平成24年度研究調査プロジェクト（H2429）

インドにおける交通安全のための コミュニティデザインに関する研究調査

報 告 書

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インドにおける交通安全のためのコミュニティデザインに関する研究調査

１．はじめに

１．１　問題意識

近年，急激な都市開発とモータリゼーションにより，新興国においては交通事故の増加に歯止めがかからず，きわめて憂慮すべき状態にある．図-1 に示すように筆者らの分析によれば, 世界における人口 1000 万人以上のメガシティの数は，2000 年時点での 16 から，2050 年には 40 にまで増加することが予測されている [1]．インドは，人口の急増により，メガシティの誕生が最も顕著に予測されるとともに，今後自動車の普及による急速なモータリゼーションの到来が予測されている．インドの交通死亡事故に関する調査・分析の結果は，今後アフリカなどの途上国においても重要な知見として活用しうると考えられる．

2012 年の交通死亡事故統計および現地報道によれば，世界の交通死亡事故の約 1 割がインドで発生している．換算すると，世界の交通死亡事故の 10 件に 1 件，車両同士の衝突など交通事故の 6 件に 1 件が，インドで起きていることになる．死亡事故に至っては，1 時間に 14 件を超えるペースで発生している計算である．モータリゼーションが進行しているとは言え，未だ自家用車の保有率の低いインドが既に世界最悪の交通事故死亡国であるという事実は衝撃を与えた．図-2 は 1 億以上の人口を抱える国を対象として 2008 年までの各国の交通事故死亡者数の推移を示している．これを見るとインドのみが顕著な増加を示しており，その後も 2010 年の 13 万 2000 件，そして 2011 年の 14 万 3000 件と更に大きく増加している．

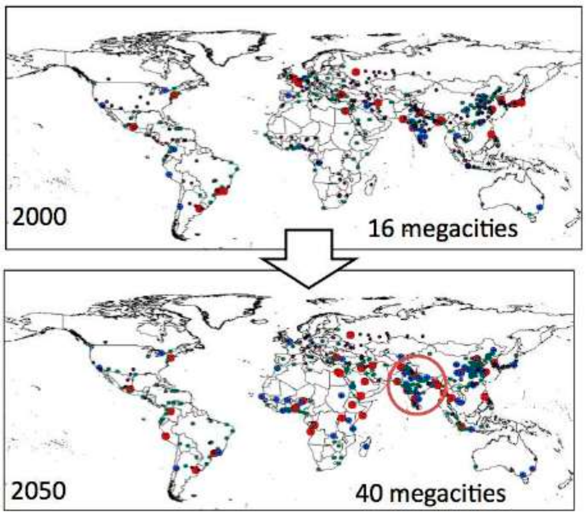

図-1 南アジアやアフリカで増加するメガシティ [1]

2012 年，世界保健機関（WHO）は，世界で増加する交通死亡事故の解決策について話し合う会議をニュージーランドで開催し，参加した各国の専門家からは，インド政府に対し，道路の安全向上に取り組む専門の機関の設立を促す意見が出された．

インド首相の諮問委員会においては，①エネルギー，②気候変動, ③安全, ④モビリティの 4 項目が重視され，これらは独立した課題ではなく，相互に関連しているとの認識が示されている．本研究においても，安全の重要性を訴えるとともに，社会・経済および文化的な要素も踏まえ，①から④の問題の全体構図にも言及する．

１．２　プロジェクトの目的

本研究では, 急増するインドの交通死亡事故の実態を，まず疫学的アプローチによって調査分析し，原因や特徴の解明を試みる．疫学的アプローチとは，特定の集団内を対象に死亡率や疾病率など，健康に関わる事柄・事象の頻度, 時間的変動などを調査し, 健康に関わる事柄と，その要因と考えられるものの間に存在する関係を解明する研究手法である [2)-4)]．また，人口100万～200万人の中規模都市群から, 人口当たりの事故死亡率の異なる6つの都市を抽出して，比較分析を行う．その結果に基づき，事故犠牲者・車両のモード構成を明らかにし，道路ユーザ毎のリスクを捉える．

なお，本研究は，都市内の道路交通死亡事故の抑制策を「道路・車両デザイン」「土地利用・都市環境デザイン」「コミュニティデザイン」の3つの観点から分野横断的および俯瞰的に捉えた上で，交通安全のためのコミュニティデザインのあり方を提案することを最終的な目

