Recommendations for driver licensing and traffic law enforcement in India aiming to improve road safety

Ashish Verma[1,*], S. Velumurugan[2], Neelima Chakrabarty[2] and Sushma Srinivas[1]

[1]Department of Civil Engineering, Centre for Infrastructure, Sustainable Transportation and Urban Planning, Indian Institute of Science, Bangalore 560 012, India
[2]Traffic Engineering and Safety Division, Central Road Research Institute, Mathura Road, New Delhi 110 025, India

During the last decade, developing countries such as India have been exhibiting rapid increase in human population and vehicles, and increase in road accidents. Inappropriate driving behaviour is considered one of the major causes of road accidents in India as compared to defective geometric design of pavement or mechanical defects in vehicles. It can result in conditions such as lack of lane discipline, disregard to traffic laws, frequent traffic violations, increase in crashes due to self-centred driving, etc. It also demotivates educated drivers from following good driving practices. Hence, improved driver behaviour can be an effective countermeasure to reduce the vulnerability of road users and inhibit crash risks. This article highlights improved driver behaviour through better driver education, driver training and licensing procedures along with good on-road enforcement; as an effective countermeasure to ensure road safety in India. Based on the review and analysis, the article also recommends certain measures pertaining to driver licensing and traffic law enforcement in India aimed at improving road safety.

Keywords: Driver behaviour, driver education, driver licensing, road safety, traffic law.

Introduction

THE basic goal of any transportation system is to provide safe mobility. Higher mobility minimizes travel time but may decrease safety. Hence, it becomes imperative that the concept of road safety be seen in a different and more serious light. Moreover, ensuring and maintaining higher level of road safety is an important element in achieving sustainable transport. The statistics from WHO as shown in Table 1 and Figure 1 confirms the fact that road traffic-related injuries are one of the prominent killers all over the world. Hence, road traffic injuries must be considered as a global health epidemic and effective countermeasures are required to tackle this pandemic. Also, according to the WHO[1] report on road safety, India tops the list of countries in the world, in terms of the number of road traffic deaths.

Road traffic in India is extremely heterogeneous in nature, consisting of pedestrians, bullock carts, bicycles, rickshaws, motorized two-wheelers, cars, buses, trucks, etc. Due to lack of segregation, the same road space is used by motorized as well as non-motorized traffic, thus creating unsafe conditions for the road users[2] especially vulnerable road users such as pedestrians, cyclists and motorcyclists. Table 2 presents the data on the number of road accidents by the type of vehicles involved in road crashes, in Europe. It is clear from the table that males are predominantly more injured than females. Looking at the fatalities in terms of vehicles, these occur mainly due to two wheelers (17.8%). Pedestrians, bi-cyclists and two-wheeler riders are the most vulnerable road users in India. In 2004, the number of fatalities per 10,000 vehicles was 1.1 and in the case of two-wheeler riders, it was 2.9.

Table 3 presents how the road traffic mortality rates have changed with time (1975–1998) in some countries (including India). Table 4 presents the number of road fatalities in Germany, Sweden, Denmark, Great Britain and India. It can be seen from the table that during 1980–2007, Germany has shown considerable decrease in road fatalities whereas India has shown a reverse trend with sharp increase in the number of road fatalities. Similarly, Figure 2 shows road traffic injury mortality rates (per 100,000 population) for WHO region. According to WHO[1], approximately 62% of the reported road traffic deaths occur in 10 countries – which in order of magnitude are India, China, the United States, the Russian Federation, Brazil, Iran, Mexico, Indonesia, South Africa and Egypt – and accounts for 56% of the world's population.

Overall, it is clear that the road safety scenario in India is alarming, and therefore it is important to understand and study the various factors that contribute to the road safety risk and make suitable recommendations for

*For correspondence. (e-mail: ashishv@civil.iisc.ernet.in)

Table 1. Leading cause of deaths by age group in the world (2004)

Rank	0–4 yrs	5–15 yrs	15–20 yrs	30–44 yrs	45–60 yrs	70+ yrs	Total
1.	Perinatal causes	Road respiratory infections	Road traffic injuries	HIV/AIDS disease	Ischaemic heart disease	Ischaemic heart disease	Ischaemic heart disease
2.	Lower respiratory infections	Road traffic injuries	HIV/AIDS	Tuberculosis	Cerebrovascular disease	Cerebrovascular disease	Cerebrovascular disease
3.	Diarrhoeal disease	Malaria	Tuberculosis	Road traffic injuries	HIV/AIDS	Chronic obstructive pulmonary disease	Lower respiratory infections
4.	Malaria	Drownings	Violence	Ischaemic heart disease	Tuberculosis	Lower respiratory disease	Perinatal causes
5.	Measles	Meningitis	Self-inflicted injuries	Self-inflicted injuries	Chronic obstructive pulmonary disease	Trachea, bronchus, lung cancers	Chronic obstructive pulmonary disease
6.	Congenital anomalies	Diarrhoeal disease	Lower respiratory infections	Violence	Trachea, bronchus, lung cancers	Diabetes mellitus	Diarrhoeal disease
7.	HIV/AIDS	HIV/AIDS	Drownings	Lower respiratory infections	Cirrhosis of the liver	Hypertensive heart disease	HIV/AIDS
8.	Whooping cough	Tuberculosis	Fires	Cerebrovascular disease	Road traffic injuries	Stomach cancer	Tuberculosis
9.	Meningitis	Protein–energy malnutrition	War and conflict	Cirrhosis of the liver	Lower respiratory infections	Colon and rectum cancers	Trachea, bronchus, lung cancers
10.	Tetanus	Fires	Maternal haemorrhage	Poisonings	Diabetes mellitus	Nephritis and nephrosis	Road traffic injuries
11.	Protein–energy malnutrition	Measles	Ischaemic heart disease	Maternal haemorrhage	Self-inflicted injuries	Alzheimer and other dementios	Diabetes mellitus
12.	Syphilis	Leukaemia	Poisonings	Fires	Stomach cancer	Tuberculosis	Malaria
13.	Drownings	Congenital anomalies	Abortion	Nephritis and nephrosis	Liver cancer	Liver cancer	Hypertensive heart disease
14.	Road traffic injuries	Trypanosomiosis	Leukaemia	Drownings	Breast cancer	Oesophagus cancer	Self-inflicted injuries
15.	Fires	Falls	Cerebrovascular disease	Breast cancer	Hypertensive heart disease	Cirrhosis of the liver	Stomach cancer
16.	Tuberculosis	Epilepsy	Diarrhoeal disease	War and conflict	Nephritis and nephrosis	Inflammatory heart disease	Cirrhosis of the liver
17.	Endocrine disorders	Leishmaniasis	Falls	Falls	Oesophagus cancer	Breast cancer	Nephritis and nephrosis
18.	Upper respiratory infections	Violence	Meningitis	Diarrhoeal diseases	Colon and rectum cancers	Prostate cancer	Colon and rectum cancers
19.	Iron deficiency anaemia	War and conflict	Nephritis and nephrosis	Liver cancer	Poisonings	Falls	Liver cancer
20.	Epilepsy	Poisonings	Malaria	Trachea, bronchus, lung cancers	Mouth and oro-pharynx cancers	Road traffic injuries	Violence

