Traffic Injury Prevention, 13:544–553, 2012

ISSN: 1538-9588 print / 1538-957X online
DOI: 10.1080/15389588.2012.663518

Taylor & Francis
Taylor & Francis Group

Alcohol, Drugs, and Road Traffic Crashes in India: A Systematic Review

ASHIS DAS,[1] HALLVARD GJERDE,[2] SAJI S. GOPALAN,[3] and PER T. NORMANN[2]

[1]The World Bank, Washington, DC
[2]Norwegian Institute of Public Health, Oslo, Norway
[3]IKP Center for Technologies in Public Health, Chennai, India

Objective*: India reported the highest number of road traffic crashes, related injuries, and deaths among all countries in the world, with 105,725 road traffic fatalities and 452,922 nonfatal road traffic injuries in 2007. In this report we present a systematic review of available literature on the use of psychoactive substances (alcohol and drugs) among road users, particularly those involved in road traffic crashes (RTCs).*

Methods*: MEDLINE, EMBASE, Ind Medica, and several other databases were searched for reports published between 1980 and 2011 that present data on the prevalence or extent of substance use among road users in India.*

Results*: Among the 23 studies eligible for the review, alcohol was reported by all, but only 2 mentioned the use of drugs. Most of the studies were hospital based, included injured or killed road users, and belonged to southern parts of India. Seven studies did not report any method for detecting alcohol use, whereas 7 used analytical testing, 7 used self-reporting, and 2 used observation. Utilizing the various means of verification, the studies reported that 2 to 33 percent of injured and 6 to 48 percent of killed RTC victims had consumed alcohol or drugs; only 2 mentioned drugs without specifying which types. Most studies did not distinguish between drivers, passengers, bicyclists, and pedestrians, and none investigated alcohol or drug use among those responsible for the accident.*

Conclusion*: A significant proportion of injured or killed road users in India had used alcohol before the accident. However, the existing studies cannot be used to estimate the risk of accident involvement among drunk drivers. There is a need for more rigorous research and capacity building on substance use vis-à-vis road traffic crashes.*

Keywords Road traffic crashes; Drunk driving; Alcohol; Substance use; Developing countries; India

INTRODUCTION

Road Traffic Crashes: A Global Challenge

Road traffic crashes (RTCs) have emerged as a major public health threat across the globe. According to the estimates of the World Health Organization (WHO), RTCs will be the fifth leading cause of global deaths by 2030 (WHO 2009a). Globally, more than 1.2 million individuals are killed per year on roads and around 50 million are injured, causing an economic loss of US$518 million annually. Low- and middle-income countries (LMICs) show an increasing trend for RTCs compared to the high-income countries (HIC) and constitute over 90 percent of the global RTCs with only a 48 percent share of global vehicles. The social gradient is more unfavorable for LMICs because the majority of victims are vulnerable road users such as pedestrians, cyclists, or motorized 2-wheeler riders (Dharmaratne and Stevenson 2006; Odero 1995). RTCs pose considerable public health challenges because they demand substantial skilled human resources, infrastructure, trauma, death investigations, and related health care (Department for International Development 2003). Dealing with the mental health of the victims and family members also demands huge preparations from the health systems (WHO 2009a).

The adverse social impacts of RTCs are well established and lead to a significant increase in disease burden and thereby indirectly to poverty. RTCs are even reported to curtail the progress toward Millennium Development Goal 1 on reducing poverty, because young people and those supporting a household are predominantly affected by RTCs (Paulozzi et al. 2007; Shah and Menon 2006).

Burden and Impact of Road Traffic Crashes in India

LMICs contribute to a 62 percent global burden of RTCs, and India tops such countries in this regard (WHO 2004). A total of 105,725 road traffic fatalities and 452,922 nonfatal road traffic injuries were reported in 2007 (WHO 2009b). The traffic fatality

Received 8 November 2011; accepted 31 January 2012.
Address correspondence to: Ashis Das, The World Bank, 1818 H Street NW, Washington, DC 20433, USA. E-mail: drashis@gmail.com

risk (fatalities per 100,000 inhabitants) in India is 16.8, whereas it is less than 6 in some HICs, and the fatality rate (fatalities per 10,000 vehicles) is 14.5, whereas it is less than one in some HICs (WHO 2009b). The burden and impact of RTCs in the country vary across the states depending on the infrastructural capacity, law enforcement, and the preparedness of the health system to meet the increasing demand for trauma care (National Crime Records Bureau 2007). During the past 4 years, RTCs contributed to 78 percent of deaths due to injury, the major cause of mortality for young adults under 45 years, disability of 2 million people, and economic loss of 550 billion Indian national rupees (INRs; US$12.1348 billion; WHO 2009b). The RTC-related fatalities per 1000 persons increased from 82 to 92 during 2002–2004 (National Crime Records Bureau 2007). As per the estimates, the burden due to RTC in India is expected to increase to 154,600 fatalities, about 3 million serious injuries, and 10 million minor injuries by 2015 (WHO 2008). Reportedly, lower socioeconomic groups are more at risk of RTCs than their affluent counterparts. A study in Bangalore observed 13.1 percent mortality among those in rural areas who are economically worse off (48.1% in urban counterparts) compared to 7.8 percent among those in rural areas who are well off (26.1% in urban counterparts; Gururaj 2008).

Nexus Between Substance Use and Road Traffic Crashes: What Is Known?

