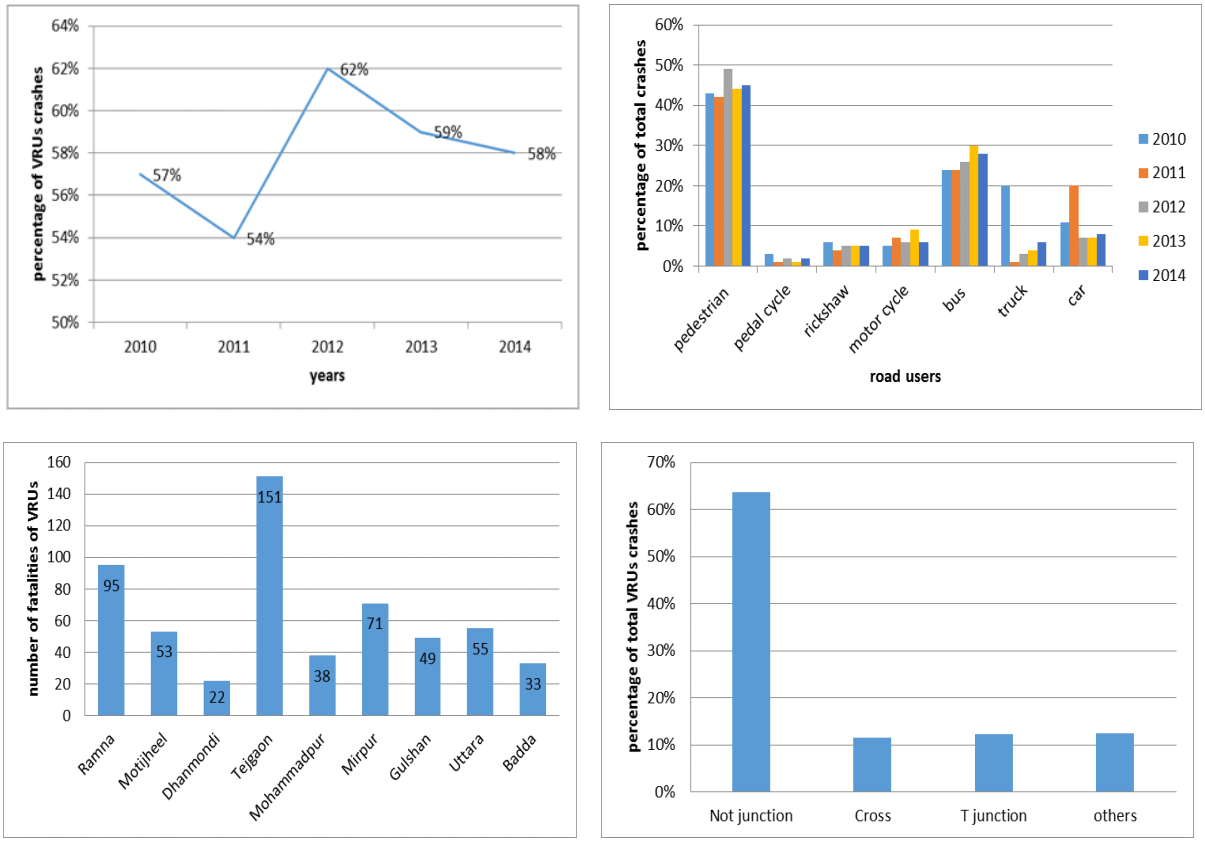

Figure 4: Condition of VRUs fatalities in Dhaka city (2001-2014)

From the left top graph of figure 4,it is obvious that VRUs crash percentage is more than half of total percentage of crashes in Dhaka city of which pedestrian crashes always remain between 40% to 50%,which is the highest one followed by buses and cars as illustrated in

the right-top graph .Tejgaon Thana of Dhaka city had experienced peak number of VRUs fatalities. However locational distribution for individual vulnerable road users crashes during 2001-2014 are as follows

- Nearly 65% of VRUs crashes occurred on the links (not junction) which is dominated by 83% of pedestrian affected with crashes on the links.
- Well above 45% motorcycle crashes occurred at crossing and remaining 22% occurred at straight road and 13% at T-junction.
- Most of the pedal cycle crashes (48%) occurred where there is no junction.
- Nearly 60% pedal rickshaw fatalities occurred at links or mid-blocks and remaining 40% occurred at intersections (T-junction 19%; crossing 10% and others 11%)

Distribution of fatalities for individual vulnerable road users during 2001-2014based on crash type are as follows

- Head on collision is the predominant type of motorcycle crashes (30%) whereas hit pedestrians 28%; rear end 25 %; side swipe 10%
- Among pedal rickshaw crash type, rear-end crash (83%) was the most critical.
- Rear end (58%) and head on (21%) was predominant crashes for pedal cyclists.

5. RISK FACTORS FOR VULNERABLE ROAD USERS

Figure 5: Heterogeneous traffic flow in Mirpur road near bolaka cinema hall.

Figure 6: Foot over bridge occupied by floating shops in Dhaka

5.1 Pedestrian concern

- Incompatible mix of vehicles and pedestrian
- Pedestrians are often exposed to danger during construction work
- Pedestrian facilities are occupied by hawkers and illegal shops
- Inoperative traffic signal and practice of avoiding signal

A star rating score is assigned to pedestrians based on crash likelihood, severity, operating speed, external flow influence and median travers ability using different equations following the iRAP methodology fact sheet #7: Star Rating Bands.