Source: Ref. 24.

improving the present scenario in India. In general, vulnerability of road users occurs due to factors such as errors committed by people within the system, quantum and nature of kinetic energy of the impact to which people in the system are exposed, tolerance of individual to the impact, the quality and availability of emergency services[3].

Road safety is considered to be a function of four elements, viz. factors influencing exposure to risk, factors influencing crash involvement, factors influencing crash

severity and factors influencing severity of post-crash injuries[3,4]. These four elements include factors that can be described as acute impairments such as driver's age, gender-related differences, alcohol, drugs, engineering factors related to vehicles, environmental factors, impact of drivers' behavioural and psychological changes, faulty road design, the road layout, maintenance of roads and so on.

Countermeasures against the road safety epidemic include the three Es, viz. education, engineering and enforcement. Education involves spreading awareness related to road safety issues in schools, through traffic parks, media and awareness programmes, banners and hoardings; driver education, training and licensing, etc. Engineering measures primarily includes improving road safety by utilizing concepts of traffic engineering, transport planning, geometric design of roads, etc. Enforcement encompasses aspects such as enforcing traffic rules by traffic police personnel, credit system on license, incentives for safe/violation free driving, use of technologies such as radar gun, closed-circuit television (CCTV) intelligent transportation system (ITS), etc. Besides these, various psychophysical factors of the driver also have a substantial effect on road safety.

The Indian government in recent years has been emphasizing on engineering measures by making the Road Safety Audit (RSA) compulsory for all new and existing highways, however there is still little focus on education and enforcement measures and improvement in the psychophysical traits of drivers as countermeasures for road safety in India. Therefore, this article focuses only on improvements in psychophysical traits of the driver, as well as education and enforcement.

Psychophysical factors affecting road safety

The human factors governing road-user behaviour predominantly involves: visual feedback, visual performance, speed judgement, speed adaptation, judgement of relative speed, judgement of spacing, overtaking, reaction time, etc. Some personality factors of the driver may contribute in a significant manner towards road traffic hazard involvement. Personality denotes stable character traits that do not change over short time periods. Emotional stress may produce short- or medium-term departures from an individual's long-term average driving behaviour[5].

Driving is a serious responsibility and it demands and deserves full and undivided attention of the driver. However, there are many driver distractions which contribute to crashes and injuries. The level of safety of road system is influenced by all road users among which the driver plays a crucial role in road safety through scanning, processing and applying appropriate action patterns towards oncoming stimuli. For escalating fear of unsafe driving conditions, testing and evaluation of driver's psychophysical ability traits has become an integral part of road safety. Driving is a skill that requires constant and complex co-ordination of mind and body of the driver. It involves multi-task activities, i.e. operating heavy machinery at high speed, navigating across changing terrain, calculating speeds and distances and responding to all the other drivers and obstacles. It becomes all the more difficult to drive on Indian roads (and developing countries in general) where there is lack of lane discipline and the traffic is extremely heterogeneous. A driver's ability to manage driving-related psychomotor functions varies widely and can change from day-to-day depending upon his level of stress and fatigue. A driver requires certain basic skills to perform his driving task efficiently. The skills needed by a driver include the following.

- *Visual skill* (seeing), e.g. watching the road in front and around the vehicle, using mirrors, shoulder checks, checking gauges, speedometer, etc.
- *Auditory skill* (listening), e.g. squealing of brakes, the sirens of an emergency vehicle, vehicle sounds, etc.
- *Bio-mechanical* (performing hand–eye co-ordination), e.g. turning the steering wheel, activating signals, headlights, horn, etc.; pressing the accelerator, brakes, clutch, etc.
- *Cognitive* (thinking), e.g. anticipating any future movements, dynamic route planning, assessing situations such as movements of other vehicles, weather conditions, preparing to avoid hazards, etc.

In a recent study done at Guwahati, India[6], an attempt was made to identify the shortcomings in physical attributes of the drivers that may pose road safety hazards such as visual acuity, peripheral vision, depth perception, glare recovery, colour vision, contrast sensitivity, phoria, etc. Based on the analysis of data collected, the following important findings were reported by them.

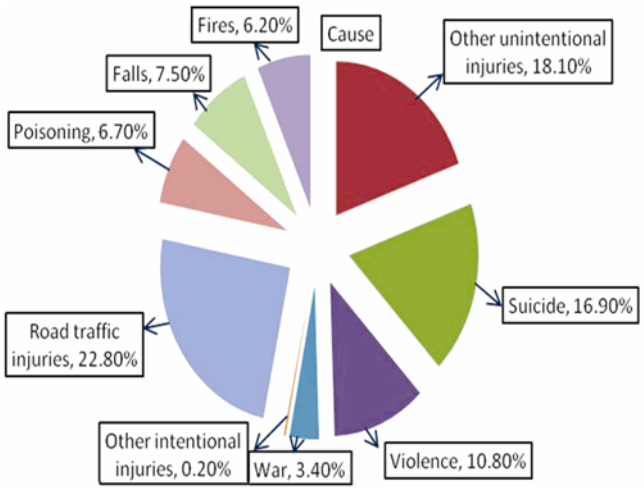

Figure 1. Distribution of global injury mortality by cause. Source: ref. 3.