Among all of the determinants of RTCs, the use of psychoactive substances, particularly alcohol but also drugs, is established as a crucial risk factor globally. The use of such substances can impair judgment and increase the possibility of other high-risk behaviors such as speeding, risk-taking, and violating traffic rules and thereby contribute to involvement in RTCs (Blomberg et al. 2009; Gjerde et al. 2011; Gururaj 2004a; Penning et al. 2010; Ramaekers et al. 2004; Walsh et al. 2004; Zhao et al. 2010). The Southeast Asia region (SEAR) has the largest burden of RTCs and related injuries in the world. It has been estimated that SEAR has about 30 and 50 percent of all RTCs contributed by alcohol and drugs, respectively (Dhawan and Mohan 1999; Gururaj 2004a; WHO 2009b). However, many LMICs have not studied the prevalence of substance use among RTC victims, and its impact on RTCs may therefore not be widely acknowledged (Gururaj and Benegal 2002; Mohan 2002). A comprehensive understanding of the various dimensions of substance use such as timing, profile of users, and geographical distribution and its impact is essential for an informed policy approach to law enforcement.

Objectives of the Review

This review was undertaken to synthesize the evidence on the prevalence of substance use among road users and its impact on RTCs in India from the existing literature. The review intends to assess the (1) prevalence of substance use among road users and (2) impact of substance use on road traffic crashes. This review will highlight the strengths and gaps in the current evidence base for a policy guide in India and similar global settings and explore the regional variations in the prevalence of substance use in the country. The study outcomes would be relevant for policy, law enforcement, and future research.

METHODS

This systematic review was performed according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher et al. 2009).

Criteria for Considering Studies

Types of studies. Studies meeting the following criteria were included: (1) conducted in India after 1980, (2) included road users of any kind, (3) reported substance use, and (4) presented quantitative information. The decision to include studies only after 1980 was based on a preliminary search. Studies that did not describe the methodology, were not published in English, and were not of a qualitative nature (without reporting any quantitative data) were excluded. Further, review articles were also not considered. Substance use among road users was recognized if the drivers of vehicles (motorized or nonmotorized) or pedestrians were under the influence of any psychotropic substance (alcohol or drugs) that could impair their motor skills, reaction time, and judgment or any such substance could be detected in blood or breath samples.

Types of participants. Participants included all road users; that is, pedestrians, bicyclists, and drivers of all motor vehicles.

Type of outcome measure. The 4 major outcome measures were (1) prevalence of substance use among different kinds of road users; (2) type of substance in the body fluids; for example, blood, serum, saliva, or urine; (3) level of substance in the body fluids; and (4) impact of substance use on RTCs and related burden (i.e., number of accidents, fatalities, injuries, socioeconomic burden, etc.). Given the dearth of literature in this regard, studies applying any means of verification for substance use such as self-reporting, observation, breathalyzer, or any analytical test method were included.

Search Strategy for Identification of Studies

The electronic database searches included MEDLINE, EMBASE, Web of Science, Google Scholar, Elsevier, Science Direct, IND MEDICA, Transport Research Information Services (TRIS), the Cochrane Central Register of Controlled Trials (CENTRAL), the Campbell Collaboration, the British Library of Development Studies (BLDS), the World Health Organization, the World Bank, the Transport Research Board, the National Institute of Mental Health and Neuro Sciences (Bangalore, India), the Indian Institute of Technology (New Delhi, India), the Ministry of Shipping and Road Transport (New Delhi, India), the National Crime Records Bureau (NCRB), IDEAS (Repec) for economic working papers, Journal Storage (Jstor), and Inter-Science (Wiley). A hand searchenabled a look through the bibliographies of the retrieved articles. In addition, experts, researchers, officials, and organizations known to be

involved in road traffic injuries or substance use research were contacted to obtain unpublished or upcoming research in India. The search screened published and unpublished articles, working papers, dissertations, reports, and other gray literature documented or published between 1980 and 2011.

Search Algorithms

The search keywords were entered in all searchable, subject-specific fields (title, keyword, and abstract), medical subject heading (MeSH) and free-text terms, different for various search engines. An initial literature search prompted us to modify the algorithm and exclude some of the MeSH terms to limit the inclusion of irrelevant papers. The following key words were used to locate studies: *road traffic injury*, *road traffic accidents*, *road traffic crash*, *road traffic trauma* all separately combined with: *psychotropic substance*, *substance use*, *substance abuse*, *alcohol*, *drugs*, *drug use*, *drug abuse,* and *India*.

Data Collection and Synthesis

The references stored in EndNote software (Thomson Reuters, Carlsbad, Calif) were screened and assessed independently by 3 of the authors (AD, HG, and SSG) and were included in the final review through discussions. Data extraction, which was designed after the initial search, collected information on (1) general study characteristics such as year, site (hospital or roadside), geographical distribution, population, and sample size; (2) study objectives; (3) prevalence or incidence of substance use among road users; and (4) means of verification. Data were reviewed for duplication after the extraction was completed and entered in Microsoft Excel. The quality of the selected studies was assessed independently by 3 of the authors (AD, HG, and SSG) based on how they presented population-level disaggregated data (age and gender), 24 h per day collection of sample during the study period, means of verification and blood alcohol concentrations, and differentiation between types of road users. An in-depth statistical analysis was impossible because the studies were heterogeneous in terms of their objectives, samples, and study design. Rather, a descriptive analysis of extracted data was performed. The proportion of road users under the influence of any substance from each study was retrieved and calculated. The proportion among each group of road users was assessed wherever such information was available. Data analysis was done with Microsoft Excel software.

Apprising Methodological and Reporting Quality of Studies

Quality evaluation was conducted by assessing 7 parameters. (1) gender disaggregated data on substance use (score 0 or 1); (2) age-specific data on substance use (0 or 1); (3) collection of study participants 24 h per day, 7 d per week (0 or 1); (4) detection of alcohol or drugs (no information, 0; self-reported/observation, 1; analytical method, 2); (5) reporting of blood alcohol limit (0 or 1); (6) differentiation between different types of road users when presenting results (0 or 1); and (7) peer-reviewed paper (0 or 1). The studies were classified as having low (score 1–3), medium (score 4–5), or high (score 6-8) quality based on the sum of scores for all parameters.