Table 2: iRAP star rating of roads of Dhaka city for pedestrian

Star Rating	Pedestrian Star Rating Score		
	Total	Along	Crossing
5	0 to <5	0 to <0.2	0 to <4.8
4	5 to <15	0.2 to <1	4.8 to <14
3	15 to <40	1 to <7.5	14 to <32.5
2	40 to <90	7.5 to <15	32.5 to <75
1	90+	15+	75+

Pedal Rickshaw and bicycle concern:

- Improper use of segregated lane
- Poor design of road junction and road section

Figure 7: Open drains on footpath in Dhaka city

Figure 8: No head protection while motor cycle riding

5.2 Motor cycle concern:

- Lack of obey stop sign/cross walk/intersection etc.
- Poor monitoring and law enforcement of helmet use
- Wrong perception of vehicle driver in right turn

6. SAFE SYSYTEM COUNTER MEASURES FOR VULNERABLE ROAD USERS

To produce effective road safety for VRUs, good management in all aspects of safety system in roads of Dhaka city is required.

6.1 Safe roads and roadsides elements:

Footway facilities: In Dhaka city hawker-free and attractive footpaths should be provided properly with efficient monitoring. Footway facilities show importance to separate the pedestrians away from the main traffic stream which will ultimately reduce the hit-pedestrian type of accident.

Crossing facilities:About 53% pedestrian casualties occurred while crossing the road in Dhaka city in 2010.So it is very important to provide crossing facilities.Median guard rail, shoulder etc. should be provided properly at midblock or link. Zebra crossing with high visibility should be applied in right place on the road. For school-goers of young ages pedestrian flag facilities can be applied.

Speed hump and pelican crossing facility: At low volume of traffic zone i.e. residential zone, speed hump and pelican crossing facility need to be applied.

Refuge island, dropped kerb, tactile surface:Refuge Island for pedestrian safe crossing the wide road, dropped kerb for road user with physical impairment and tactile surfaces for blind road user should be provided in city areas.

Segregated Lanes:Bicyclists, motor cyclists and pedal rickshaws are legal road users and have the right to use the roadway. Segregated lanes are wished to be used all over the world by such road users. Physical separation for bicyclists, rickshaws and motor cyclists by segregated lanes need to provide in Dhaka city to decrease fatalities of such road users.

6.2 Safe speed

Table 3 depicts that roads with vulnerable road users and motorized vehicle is crash prone when impact speed exceeds 30km/hr. If roadside hazards are protected (with barriers) and intersections are treated to reduce speeds to 50 km/h the travel speeds on the road can be 70 km/h. The addition of median barriers would enable higher operating speeds to be considered as well. Where motorcycles are a large proportion of the traffic, lower speed limits, perhaps 40 km/h, may be necessary. Speed management is at the centre of developing a safe road system. Where infrastructure safety cannot be improved in the foreseeable future and a road has a high crash risk, then reviews of speed limits, supported by appropriate and competent enforcement to support compliance, are a critically important option. Support through targeted infrastructure measures to achieve lower speeds should be considered. The scientific and evidence-based research shows that this will deliver a reduction of up to some 20% in the fatalities occurring on these lengths of roads (e.g. (Sliogeris, 1992). This of course assumes some enforcement support.

Table 3: Survivable impact speeds source: Tingvall& Haworth 1999

Impact speeds above which chances of survival or avoiding serious injury decrease rapidly		
Crash Type	**Impact Speed**	**Example**
Car/Pedestrian or Cyclist Car/motorcyclist	30 km/h	Where there is a mix of vulnerable road users and motor vehicle traffic
Car/Car (Side impact)	50 km/h	Where there is a likelihood of side impact crashes (e.g. intersections or access points).
Car/Car (Head-on)	70 km/h	Where there is no separation between opposing traffic streams

6.3 Safer vehicles

Especially in developed economies, the introduction of modern vehicle safety technologies has made a significant contribution to improved road safety. Modern bicycle,motor cycle and pedal rickshaw can be built with the 'safe system' concept central to their design, provided that they are driven within the limits of the environment (road, weather, traffic conditions etc) they are designed to withstand a crash.

The most significant improvements in crashworthiness have been active safety systems such as stability control. Now autonomous emergency braking and other advanced driver assistance systems are further reducing the vulnerability of vehicle occupants and other road users

6.4 Safe road user

Safety edge policy can be useful to prevent fatalities of road users, even protecting the pedestrians. It deals some precautionary rules and customs that are essential to avoid vulnerable road users' crashes. Here 10 tips are suggested for cyclists and motorcyclists.

Figure 9: 10 tips for pedal cyclist and motor cyclist safety in city road

POST CRASH CAR

Increased responsiveness to post-crash emergencies and improvements in the ability of health and other systems to provide appropriate emergency treatment and longer term rehabilitation for crash victims is also an important contribution to the Safe System.With improved bicycle, rickshaw and motorcycle safety and road design the number of deaths is likely to reduce but the long-term care of injured victims is an important social and public health consideration.

7. DISCUSSIONS AND CONCLUSIONS

Clearly the fatalities involving VRUs in road crashes are a serious problem.Crash studies and field investigations showed that indiscriminate driving on road, deficiencies associated with road infrastructure and lack of safe system are major contributors to VRUs fatalities and injuries. It is possible to provide safety for them by ensuring proper measures .Proper safe system andsafety infrastructure can resolve the crash problems of pedestrians, bicyclists, pedal rickshaws and motor cyclists in Dhaka city .Pedestrians and cyclists need to be fully

separated at all times with good line marking and delineation along with wide sealed shoulders. Wide clear median should be introduced whilethere is no median barriers present. Moreover, well managed crossing points need to be implemented for all VRUs ,particularly for motor cyclists. In order to reduce crash severity ,speed limit should not be exceeded 30 km/hr in heterogeneous road users system.The general drink-drive blood alcohol should be limited to 50mg /100ml. Security and aesthetics also are important factors to motivate road users to let VRUs engage with successful safe system.

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