Table 2. Sex-wise road accident deaths by type of vehicle during 2006 in Europe

Type of vehicle	Number of road accidental deaths			% share of total vehicles
	Male	Female	Total	
Truck/Lorry	20,958	2,910	23,868	22.6
Government	440	78	518	0.5
Private	20,518	2,832	23,350	22.1
Bus	10,170	2,455	12,625	11.9
Government	3,556	800	4,356	4.1
Private	6,614	1,655	8,269	7.8
Tempo/Vans	4,592	1,047	5,639	5.3
Government	124	27	151	0.1
Private	4,468	1,020	5,488	5.2
Jeep	7,480	1,636	9,116	8.6
Government	209	56	265	0.3
Private	7,271	1,580	8,851	8.4
Car	7,507	2,027	9,534	9.0
Government	144	36	180	0.2
Private	7,363	1,991	9,354	8.8
Three-wheeler	4,757	1,128	5,885	5.6
Two-wheeler	16,491	2,342	18,833	17.8
Bicycle	2,672	235	2,907	2.7
Pedestrian	7,403	1,503	8,906	8.4
Others	7,147	1,265	8,412	8.0
Total	89,177	16,548	105,725	100.0

Data from ref. 25.

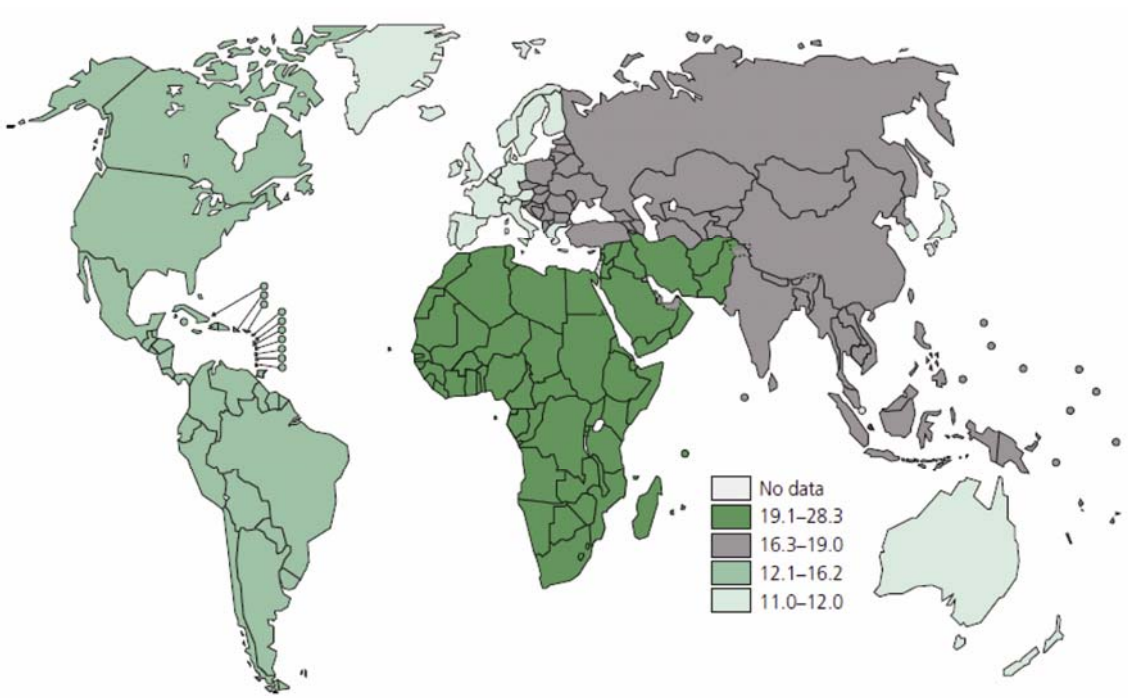

Figure 2. Road traffic injury mortality rates (per 100,000 population) in WHO regions, 2002. Source: Ref. 3.

- Three per cent of the drivers failed in the phoria test, which checks for proper eye muscles and co-ordination of both eyes to correctly identify the placement of an object ahead. If a particular driver performs 'unacceptable' in this test, then it indicates that the driver may not be able to identify the position of an object such as, vehicle, pedestrian, etc. in front of him/her on the road correctly.

Table 3. Changes in road traffic fatality rates (deaths per 10,000 population), 1975–1998

Country/Area	Change (%)
Canada	–63.4
China	
Hong Kong SAR	–61.7
Province of Taiwan	–32.0
Sweden	–58.3
Israel	–49.7
France	–42.6
New Zealand	–33.2
United States of America	–27.2
Japan	–24.5
Malaysia	44.3
India	79.3[a]
Sri Lanka	84.5
Lesotho	192.8
Colombia	237.1
China	243.0
Botswana	383.8[b]

SAR: Special administrative region. [a]Refers to the period 1980–1998. [b]Refers to the period 1976–1998. Source: Ref. 3.

- Twelve per cent of the drivers performed 'unacceptable' in the depth judgement test, which is a very important physical attribute to ensure that safe overtaking or safe stopping distance is maintained by a driver on the road.
- Seven per cent of the drivers failed in the glare recovery test, which is an important parameter for safe driving during night, especially on undivided roads, which are predominant in India, and where there is a substantial glare of headlight of the opposing vehicles.
- Five per cent of the drivers were found to have problem of tunnel vision while driving, which shows that such drivers may not be able to identify the side obstructions and correspondingly respond to the stimulus on time.
- Fifteen per cent of the drivers were found to have unacceptable acuity vision in one of the eyes and 4% in both the eyes.
- Five per cent of the drivers had problem with night vision (vision in the presence of headlight).
- Performance of 5% of the drivers was found 'unacceptable' in colour vision test.

Similarly, based on a study conducted in Hyderabad[7] in India, it was observed that about 11% of motorized two-wheeler drivers drive the vehicle without possessing driving license. This tendency was higher in the case of drivers aged between 16 and 25 years. Also, 0.5% were found to get a driver license before 15 years of age. Out of all license holders who were surveyed in the study, 21.4% had obtained the license without taking the mandatory driving test. Thirty per cent of the drivers were found to overtake other vehicles from any side depending on traffic conditions. Over 50% were found to drive the vehicle in the direction opposite to the flow of traffic. Out of all the drivers who were caught by the traffic police, 56% paid the fine while 26% paid bribe to escape. Regarding vehicle conditions, 49% of drivers had no rearview mirror.

Further, studies conducted worldwide highlight the three different stages a person undergoes while learning driving. First is the direct feedback stage, in which the driver learns basic driving skills through trial and error. The second stage is the intermediate and associative phase, in which the driver begins to distinguish different types of skills and psychomotor traits associated with driving. In the final stage, the driver becomes autonomous or habitual and merely follows traffic rules keeping the goal of driving in mind. However, once the confidence is achieved, the drivers indulge themselves in more risk-taking practices and will even violate traffic rules to achieve their goal. This stage is called automaticity in cognitive psychology. Generally young drivers become habitual of this stage for feeling pleasure in speed while driving and to set themselves above their peers. Particularly, young male drivers overestimate their own competence and therefore, violate traffic rules and create traffic hazards[8–10]. To check out habituation of speed and other risk-taking practices, evaluation of driver's psychomotor abilities is an essential aspect in road safety. The purpose of testing the psychomotor abilities of drivers is to make them realize their own habitual practices that are dangerous in driving and give them necessary guidance for safe and careful driving. However, in many circumstances traffic psychological examinations are specially required for extensive diagnostics.