RESULTS

Literature Search

Our database search produced a total of 390 papers and an additional 32 records were obtained through Web sites and individual contact with researchers (Figure 1). After checking for duplicates, there were 181 papers for title and abstract screening, of which 29 were included for the full screening of the paper. The reasons for the exclusion of 152 papers at this stage were that the studies were not conducted in India ($n = 52$), not related to RTCs ($n = 71$), and only reported substance use ($n = 29$). A further 11 records were added after hand searching of the references. Forty full-text records were assessed for their eligibility and 18 were excluded because they were not primary studies ($n = 7$), review articles and commentaries ($n = 5$), did not report substance use ($n = 4$), and only reported qualitative data ($n = 2$). Finally, a total of 22 papers met the inclusion criteria and were included in this review. One of the papers (Gururaj and Benegal 2002) presented a roadside survey along with a hospital-based study. Those 2 studies were independent, thereby increasing the number of records to 23. All of these studies reported alcohol use among various categories of road users. Two studies reported the use of alcohol or drugs without specifying which types of drugs.

Quality of the Included Studies

The mean quality score was 4, with studies ranging from 1 (lowest) to 8 (highest). Only 2 studies were of high quality (scores 6–8; Millo et al. 2008; Tabin et al. 2007), whereas 14 were of moderate quality (score 4–5); 7 had low scores (<4).

Characteristics of Included Studies

Study populations and settings. Most of the studies (n = 16) were conducted after the year 2000 (Table I). Though the studies were carried out across India, a large proportion (43%) were conducted in the southern region of the country. However, Delhi topped the list with 9 studies, followed by Karnataka with

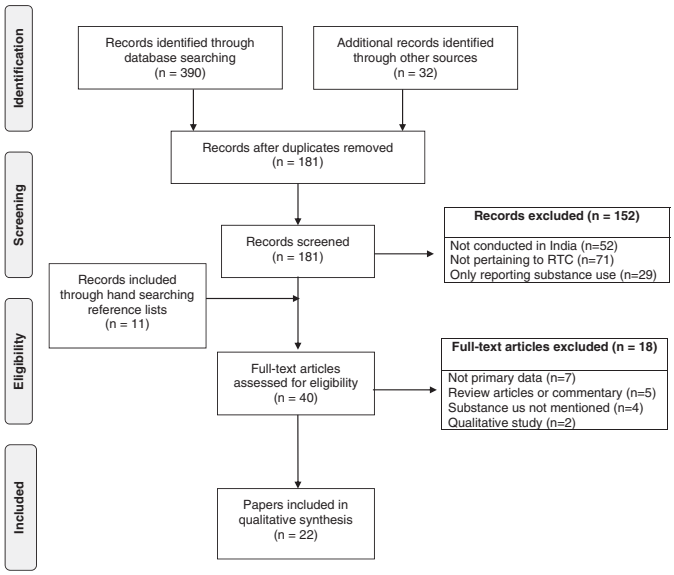

Figure 1 PRISMA 2009 flow diagram for selection of papers.

Table I Basic characteristics of the study: a descriptive comparative assessment

Characteristics	*N*
Year of study	
1980–1990	2
1991–2000	5
2001–2010	16
Total	23
Site	
Hospital	19
Community	3
Roadside	1
Region	
South	10
North	10
East	2
West	1
Study population	
Random community members	1
Random road users	1
Students	1
Injured RTC victims	15
Killed RTC victims	4
Injured or killed RTC victims	1
Alcohol or drug exposure assessment	
Not mentioned	6
Self-reported	7
Analytical testing	7
Observation	3

7. The study populations constituted diverse groups and most included injured (n = 15) or killed (n = 4) road users or both (n = 1), though a few focused on community members (n = 1), students (n = 1), and random road users (n = 1). The community members consisted of general population and adolescents, and random road users constituted drivers, pedestrians, and passengers. The majority were 2-wheel drivers. The most common study setting was a hospital (n = 19); only one was a roadside survey.

Study Objectives and Design

There were only a few studies ($n = 4$) whose primary intent was to investigate the prevalence of alcohol among road traffic injury cases (Gururaj and Benegal 2002; Kochar et al. 2002; Millo et al. 2008; Tabin et al. 2007) and one explored it among general road users (Gururaj and Benegal 2002). The relative focus of the studies was more on exploring epidemiological, sociodemographic, and contextual factors related to road traffic injuries, such as type, incidence, prevalence, mode and pattern of injury, and road safety behaviors among injured, killed, and random road users. All of them were observational and none had a comparison group.

Means of Verification of Substance Use

Six studies did not report any method for detecting alcohol or drug use, whereas 10 assessed it through self-reporting by the respondents or observation by their attendants. Four studies analyzed the alcohol content in body fluids using a gas liquid chromatography (GLC) method (Behera et al. 2009; Biswas et al. 2003; Millo et al. 2008; Tabin et al. 2007), a breath analyzer was used only in the roadside study (Gururaj and Benegal 2002), and one study used an alcohol estimation kit (Kochar et al. 2002). One study reported the analysis of alcohol or drugs without specifying which types of analytical methods and which types of drugs (Singh et al. 2005). Results for drugs alone were not reported.

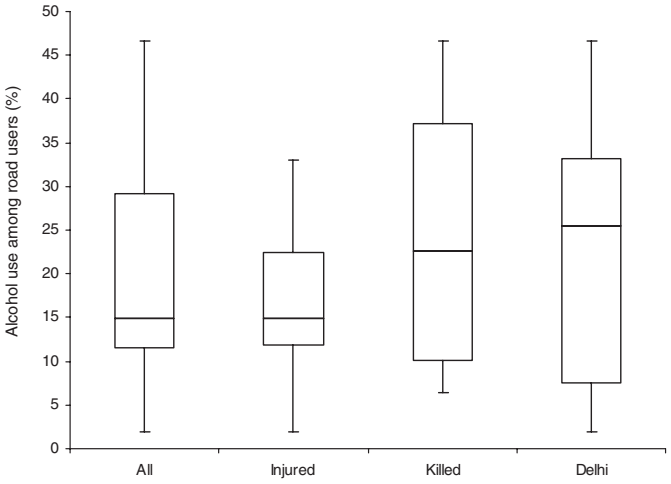

Figure 2 Proportion of road users having used alcohol or drugs.