Driver education: an overview

Besides psychophysical factors, driver education is also a significant tool to improve driver performance and increase driver responsibility. It helps them adhere to rules, regulations as consciously as possible. Driver training and education is not the same thing; the former is included in the latter as a subset[11]. It can provide primary prevention in reducing crash risks and it obligates new drivers to use safety equipments provided in vehicles and to do so in a correct manner[12].

Cornerstones of driver education

The three cornerstones of driver education can be described as: the goal of driver education, content and method of driver education, and the testing procedure. All of these should form a harmonized entity for effectiveness[13]. Essence of each part should be reflected in other parts. Such type of harmonization requires involvement of qualified instructors, examiners having necessary knowledge, competence and teaching skills to fulfil all

Table 4. Road fatalities, 1980–2004

	Germany	Sweden	Great Britain	Denmark	India
1980	15,050	848	6240	690	24,000
1990	11,046	772	5402	634	54,100
2000	7,503	592	3580	498	78,911
2001	6,977	583	3598	431	80,888
2002	6,842	560	3581	463	84,674
2003	6,613	529	3658	432	85,998
2004	5,842	480	3368	369	92,618
2005	5,361	440	3336	331	94,985
2006	5,094	445	3298	251	105,725
2007	4,949	471	2946	293	114,590

Source: Refs 1, 15 and 16.

Table 5. GDE matrix

Level	Knowledge and skill	Risk increasing aspects	Self-assessment
Goals for life and skills for living	Understanding the importance of lifestyle, age group, culture, social circumstances, etc.	Understanding the importance of sensation seeking, risk acceptance, group norms, peer pressure, etc.	Understanding the importance of introspection, competence, personal preconditions for safe driving, impulse control, etc.
Goals for and context of driving	Understanding the importance of modal choice, time-of-day, motives for driving, route planning, etc.	Understanding the impact of alcohol, fatigue, low friction, rush hour traffic, Peer-age passengers, etc.	Understanding the importance of personal motives, self-critical thinking, etc.
Driving in traffic situations	Mastering traffic rules, hazard perception, etc. Automating elements of the driving process. Cooperating with other drivers, etc.	Understanding the risks associated with disobeying rules, close-following, low friction, vulnerable road users, etc.	Calibration of driving skills, developing a personal driving style, etc.
Vehicle control	Mastering vehicle functioning, protective systems, vehicle control, etc. Understanding the impact of physical laws.	Understanding risks associated with non-use of seat belts, breakdown of vehicle systems, worn-out tyres, etc.	Calibration of car control skills

Source: Ref. 16.

aspects of driver training[12]. In case of disharmony, there may be a negative impact on the content of driver education[14]. Messick[14] discussed that all the areas constituting driver education system should get equal importance from both instructors and learners. Aspects of training that cannot be tested should be obligatory elements within training[15].

Goals of driver education

The goal of the licensing process, including driver training, should be to create drivers who are safe, environmentally conscious and not just technically competent[15]. In addition to this, driver training should enhance the skills of the drivers making them aware of their limitations. Driver education should involve all aspects that cause road injuries in an effective manner along with concentration on vehicle control and the application of traffic rules. In an international review of literature on effectiveness of driver training as a road safety measure[11], the following important observations were made emphazing the need for carrying out driver training and education.

- The research evidence suggests that driver training of a conventional nature seldom contributes to reductions in road crash involvement or risk among drivers of all ages and experience groups.
- Improvement in driver training can be achieved in the longer term by concentrating on cognitive and perceptual skills, together with a greater emphasis on how factors such as attitude and motivation shape driver behaviour.
- Drivers, particularly young drivers, do take risks that have less to do with how much skill and/or knowledge they possess, but more to do with motivation and higher-order factors.

Considering the above limitations, Hatakka *et al.*[16] developed the Goal to Driver Education (GDE) matrix to provide an overview about what should be covered under driver education and training. Table 5 shows the GDE matrix. The matrix comprises a four-level hierarchy and three main training dimensions which should be included in a driver training system. The GDE matrix has been designed based on the understating that it is the attitudinal and motivational factors that are more influential in controlling driver behaviour and consequently the crash risks, as compared to driving in various traffic situations and vehicle control abilities.

The following is a brief description of each level:

Level 4. Goals for life and skills for living: The highest level refers to personal motives, objectives and tendencies in a broader perspective. This level is based on the presumption that lifestyles, group norms, gender, social background, age and other social and individual preconditions will influence road-user behaviour and consequently, crash involvement.

Level 3. Goals for and context of driving: This refers to the goals behind driving and the context in which driving is performed as well as decisions related to why, where, when and with whom driving occurs, all in relation to the purpose of the trip.

Level 2. Driving in traffic situations: The second level concerns about mastering driving in specific traffic situations. The ability to adapt her/his driving behaviour with the changes occurring during driving and to identify potential hazards in traffic and to act correctly to avoid them also exists at this level.

Level 1. Vehicle control: The lowest level focuses on the basic manoeuvering skills of the driver. The ability to manage the vehicle (i.e. steer, brake, shift gears, etc.) belongs at this level. The proper use of injury preventive systems, such as seat belts, child restraints and airbags, also belongs here, as these are subsystems of the vehicle.

The idea behind this hierarchical approach is that both success and failure on the higher levels can affect the demands on the lower levels, even though the process can also occur in reverse, i.e. changes at the lower levels may also have an impact on the higher levels. These four levels when combined with three training dimensions which are knowledge and skills, risk-increasing factors and self-evaluation become the core of the GDE matrix. The cells of the GDE matrix thus form the conceptual structure in order to produce a safe and environment-friendly driver. The GDE matrix provides a useful tool for ensuring that driver education curriculum covers all necessary goals by categorizing different aspects of the training process[15]. Presently, driver education in countries such as Norway, Finland and Sweden is based on the GDE matrix.

Driver education system

European countries: The driver education system can be categorized into three categories based on the possibility of fulfilment of the objectives of education. The first category contains little or no compulsory education as followed in Sweden and Great Britain. The second category consists of compulsory education as well as private education as followed in Finland, Iceland and Norway. The third category consists of formal driver education but private education is forbidden. This is practised in Germany and Denmark.

Both Sweden and Great Britain have minimal control over driver education. Thus, the theoretical and practical tests are the only way to make sure that the objectives of the curriculum are fulfiled. In Sweden, efforts have been made to integrate the theoretical and practical parts as much as possible. The education curriculum is also focused more on traffic safety. As the curriculum does not contain any mandatory areas, the effect of this strategy is limited.

Finland, Iceland and Norway are all countries where major parts of the driver education are mandatory. Here, the driver education system has different stages, as education can emphatically describe different knowledge and abilities at different stages. In Finland, the mandatory areas of the first stage of education involve necessary attitudes and abilities to drive independently. The second stage emphasizes on developing further driving abilities. Much effort is being made to develop the student's capacity for self-evaluation. In Norway, the mandatory education consists of three parts: driving in traffic, driving after dark and driving on slippery surfaces. The parts comprises 9.5 hours training, which a student has to go through under the supervision of a qualified instructor.

Germany and Denmark are two countries where driver education must be conducted at a driving school since private education is forbidden. In Germany education is divided into different phases. An applicant for driving license must first attend a special first-aid course. On successful completion of the first-aid course, he/she is allowed to begin the driver education. The course is divided into basic and special education. During the basic practical education the student shall achieve the necessary knowledge and abilities needed in order to profit from the special education[13].

United States: In North America, there persists a long historical link between driver education and the licensing process. In most jurisdictions, a driver education programme is mandatory for new applicants as a part of the licensing process. This can take several forms, e.g. all

beginners regardless of age must take driver education, or beginners aged 16 and 17 can only get license if they take the driver education programme; those aged 18 years and above need not do so, etc. In some jurisdictions where driver education is available on a voluntary basis, beginners often take the course to prepare for the practical road test. These types of courses typically focus on the skills and knowledge that are needed to pass the road test and obtain a driver's license.

In 1994, NHTSA[17] recommended a two-phase driver education programme as part of graduated licensing. This involves two phases of education. In the first phase, basic vehicle handling skills and rules of the road are taught and in the second phase safe driving procedures, including perceptual and decision-making skills are taught. Consistent with the multi-stage structure of graduated licensing, phase-one occurs during the learner stage and phase-two during the intermediate stage of this licensing process. To date, Michigan is the only jurisdiction to adopt such a two-phase driver education programme[18].

Driver licensing systems: Despite dissimilarities among all driver licensing systems, they are based on a certain, albeit widely varying framework (comprising among other things: laws, regulations, administrative processes, a curricula and test procedures) that states the requirements for obtaining a license to operate a motor vehicle in road traffic[15].

Categories of licensing systems: Traditional licensing systems include only one phase of theoretical and practical training that ends with a written and a driving test. The traditional licensing system is often called as 'single-phase licensing system'. This system is quite common in Europe for example in countries such as Belgium, Denmark, France, Netherlands, etc. In other systems, probationary license systems which are very similar to single-phase but candidate must complete a provisional phase of driving before becoming a fully licensed driver. Countries following this single-phase system with probationary license are Germany, Austria, Norway, Sweden, etc. The last general variant of traditional driver licensing is the two-phase system, where the candidate receives a provisional or probationary license after passing written and practical driving tests which ends the first phase. This provisional license is valid for a certain period, after that, a full license is issued on completion of the second phase of theory and training, but without further testing. Finland and Luxembourg follow this kind of system[12,15,19].

Graduated driver licensing systems: These systems include three stages such as 'learner', 'provisional' and 'fully licensed'. These stages are aimed at ensuring that the driver will gain experience under conditions that are as safe as possible. First is the learner stage, which ends when the applicant passes a driving test. Only supervised practice is allowed during this period. A minimum number of hours of such practice is often required, and the learner's permit must be held for a certain length of time, and in some cases there are certain restrictions (e.g. learner license holder cannot carry other passengers or the learner is not permitted to use a cell phone while driving). Next is the intermediate or provisional stage and it entails a period with a provisional license that is valid for a specified length of time during which unsupervised driving is permitted. This stage involves different driving restrictions, such as on night-time driving, peer-age passengers and/or alcohol and restraints regarding the presence of passengers in the vehicle. If the driver complies with the restrictions, he/she receives full license privileges as soon as the stipulated time period is over, and thus this is the last stage of the graduated licensing system, and no further tests are required. There are many varieties of graduated systems which are used in the United States, Canada, New Zealand and Australia. The differences among the systems of different countries are the age at which an applicant is allowed to start practising, the length of the learner stage, restrictions while driving and minimum requirements[18,20]. Evaluations of graduated driver licensing (GDL) programmes in New Zealand and North America show significant reductions in novice driver crashes ranging from 7% to over 55%. Preliminary evaluation of the South Australian GDL suggests that it has contributed to significant reductions in casualty crashes involving 16–19 year olds[11].

Effectiveness of elements of licensing process

An effective driver licensing process can put a check on reckless driving and would help in creating safe drivers. The following sub-sections discuss some of the important elements of the licensing process in the context of road safety.

Licensing age for solo driving

The minimum age for driving is decided based on local conditions, degree of urbanization and road safety measures. Mainly young drivers are involved in crash risks[7], so the decision taken in this regard will surely affect the crash risks. Figure 3 shows how road traffic fatalities varies among youth under the age of 25 years (by age group and gender), and it can be seen that the fatality trends are inversely proportional to the age and also males carry higher risk as compared to females. Further from Figure 4, it can be seen that the road traffic injuries and fatalities among road users below 25 years of age in India, are very high for motorcyclists. Also, the studies have revealed that the crash risk is inversely proportional to the driving age before any individuals attains the age of 18 years. In Sweden[21], the norm for the issuance of learner driving

license has been lowered to 16 years while retaining the driving licensing age at 18 years for solo driving and this strategy has enabled the drivers possessing learner license to acquire more driving practice time which in turn proved to be effective in enhancing road safety.

Content and method of training

The GDE matrix provides the necessary content to be included in a driver education and licensing system. GDE matrix being hierarchical provides a formulation of driver's task, including the personal and psychological behaviours, attitudes and abilities[16]. Traditionally, driver training laid emphasis on bottom levels of GDE, but Hatakka *et al.*[16] proposed the necessity to focus on all levels as they pose the greatest influence on drivers in situations in which they will most likely find themselves.