Outcome of Interest

Two studies were excluded from the presentation of alcohol and drug use in Figures 2 and 3 and in the discussion below because only small fractions of the road users were assessed regarding substance use (Biswas et al. 2003; Fitzharris et al. 2009).

Utilizing various means of verification, the studies reported that a median of 15 percent of the road users had consumed alcohol or drugs (Table II and Figure 2)—15 percent among injured and 23 percent among killed victims. The only roadside study reported that alcohol was detected in 42 percent of the population (Gururaj and Benegal 2002). The results of breath testing indicated that 35 percent had alcohol concentrations above the

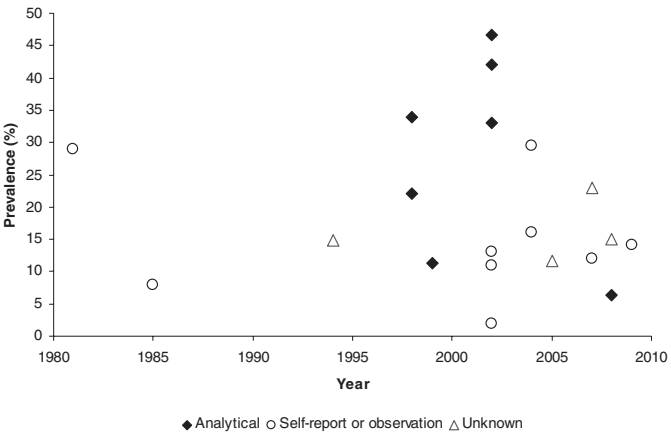

Figure 3 Prevalence of alcohol or drug use in relation to year of study and type of alcohol and drug determination.

Table II Study characteristics and summary of findings

Study location and year	Study site	Sample size (RTC)	Population	Means of verification	Alcohol Use	Quality score[b]	Indexed in Pubmed	Reference
Delhi, 1980–81	Hospital	87	Injured riders of motorized two-wheelers	Self-reported	29%	4	No	Mishra et al. (1984)
Delhi, 1985	Hospital	302	Injured motorised two-wheel crash victims. 66.6% drivers, 33.3% pas.	Self-reported	8%	4	Yes	Sood (1988)
Chennai, 1993–4	Community	4333	Random families	Not mentioned	Relative risk 2.26 for RTIs in adult males consuming alcohol daily	3	Yes	Sathiyasekaran (1996)
Pondicherry, 1994	Hospital	726	Injured crash victims. 16% drivers, 43% pas., 13% bikers, 22% ped. 6% bullock drivers	Not mentioned	Among drivers, bullock drivers and bicyclists 14.9%	2	No	Jha et al. (2003)
Delhi, 1997–8	Hospital	500	Injured crash victims. 49.8% drivers, 29.8% ped., 20.4% unknown	Analytical test (GLC of blood)	In total: 22% 16% >0.05 g/dL Drivers 22%, pas. 20%, ped. 22%	7	No	Tabin et al. (2007)
Delhi, 1997–8	Hospital	500	Killed crash victims 51% drivers, 10% pas,.39% ped.	Analytical test (GLC of blood)	34% 30% >0.05 g/dL Drivers: 20%	7	No	Millo et al. (2008)
Delhi, 1999–2000	Hospital	110	Killed crash victims 20.0% drivers, 12.7% bikers, 25.7% pas., 44.5% ped.	Analytical test (GLC of urine)	7 out of 11[c]	2	No	Biswas et al. (2003)
Assam, 1999–2003	Hospital	1872	Killed crash victims. 14.2% drivers, 27.6% pas., 10.5% bikers, 47.0% ped.	Analytical tests (not specified)	Alcohol or drugs: In total 11.3%, drivers 33.1%, ped. 7.4%, pas. 8.3% bikers 7.7%	5	No	Singh et al. (2005)
Karnataka, 2002	Hospital	161	Injured crash victims. 39.8% drivers, 60.2% ped.,	Self-reported	In total: 13% Males 15%, females 0%	4	No	Kiran et al. (2004)
Delhi, 2002 [a]	Hospital	160	Injured and killed crash victims. 36.9% 3/4-wheel drivers/pas., 18.8% 2-wheel drivers/pas., 6.8% bikes, 37.5% ped.	Analytical test (alcohol estimation kit for blood)	Injured 33.0% >0.03 g/dL, Killed 46.7% > 0.03 g/dL	5	No	Kochar et al. (2002)
Karnataka, 2002	Hospital	1605	Injured crash victims. 43.3% drivers, 23.9% pas., 3.7% bikers, 25.3% ped., 3.9% others	Observation	11%	5	No	Gururaj and Benegal (2002)
Karnataka, 2002	Roadside	480 (random)	Random road users (between 8 or 9 pm and midnight). 75.4% riders/pillion, 24.2% 3–4 wheel drivers, 0.4% ped.	Breathalyzer	42% 35% >0.03 g/dL 2-wheeler drivers/pas: 44% 3/4-wheeler drivers/pas: 34%	5	No	Gururaj and Benegal (2002)