The GDE matrix was initially developed in the European context, although its applicability can be considered to have wider scope. Before the development of GDE framework in Sweden, the old curriculum was very detailed but an implication of GDE was that it was more goal oriented and tried to focus evenly on lower as well as higher levels[22]. From the North American point of view, Mayhew[18] notes that driver education curriculum should focus on hazard perception, skill deficiencies, over reaction and slow response, errors occurred while driving, risky and inappropriate behaviour, as well as on self awareness and the context in which driving is being performed. This also shows the utility of GDE framework. At present, GDE is a theoretical concept but it is fast finding its place in driver education curriculum of various countries.

Regarding content in European scenario, the topics covered in theoretical training (according to priority) are: traffic regulation, behaviour towards others, vehicle technique, hazard perception, environmental friendly driving and first aid training. Main topics emphasised in practical (pre-test) training are safety car checks, driving away, changing directions, mastery of traffic situations, reversing the vehicle, etc.[13].

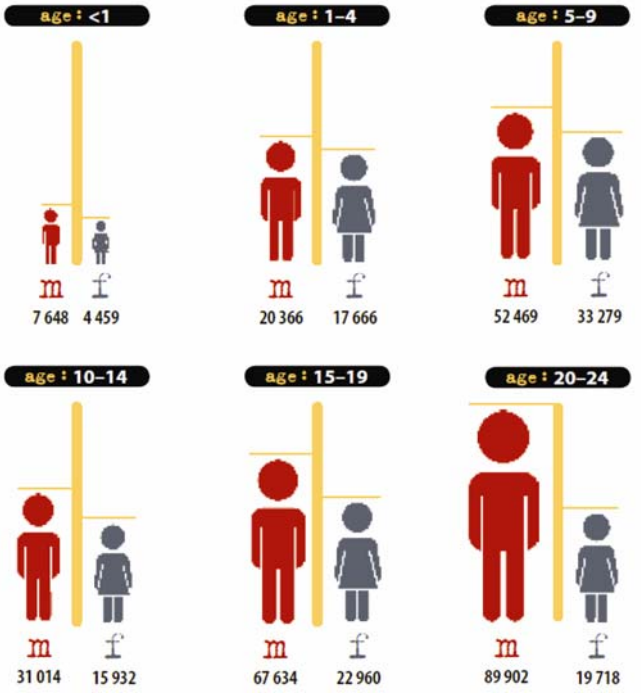

Figure 3. Road traffic fatalities among youth under the age of 25 years, by age group (in years) and sex, 2002. Source: WHO (2007).

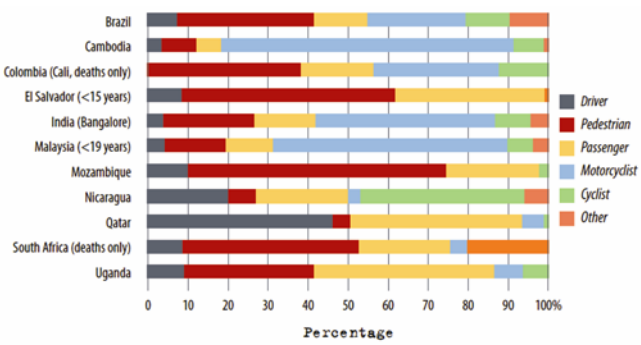

Figure 4. Injuries and fatalities among road users in selected countries (<25 years). Source: Ref. 26.

Formal pre-licensing training

In formal pre-license training, the learner driver performs under the supervision of an instructor. Formal pre-license training is defined as training in which a candidate driver practices under the supervision of a qualified driving instructor, while simultaneously receiving instruction regarding how to drive and as part of a structured training process. Different reviews and journals have studied the effectiveness of formal pre-license driver training and have found that this training is not consistently effective as a safety measure as there is mixed evidence suggesting reduction in crash rates[11,19].

Recent overviews on the content of formal pre-licensed training OECD[15] have shown that current driver training systems primarily focus on the 'bottom order' such as vehicle control and the execution of manoeuvers like overtaking, etc., while there is not much emphasis given to the training on issues like route finding and self-assessment of driving skills. Including the higher levels in driver training can make an effective countermeasure for road safety.

Informal pre-license training (accompanied driving)

Informal pre-license training is also named as accompanied driving as it allows the novice drivers to gain experience in the presence of an experienced driver without

requiring a driving instructor. Pre-license training is followed in Sweden, France and Norway as a part of their driver education curriculum by lowering the age for training while fixing the same age for granting full license. The training should be conducted in such a way that learners can attain a higher level of practice before driving individually[15].

Use of driving test as a selection instrument

Most of the countries use two types of procedures to test the applicant drivers: theoretical and practical. Tests are means of assessing the performance of test takers and allowing them to get a license to drive. Driving test is an important tool to assess whether the objectives of driver education are fulfilled. Driver licensing test should be of good standard[23].

In Great Britain and Norway, standardized test routes are used to ensure that the test contains certain specific elements. In Sweden, the practical test is carried out in the real traffic environment and the examiner ensures that all relevant traffic situations are present in the route[13]. Any changes regarding driving test should be related to aspects of safety and mobility. Furthermore, this process of licensing system must be free from all types of corruptions[7,15] as permission to drive is a much-sought-after commodity in any country.

From the above discussion, it is obvious that many types of driver licensing systems are in vogue in different countries and the next section elaborates on the driving licensing system practised in India.

Current driving licensing system in India

In India, issuing license is considered officially a state matter. In each state, driving license is issued by the Regional Transport Offices (RTOs). Unfortunately, prior driver education is not mandatory for getting a driver license. All matters related to driver education and licensing in India are presently regulated by the Motor Vehicle Act 1988 and the Central Motor Vehicles Rule 1989. The following are some of the glaring lacunae in these regulations.