Delhi, 2002	Community	680	Injured crash victims. 57.7% drivers/pas., 14.1% bikers, 24.9% ped., 4.1% others.	Self-reported	Alcohol or drug use: 1.9%	3	No	Verma and Tewari (2004)
Maharashtra, 2003–4	Hospital	350	Injured crash victims. 28.9% drivers, 49.7% pas, 7.4% bikers, 13.4% ped, 0.6% bullocks.	Observation	Drivers: 29.5%	4	Yes	Patil et al. (2008)
Karnataka, 2004[a]	Hospital	1553	Male trauma patients. 42% motorcycle occupants, 18% pas., 20% ped.	Self-reported	16%	5	Yes	Gururaj (2004b)
Madhya Pradesh, 2004–5	Hospital	164	Injured crash victims	Not mentioned	11.58	2	No	Swarnkar 2010
Hyderabad, 2005–6	Hospital	378	Injured motorised two-wheel crash victims. 66.7% drivers, 33.3% pas.	Not mentioned	35 out of 58 riders[c] 13 out of 24 pillons[c]	4	Yes	Fitzharris et al. (2009)
Karnataka, 2006–7	Hospital	540	Injured crash victims. Drivers 30.5%, pas. 42.6%, ped. 26.8%	Observed	12.1%	2	No	Gudadinni (2007)
Karnataka, 2006–7	Hospital	144	Injured motorized two-wheeler crash victims. 75.7% drivers, 24.3% pas.	Not mentioned	22.9%, all males Drivers 24.1%, pas. 20.0%	5	Yes	Mallikarjuna and Krishnappa (2009)
Delhi, 2007[a]	Community	550	Adolescent students	Self-reported	20% had been passengers of drunk driver during last month	4	Yes	Sharma et al. (2007)
Delhi, 2007–8	Hospital	94	Killed motorcycle crash victims	Analytical test (GLC of blood)	6.38%	4	No	Behera et al. (2009)
Orissa, 2008	Hospital	40	Injured crash victims. 37.5% drivers, 47.5% pas., 15% ped.	Not mentioned	15%	2	No	Sarangi et al. (2009)
Karnataka, 2008–9	Hospital	251	Injured crash victims 82.9% vehicle users, 17.1% pas.	Self-reported	14.1%	4	Yes	Uthkarsh et al. (2012)

[a]Indicates year of publication.
[b]Quality score takes into account: 24 hour sample collection; age and gender disaggregated information presented; differentiation between different types of road users, means of verification of substance use, BAC cut-off mentioned, and peer reviewed (maximum score 8, minimum score 0).
[c]Not included in calculations or Figures 2 and 3 due to small fraction analyzed or questioned about alcohol or drug use.
Drivers = drivers of two-wheel, three-wheel or four-wheel motor vehicle of any type; pas. = passengers or pillon riders; ped. = pedestrians; bikers = bicycle riders.

legal limit of 0.03 g/dL blood (Gururaj and Benegal 2002). That study was performed at night (between 8 or 9 pm and midnight) during a 15-day period at selected sites in Bangalore and therefore does not reflect the general prevalence of alcohol in breath samples from road users in that city. All types of road users were included in the study, and the majority of the alcohol-positive road users were 2-wheel drivers.

Four studies found a greater prevalence of drink driving among those in the 20- to 30-year age group in comparison to older (>30 years) age groups (see the 2 studies presented in Gururaj and Benegal 2002; Millo et al. 2008; Tabin et al. 2007). Four studies reported gender disaggregated data on the presence of alcohol among road users (Gururaj 2004b; Gururaj and Benegal 2002; Kiran et al. 2004; Mallikarjuna and Krishnappa 2009). One of the community-based studies found that the relative risk of road traffic injuries among adult males reporting daily alcohol consumption was 2.26 (Sathiyasekaran 1996).

Despite diverse populations, study settings, and methodologies, the use of analytical tests seemed to result in higher prevalences of alcohol or drugs than self-reported or observed data (see Figure 3). This might be related to the fact that analytical tests were primarily used in studies of killed drivers.

With respect to the regional distribution of the prevalence of alcohol use among the study population, irrespective of the means of verification, Delhi reported a higher proportion of alcohol used (median 26%) than the rest of the country (median 15%).

Three hospital-based studies and one roadside study reported blood alcohol concentration (BAC) levels among the study population (Gururaj and Benegal 2002; Kochar et al. 2002; Millo et al. 2008; Tabin et al. 2007). The BACs among the injured road users were above the legal limit of 0.03 g/dL or over 0.05 g/dL in 16 to 33 percent of the patients (Kochar et al. 2002; Tabin et al. 2007), whereas it was 30 to 46.7 percent in killed RTC victims (Kochar et al. 2002; Millo et al. 2008). In all of these studies conducted in Delhi, the 20- to 30-year age group had the highest prevalence of alcohol.

DISCUSSION

This article is an attempt to explore the current evidence on substance use among road users and its impact on road traffic crashes in India through the existing literature. The review outcomes have relevance for settings where the influence of substance use on RTCs has not been widely explored.

Very few studies on road traffic crashes in India have been performed compared to the extent of their burden on health consequences and household economy (WHO 2004). Many developed country settings have widely investigated road traffic crashes and their determinants (WHO 2009a). Further, among the determinants of road traffic crashes in India, the influence of substance use has been grossly uninvestigated. Many countries in Asia, Europe, Africa, and North America have studied the impact of substance use on road traffic crashes (WHO 2004).

The geographical distribution of studies across Indian states and territories was skewed with the gross neglect of regions with more use of alcohol (e.g., Kerala) or illegal drugs (northeastern states) than the country's average. Further, many studies were confined to metro cities and capital cities and neglected national highways and rural regions. This low level of investigation along with the inappropriate method of assessing the alcohol content (as discussed further), and no drug testing might have led to an underreporting of alcohol or drug influence in RTCs.

Despite the heterogeneity of the extracted studies, a significant proportion of random, injured, and killed road users were found to have consumed alcohol. The observed alcohol use (42%) among road users in Bangalore at night was unexpectedly high. Usually, roadside surveys in other countries study alcohol and sometimes drug use among motor vehicle drivers only, not among pedestrians, passengers, and bicyclists. Studies at sobriety checkpoints in Brazil found that on weekend nights 22 to 38 percent of motor vehicle drivers had been drinking (Campos et al. 2008; Duailibi et al. 2007). A United States study found that on weekend nights about 12 percent of the drivers had positive BACs (Lacey et al. 2009). The recent Driving Under the Influence of Drugs, Alcohol, and Medicines (DRUID) project in Europe found large variations between countries; the prevalence of BACs of 0.01 g/dL or higher was between 0 and 17 percent for the 13 participating countries (Houwing et al. 2011). The results of the one roadside survey in Bangalore have not been confirmed by others, so it is not known whether it reflects the situation at certain sites and time points in Bangalore, whether there was a significant selection bias, or whether it reflects the general situation in India.