- As per Sub-section (1) of Section-4 of the Motor Vehicle Act 1988, a motorcycle with engine capacity not exceeding 50 cc and without gear (provided parents/guardian consent obtained) may be driven in a public place by a person after attaining the age of 16 years. This is potentially hazardous as young drivers are more involved in crashes and two-wheeler drivers are among the vulnerable road users.
- As per Sub-section (3) of Section-8 of the Motor Vehicle Act 1988, a self-declaration, medical certificate from a registered medical practitioner in case of a non-transport and transport vehicle respectively, is sufficient for grant of learner's license in India. If not declared with truthfulness, this could pose serious safety hazards due to presence of drivers with certain physical abnormalities in traffic and which may hinder the driver from safe driving. This risk is more clear from the recent study of Chauhan[6].
- As per Sub-section (3) of Section-9 of the Motor Vehicle Act 1988, where the application is for a driving license to drive a motor vehicle (not being a transport vehicle), the licensing authority may exempt the applicant from the test of competence to drive a vehicle prescribed under this sub-section, if the applicant possesses a driving certificate issued by any institution recognized by the state government. This also poses road safety risks as the driver is given license merely based on a certificate, which may not have been issued after subjecting the individual to adequate training and education which is very much essential.
- Sub-section (3) of Section-15 of the Central Motor Vehicles Rules 1989 lays down criteria of only practical driving test, which focuses only on basic vehicle control and manoeuvering capabilities. However, even these criteria are seldom followed by the person conducting the test.
- Section-31 of the Central Motor Vehicles Rules 1989 elaborates the syllabus to be followed by driving schools for imparting theoretical instructions in driving of motor vehicles. This includes only basic driving, traffic and vehicle maintenance education, which is seldom pursued by driving schools in India. Also, no formal published material (based on the prescribed syllabus) is available to impart the driver education.

Above all, the present system in India is totally based on conventional driver education and testing, which has serious limitations with respect to road safety as highlighted by Christie[11].

Traffic law enforcement in India

Among the three Es to ensure road safety, enforcement is equally important to provide an effective and sustained countermeasure against road safety. However, in India, the present system of enforcement is mostly human based, i.e. through traffic police personnel with negligible use of technology; and is therefore ineffective, error prone, inadequate and often corrupt. The following are the typical functions of traffic police personnel in India.

- Enforce traffic laws
- Administer traffic at busy intersections
- Organize proper parking of vehicles in high activity areas

- Educate road users about road rules and safe driving
- Monitor passengers and bus drivers at bus stops to prevent overcrowding and jostling
- Monitor traffic outside schools
- Assist pedestrians, especially children, old and disabled in safe usage of road
- Conduct surveys for better traffic management

However, all these activities are not satisfactorily done due to the following factors.

- Less number of traffic police personnel for surveillance in proportion to the road users. Moreover, there is negligible use of ITS technologies for traffic monitoring and law enforcement.
- Somehow, corruption is deep rooted in some parts of the system and thus creating disbelief regarding law among the citizen which ultimately create disobedience for the traffic rules.
- Highly influential citizens and youth often break the traffic rules to show off their power and ego.
- Low moral education and reducing ethical values among road users create more negligence for obeying traffic rules and regulations.
- Major loopholes, e.g. no compulsory helmet use for women and Sikhs while riding motorbikes, no rule for bicycles and cycle rickshaws also create hazards on road and disobedience of traffic rules.

Recommendations for Indian conditions

Currently, India follows a single-phase licensing system with probationary period. It is worth amending the driving licensing system in India considering the international experience quoted in this paper and hence the following preliminary recommendations have been made for improving the road safety situation in India.

Licensing age: It has been established from past studies that the lowering of the learner licensing age limit is a good strategy for lowering the road traffic crashes since it facilitates more time for the novice drivers to learning safe driving. In India, two-wheelers are involved more than any other vehicle in road crashes, while the learner age for two-wheeler vehicle (up to 50 cc, i.e. moped) is 16 years, one can get full license at the age of 16.5 years, i.e. within 180 days of getting a learner license. Considering the fact that the motorized two-wheelers are the prime cause for road traffic injuries, the age limit for solo driving of two-wheelers in India can be made 18 years.

Experience: The curriculum should be such that learner drivers can get sufficient amount of practice and are better prepared to handle high risks, which they may encounter in initial years after getting a license for solo driving. Swedish research shows that learners who received about 118 hours of supervised experience had up to 35% fewer crashes than those who received only 41–47 hours.

Pre-licensing training: Sufficient amount of practice, at least 50 hours of pre-licensing practice should be made mandatory before embarking upon solo driving. These policies may not be implemented very easily as in the case of Victoria in Australia where a 120 hours training was announced as a long-term plan but became mandatory only after seven years, but efforts are needed in this direction.

License renewal: The first renewal age for licenses is 40 years in India. According to a study conducted in Guwahati, middle age group drivers fail the most in vision-related physical tests for safe driving, yet after issuing license initially, they are never tested again. Hence, the renewal period can be revised spanning a time duration of 5–7 years.

Test according to specifics of a driver: In India, the testing procedures are common for all the drivers. But, considering the heterogeneity of traffic situation in India, different tests based on the type of vehicle, age, etc. may be conducted.

National licensing system: Previous researches have shown little effectiveness resulting from formal training practices, so changes in existing training and testing procedures should be considered. In any driving curriculum, the three elements (goals of driver education, content/method of education and testing procedures) should be in harmony with each other. It is also considered meaningful to borrow some trends and contents from international driving education and licensing system. Some of them are summarized here.

- Mandatory physical tests to assess various physiological characteristics of the driver, which are important for safe driving.
- Compulsory and formal driver education (possibly based on GDE) as part of the licensing process
- Graduated driver licensing system.
- Mandatory formal and informal practice before licensing.
- Involvement of hazard perception test in license test.
- Restriction gradually removed from probationary license.
- Absence of any corruption in licensing system.

Use of ITS for traffic law enforcement: Use of technologies such as vehicle-actuated traffic signals, surveillance cameras, enforcement cameras and establishment of centralized traffic management centres will go a long way in

ensuring adherence to traffic laws and thus improve road safety scenario in India.

Increased supervision and graduated licensing for novice drivers and effective traffic law enforcement for all drivers are likely to make greater and more lasting contributions to road safety. Similar efforts need to be done in India also.

Current developments in India

India is a diverse country and implementation of any stringent rules in such a democracy is always difficult. However, positive developments are taking place in the field of driver education and traffic law enforcement, aimed at improving road safety. Although these efforts are still far from being completely effective and sustained, they are worth mentioning. This section highlights some of the pioneering trends followed by various cities of the country in this regard.

Traffic Management Centre, Bangalore

Bangalore City Police have envisaged the 'Bangalore Traffic Improvement Project (B-TRAC)'. The objectives of B-TRAC are the following.