Due to various design flaws it is difficult to establish that consumption of alcohol alone would have led to road traffic crashes resulting in injuries and deaths apart from other human, vehicle, road, and environmental factors. In other words, it is difficult to establish the magnitude of the impact of the use of alcohol or other substances on road traffic crashes in India through the current literature. Nonetheless, millions of rupees are being invested in sensitization and law enforcement targeted toward drink driving without much funding on its research (Ministry of Shipping, Road Transport and Highways 2007; Patel et al. 2011).

Because the majority of the studies did not mention the method of alcohol estimation and many studies used self-reported information, it is difficult to arrive at a conclusion on the prevalence of alcohol use among different categories of road users. The presence of alcohol in breath analysis or by self-report cannot provide an idea about the concentration of alcohol in the bloodstream, which would result in impaired judgment during driving.

In general, most of the studies showed selection bias because they were hospital based. Thus, only the most seriously injured road users were included.

Underreporting alcohol use may be a concern in many of the RTC studies (Dharmaratne and Stevenson 2006). Relying on hospital-based studies provides a population on injuries and

deaths, because the studies are missing the injuries and deaths that were not reported to that particular hospital or any hospital. There is also a likelihood of missing less severe cases in hospital-based studies.

Many of the studies did not look into the pattern of alcohol use or drink driving. For instance, there are many studies in other countries showing that the incidence of drink driving is greater on weekends than during the week (Derriks and Mak 2006). There is only one published roadside study from India that has examined alcohol use among random road users. More random roadside surveys would provide more data on the prevalence, extent, and distribution of alcohol consumption among different types of road users. Many developed and developing countries have demonstrated the role of roadside surveys to determine the extent of alcohol and drug use among road users in addition to consumption patterns (Odero et al. 1997; WHO 2004).

Strengths and Limitations

To the best of our knowledge, this is the first comprehensive review of studies in India on the use of alcohol or drugs among random road users and victims of traffic accidents. This review has employed widely established and commonly utilized systematic review techniques to identify and extract data in an unbiased manner. The general search engines and Web sites of Indian journals were explored to include more number of relevant studies, which might not have been indexed elsewhere. Hand searching through the references of the selected articles enabled us to further broaden the search base.

This review has incorporated gray literature (non-peer-reviewed publications) such as reports, working papers, and dissertations in addition to peer-reviewed publications. There is definitely a concern regarding the quality of research and publication for some of the gray literature. However, considering the paucity of literature on substance use and road traffic crashes in the Indian context, we decided to apply a broad-based approach so that a rich evidence base could be created. Despite our best efforts, we might not have identified all relevant literature. Due to the heterogeneity of literature it was not possible to perform any in-depth statistical calculations so that some quantitative evidence could be derived. However, the focus of the review is more on conceptual generalizability than evidence on statistical comprehensiveness. None of the studies had a comparison group, without which it is difficult to arrive at a conclusion on the impact of alcohol use on road traffic crashes. Similarly, the studies did not adjust for any sociodemographic, road, climatic, seasonal, or vehicle factors that could have introduced confounding in the studies. The vast majority of the studies did not distinguish between motor vehicle drivers, passengers, pedestrians, bicyclists, or other road users.

Implications for Policy

The results of this review are relevant for public health planners and policy makers working on road safety. The review outcomes call for adequate policy-level attention and funding for research on substance use and road traffic crashes in the country. There is an inevitable need for a country-level nodal agency to coordinate the research, sensitization, and capacity development of human resources in this regard. Such an apex entity could further develop regional centers on research and training and technical support for policy makers in this regard. These efforts are likely to fill the current gaps in the scientific appropriateness in conducting research and infrastructural facilities of laboratories. External collaborations with various governments in other countries, policy makers, development agencies, and civil organizations are a definite need. Such collaborations augment streamlining the efforts on research, capacity development, sensitization, and behavioral change (Wang et al. 2010). More reference laboratories can be set up in India with skilled human resources to estimate substance use among road users and provide evidence for policy making.

Implications for Future Research

Additional directions for future research might include the following:

- Conducting more rigorous research on impact of substance use on road traffic crashes.
- Distinguishing between different groups of road users—for example, motor vehicle drivers versus pedestrians—and also between those road users responsible for the accident versus those not responsible.
- Including other contributing factors, such as vehicle, road, and climatic conditions, in addition to speed and risk-taking behaviors.
- Including important socioeconomic factors.
- Studying underexplored regions in India such as northeastern states, which have a higher prevalence of illegal drug use.
- Employing evidence from other parts of the country and the rest of the world for further exploration and evidence-based policy suggestions.

CONCLUSION

India lacks considerable evidence on the influence of psychoactive substance use on road traffic crashes. Among the various substances, only alcohol has been explored. Studies have reported that a large proportion of RTC victims had used alcohol, but the lack of analytical methods probably led to some underreporting, thus restricting appropriate law enforcement. A single roadside study had previously been performed, which found that a large proportion of the road users were drivers who had been drinking alcohol. Most studies did not distinguish between different types of road users, and none investigated alcohol use among those responsible for the accidents. The research findings on substance use and traffic safety performed so far in India cannot be used to estimate the relative risks of involvement in RTCs after using alcohol or drugs due to poor study design. The accumulated research portfolio cannot be used to document differences between different road user groups or between regions. India needs policy prioritization on research to generate relevant evidence on substance use vis-à-vis road traffic crashes.