- Reduce traffic congestion and accidents by 30% in the central areas of Bangalore City
- Achieve significant reduction in pollution
- Achieve substantial compliance of traffic laws and rules
- Set up an effective trauma care system

Various components form the improvement plan, some of them being: road markings; signage, both overhead and stand alone; surveillance cameras (80 nos); upgradation of signals including vehicle actuation (182 nos). The Traffic Management Centre (TMC) links various elements such as vehicle actuated traffic signals, surveillance cameras, enforcement cameras, etc. installed at various locations in the city as part of the B-TRAC project. This enables decision makers to identify and react to an incident in a timely manner based on real-time data. TMC aims at reducing incident response times, lower incident rates (mainly secondary incidents), disseminate traveler information, reducing congestion, and enhance safety. Figures 5 and 6 show glimpses of activities being carried out at TMC, Bangalore.

The use of surveillance cameras for enforcement has not only negated human interference but also resulted in increased traffic compliance in the city. Also, lack of human intervention has reduced the rate of corruption in the city. The police have introduced other means of enforcement such as use of Blackberries to record violations and accident data. This ensures proper and systematic traffic enforcement, database creation and analysis.

Figure 5. Monitoring road and junctions from a centralized TMC. Source: Ref. 25.

Figure 6. Traffic management cell and surveillance cameras. Source: Ref. 25.

Introduction of simulators for driver testing in Karnataka

Driver simulators are being set up in all RTO of Karnataka to help assess the behaviour of the four-wheeler drivers. The test examines the driver's reaction when he approaches a speed-breaker, pedestrian crossing or sudden approach of vehicles. The system is ideal for institutes imparting basic training for aspiring drivers. A number of simulators can be networked if required.

Scope for further work

The recommendations made in this article to improve road safety in India are preliminary and there is substantial scope to work further in the following directions.

- Quantification of the impacts of improved psychophysical traits on road safety and mobility in India.
- Developing the complete framework for driver education and licensing in India.
- Addressing practical issues (differences of language, literacy level of applicants, etc.) in implementation of the proposed framework.

- Finally, incorporating the proposed changes in Motor Vehicle Act 1988 and Central Motor Vehicles Rules 1989 to realize the benefits.
- Quantification of the impact of ITS-based traffic law enforcement on road safety and mobility in India.

We are presently carrying out further work in the above mentioned directions, the results of which will be shared through future publications based on this work.

1. WHO, *Global Status Report on Road Safety*, World Health Organization, Geneva, 2009.
2. Mohan, D., *The Road Ahead: Traffic injuries and fatalities in India*, IIT Delhi: Transportation Research and Injury Prevention Programme, 2004.
3. Peden, M. M. *et al*., *World Report on Road Traffic Injury Prevention*, World Health Organization, Geneva, 2004.
4. Mohan, D., Tiwari, G., Khayeshi, M. and Nafukho, F. M., *Road Traffic Injury Prevention: Training Manual*, World Health Organization, 2006.
5. Evans, L., *Traffic Safety and the Driver*, Science Serving Society, 1991.
6. Chauhan, S., Influencing traffic problem parameters through improved driver education and licensing, B Tech Thesis, IIT Guwahati, 2009.
7. Dandona, R., Kumar, G. A. and Dandona, L., Risky behaviour of drivers of motorized two wheeled vehicles in India. *J. Safety Res*., 2006, **37(**2), 149–158.
8. Finn, P. and Bragg, B. W. E., Perception of the risk of an accident by young and older drivers. *Accident Anal. Prev.*, 1986, **18**, 289–298.
9. Matthews, M. L. and Moran, A. R., Age differences in male drivers' perception of accident risk: the role of perceived driving ability. *Accident Anal. Prev*., 1986, **18**, 299–313.
10. Gregersen, N. P., Young drivers' overestimation of their own skill – an experiment on the relation between training strategy and skill. *Accident Anal. Prev*., 1996, **28**, 243–250.
11. Christie, R., The effectiveness of driver training as a road safety measure: An international review of the literature. Road Safety Research, Policing and Education, 2001.
12. Nyberg, A., *The Potential of Driver Education to Reduce Traffic Crashes Involving Young Drivers*, Linköping University, Department of Department of Health and Society, 2007.
13. Jonsson *et al*., *Curriculum, Driver Education and Driver Testing*, Universitet UMEA, 2003.
14. Messick, S., Test validity: a matter of consequences. *Social Indicators Res*., 1998, **45**, 35–44.
15. OECD/ECMT Transport Research Centre, *Young Drivers: The Road to Safety*, OECD Publishing, 2006.
16. Hatakka, M., Keskinen, E., Gregersen, N. P. Glad, A. and Hernetkoski, K., From control of the vehicle to personal self-control; broadening the perspectives to drivernext term education. *Traffic Psychol. Behav*., 2002, **5(**3), 201–215.
17. National Highway Traffic Safety Administration (NHTSA), Research agenda for an improved novice driver education program. Report to Congress. Washington, DC: US Department of Transportation, 1994.
18. Mayhew, D. R., Driver education and graduated licensing in North America: past, present and future. *J. Safety Res*., 2007, **38**(2), 229–235.
19. Engström, I., Gregersen, N. P., Hernetkoski, K., Keskinen, E. and Nyberg, A., Young novice drivers, driver education, and training: Literature Review. Swedish National Road and Transport Research Institute, 2003.
20. Morrisey, M. A., Grabowski, D. C., Dee, T. S. and Campbell, C., The strength of graduated drivers license programs and fatalities among teen drivers and passengers. *Accident Anal. Prev*., 2006, **38**(1), 135–141.
21. Gregersen, N. P., Berg, H. Y., Engström, I., Nolén, S., Nyberg, A. and Rimmö, P. A., Sixteen years age limit for learner drivers in Sweden – an evaluation of safety effects. *Accident Anal. Prev*., 2000, **32**(1), 25–35.
22. Stenlund, T., Henriksson, W., Sundström, A. and Wilberg, M., The GDE-Model as a guide in driver training and testing. Proceedings of the Conference, Umeå, 2007.
23. Henriksson, W., Sundström, A. and Wilberg, M., The Swedish driving-license test: A summary of studies from the Department of Educational Measurement, Umeå University (EM). Umeå: Department of Educational Measurement, 2004.
24. WHO, *Youth and Road Safety*, World Health Organization, Geneva, 2007.
25. Bangalore City Traffic Police website, Bangalore, Karnataka, (http://www.bangaloretrafficpolice.gov.in/traffic_management_centre.htm), retrieved 03/19/2010.
26. Department for Transport, Energy and Infrastructure, South Australia, Australia; (http://www.transport.sa.gov.au/licences_certification/hazard_perception/tsa-safe-distance-1sec-2sec.asp). Retrieved 03/19/2010.