ACKNOWLEDGMENTS

We are indebted to Asbjørg S. Christophersen (Norwegian Institute of Public Health, Oslo) for critically reviewing the manuscript. We are grateful to the authors and organizations that provided us with valuable information on the relevant studies. The views expressed are solely of the authors and they do not necessarily reflect those of the institutions to which the authors are affiliated.

REFERENCES

Behera C, Rautji R, Lalwani S, Dogra TD. A comprehensive study of motorcycle fatalities in South Delhi. *J Indian Acad Forensic Med.* 2009;31:6–10.

Biswas G, Verma SK, Sharma JJ, Aggrawal NK. Pattern of road traffic accidents in north-east Delhi. *J Forensic Med Toxicol.* 2003;20:27–32.

Blomberg RD, Peck RC, Moskowitz H, Burns M, Fiorentino D. The Long Beach/Fort Lauderdale relative risk study. *J Safety Res.* 2009;40:285–292.

Campos VR, Salgado R, Rocha MC, Duailibi S, Laranjeira R. Prevalência do beber e dirigir em Belo Horizonte, Minas Gerais, Brasil. *Cad Saude Publica.* 2008;24:829–834.

Department for International Development. *Guidelines for Estimating the Cost of Road Crashes in Developing Countries*. London: Department for Internal Development; 2003.

Derriks HM, Mak PM. *Underreporting of Road Traffic Casualties*. The Hague, The Netherlands: Ministry of Transport; 2006.

Dharmaratne SD, Stevenson M. Public road transport crashes in a low income country. *Inj Prev.* 2006;2:417–420.

Dhawan A, Mohan D. Epidemiology of alcohol and substance abuse. *NIMHANS J.* 1999;17:367–376.

Duailibi S, Pinsky I, Laranjeira R. Prevalence of drinking and driving in a city of southeastern Brazil. *Rev Saude Publica.* 2007;41:1058–1061.

Fitzharris M, Dandona R, Kumar GA, Dandona L. Crash characteristics and patterns of injury among hospitalized motorised two-wheeled vehicle users in urban India. *BMC Public Health.* 2009;9:11. Available at: http://www.biomedcentral.com/1471-2458/9/11

Gjerde H, Normann PT, Christophersen AS, Samuelsen SO, Mørland J. Alcohol, psychoactive drugs and fatal road traffic accidents in Norway: a case-control study. *Accid Anal Prev.* 2011;43:1197–1203.

Gudadinni MR. *A Study of Road Traffic Accident Cases Admitted in BLDEA's Shri B.M. Patil Medical College Hospital and Research Center, Bijapur [dissertation]*. Bangalore, India: Rajiv Gandhi University of Health Sciences; 2007.

Gururaj G. Alcohol and road traffic injuries in South Asia: challenges for prevention. *J. Coll Physicians Surg Pak.* 2004a;14:713–718.

Gururaj G. The effect of alcohol on incidence, pattern, severity and outcome from traumatic brain injury. *J Indian Med. Assoc.* 2004b;102:157–160, 163.

Gururaj G. Road traffic deaths, injuries and disabilities in India: current scenario. *Natl. Med. J. India.* 2008;21:14–20.

Gururaj G, Benegal V. *Driving Under the Influence of Alcohol and Road Traffic Injuries in Bangalore*. Bangalore, India: National Institute of Mental Health and Neuro Sciences; 2002.

Houwing S, Hagenzieker M, Mathijssen R, et al. *Prevalence of Alcohol and Other Psychoactive Substances in Drivers in General Traffic. Part I: General Results. DRUID Deliverable D 2.2.3.* Leidschendam, The Netherlands: SWOV Institute for Road Safety Research; 2011. Available at: http://www.druid-project.eu. Accessed January 11, 2012.

Jha N, Srinivasa DK, Roy G, Jagdish S. Injury pattern among road traffic accident cases: a study from south India. *Indian J. Community Med.* [serial online]. 2003;28:85–89. Available at: http://medind.nic.in/iaj/t03/i2/iajt03i2p85o.pdf. Accessed January 18, 2012.

Kiran ER, Saralaya KM, Vijaya K. Prospective study on road traffic accidents. *J. Punjab Acad Forensic Med. Toxicol* [serial online]. 2004;4:12–16. Available at: http://pafmat.com/2004_3.htm. Accessed January 18, 2012.

Kochar A, Sharma GK, Murari A, Rehan HS. Road traffic accidents and alcohol: a prospective study. *Int J Med Toxicol Leg Med* 2002;5:22–24.

Lacey JH, Kelley-Baker T, Furr-Holden D, et al. *2007 National Roadside Survey of Alcohol and Drug Use by Drivers—Alcohol Results*. Washington, DC: National Highway Safety Administration, 2009. DOT HS 811 248. Available at: http://www.nhtsa.gov/DOT/NHTSA/Traffic%20Injury%20Control/Articles/Associated%20Files/811248.pdf. Accessed January 11, 2012.

Mallikarjuna SK, Krishnappa P. Prevalence of maxillofacial injuries by motorized two wheeler road traffic accidents in Bangalore city. *Dent Traumatol.* 2009;25:599–604.

Millo T, Sharma GK, Murty OP, Bhardwaj DN, Murmu LR, Aggrawal P. Study of incidence of alcohol use in road traffic accidents in South Delhi in fatal cases. *Indian J Forensic Med Toxicol* [serial online]. 2008;2:29–32. Available at: http://www.indmedica.com/journals.php?journalid=11&issueid=120&articleid=1600&action=article. Accessed January 18, 2012.

Ministry of Shipping, Road Transport and Highways. *Report of the Committee on Road Safety and Traffic Management*. New Delhi: Government of India; 2007.

Mishra BB, Banerji AK, Mohan D. Two-wheeler injuries in Delhi, India: a study of crash victims hospitalized in a neuro-surgery ward. *Accid Anal Prev.* 1984;16:407–416.

Mohan D. *Social Cost of Road Traffic Crashes in India*. New Delhi: Government of India; 2002.

Moher D, Liberati A, Tetzlaff J, Altman DG. The PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA Statement. *BMJ.* 2009;339:b2535.

National Crime Records Bureau. *Accidental deaths and suicides in India.* New Delhi, India: Government of India; 2007. Available at: http://ncrb.nic.in/adsi/data/ADSI2007/home.htm. Accessed January 11, 2012.

Odero W. Road traffic accidents in Kenya: an epidemiological appraisal. *East Afr Med J.* 1995;72:299–305.

Odero W, Garner P, Zwi A. Road traffic injuries in developing countries: a comprehensive review of epidemiological studies. *Trop Med Int Health.* 1997;2:445–460.

Patel V, Chatterji S, Chisholm D, et al. Chronic diseases and injuries in India. *Lancet.* 2011;377:413–428.

Patil SS, Kakade R, Durgawale P, Kakade S. Pattern of road traffic injuries: a study from Western Maharashtra. *Indian J Community Med* [serial online]. 2008;33:56–57. Available at: http://www.ijcm.org.in/article.asp?issn=0970-0218;year=2008; volume=33; issue=1; spage=56;epage=57;aulast=Patil. Accessed January 18, 2012.

Paulozzi LJ, Ryan GW, Espitia-Hardeman VE, Xi Y. Economic development's effect on road transport-related mortality among different

types of road users: a cross-sectional international study. *Accid Anal Prev.* 2007;39:606–617.

Penning R, Veldstra JL, Daamen AP, Olivier B, Verster JC. Drugs of abuse, driving and traffic safety. *Curr Drug Abuse Rev.* 2010;3:23–32.

Ramaekers JG, Berghaus G, Van Laar M, Drummer OH. Dose related risk of motor vehicle crashes after cannabis use. *Drug Alcohol Depend.* 2004;73:109–119.

Sarangi L, Parhi L, Parida RK, Panda P. A study on epidemiological factors associated with road traffic accidents presenting to the casualty of a private hospital in Bhubaneswar. *J Community Med* [serial online]. 2009;5:1–6. Available at: http://www.jcmorissa.org/index_files/july09/6.pdf. Accessed January 18, 2012.

Sathiyasekaran BW. Population-based cohort study of injuries. *Injury.* 1996;27:695–698.

Shah B, Menon G. *Report of ICMR-WHO Workshop on Development of a Feasibility Module for Road Traffic Injury Surveillance*. New Delhi: Indian Council of Medical Research; 2006.

Sharma R, Grover VL, Chaturvedi S. Health-risk behaviors related to road safety among adolescent students. *Indian J Med Sci* [serial online]. 2007;61:656–662. Available at: http://www.indianjmedsci.org/article.asp?issn=0019-5359;year=2007;volume=61;issue=12;spage=656;epage=662;aulast=Sharma. Accessed January 18, 2012.

Singh YN, Bairagi KK, Das KC. An epidemiological study of road traffic accident victims in medicolegal autopsies. *J Indian Acad Forensic Med* [serial online]. 2005;27:166–169. Available at: http://medind.nic.in/jal/t05/i3/jalt05i3p166.pdf. Accessed January 18, 2012.

Sood S. Survey of factors influencing injury among riders involved in motorized two-wheeler accidents in India: a prospective study of 302 cases. *J Trauma.* 1988;28:530–534.

Swarnkar M, Singh PK, Dwivedi S. Pattern of trauma in central India: an epidemiological study with special reference to mode of injury. *Internet J Epidemiol.* 2010;9(1). Available at: http://www.ispub.com/journal/the-internet-journal-of-epidemiology/volume-9-number-1.html. Accessed January 18, 2012.

Tabin M, Sharma RK, Murty OP, Bharadwaj DN, Aggarwal P, Murmu LR. Incidence of alcohol related non-fatal road traffic accidents in South Delhi, India. *Malays J Forensic Pathol Sci*; [serial online]. 2007;2:40–51. Available at: http://www.forensiknet.com/journal/Vol.2_June_2007.pdf. Accessed January 18, 2012.

Uthkarsh PS, Suryanarayana SP, Gautham MS, Shivraj NS, Murthy NS, Pruthvish S. Profile of injury cases admitted to a tertiary level hospital in south India. *Int J Inj Contr Saf Promot.* 2012;19:47–51.

Verma PK, Tewari KN. Epidemiology of road traffic injuries in Delhi: result of a survey. *Reg Health Forum*; [serial online]. 2004;8:6–14. Available at: http://203.90.70.117/PDS_DOCS/B0031.pdf. Accessed January 18, 2012.

Walsh JM, DeGier JJ, Christophersen AS, Verstraete AG. Drugs and driving. *Traffic Inj Prev.* 2004;5:241–253.

Wang P, Rau PL, Salvendy G. Road safety research in China: review and appraisal. *Traffic Inj Prev.* 2010;11:425–432.

World Health Organization. *World Report on Road Traffic Injury Prevention*. Geneva, Switzerland: World Health Organization; 2004.

World Health Organization. *The Global Burden of Disease: 2004 Update*. Geneva, Switzerland: The World Health Organization; 2008. Available at: http://www.who.int/healthinfo/global_burden_disease/GBD_report_2004update_full.pdf. Accessed January 11, 2012.

World Health Organization. *Global Status Report on Road Safety, Time for Action*. Geneva, Switzerland: The World Health Organization; 2009a. Available at: http://www.un.org/ar/roadsafety/pdf/roadsafetyreport.pdf. Accessed January 11, 2012.

World Health Organization. *Regional Report on Status of Road Safety: The South-East Asia Region*. New Delhi: The World Health Organization Regional Office for South East Asia; 2009b. Available at: http://www.searo.who.int/LinkFiles/Publications_report-status-road-safety.pdf. Accessed January 11, 2012.

Zhao G, Wu C, Houston RJ, Creager W. The effects of binge drinking and socioeconomic status on sober driving behavior. *Traffic Inj Prev.* 2010;11:342–352.