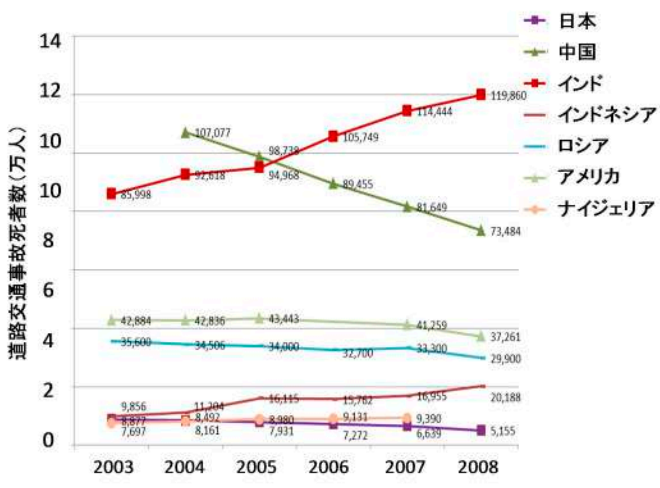

図-2　急増するインドの交通死亡事故 [5)]

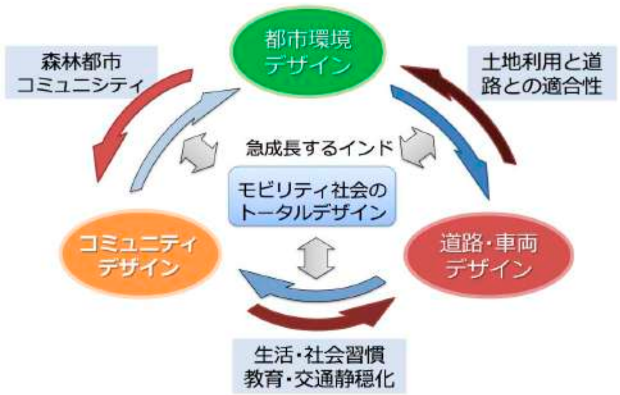

図-3　コミュニティデザインの位置づけ

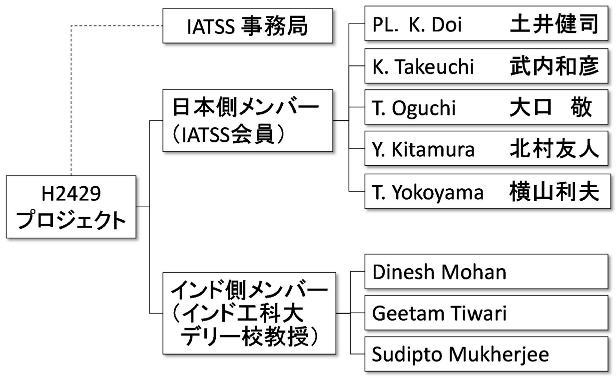

図-4　プロジェクトの実施体制

標としている．図-3は，これらの3つのデザインの相互関係と我々のプロジェクトにおけるコミュニティデザインの位置付けを示したものである．

１．３　プロジェクトの体制

研究の実施にあたり，H2429プロジェクトでは図-4に示す日印の共同研究体制を構築している．学際性を重視して，日本チームは都市計画学，環境学，交通工学，教育学および機械工学の専門家から構成し，インドチームもそれに対応して都市計画，交通工学および機械工学の専門家から構成されている．インドチームの代表はインド工科大学デリー校（以下，IITD）の著名な教授陣であり，この3名の教授に加え，調査対象都市の地元専門家にも参画を求めた．

共同研究体制の立ち上げと平成 24 年度の活動経緯は以下の通りである．

①4/13：経団連会館にて研究会・キックオフ会（土井，武内，大口，Mohan）
②5/21：IATSS と IITD の間で，2013 年度分の現地調査に関する契約を締結
③8/21-22：IITD にて研究会/中間報告会（土井，北村，Mohan，Tiwari，Mukherjee），アーグラ視察（土井）
④11/22：IITD より 2013 年度分の現地調査報告書を受領
⑤12/19：IATSS 事務局と IITD 間の Skype 通信による研究会(土井，武内，大口，北村，横山，Mohan，Tiwari，Mukherjee)
⑥2/10-12：IITD にて研究会 (土井，武内，大口，北村，Mohan，Tiwari，Mukherjee)，ヴァドーダラ視察 (土井)
⑦3/01：八重洲にて研究会（土井，武内，北村，Mohan）
⑧3/02：平成 24 年度 IATSS 内部報告会にて H2429 活動報告（土井，武内，大口，北村，横山，Mohan）

２．調査対象都市と交通死亡事故の概況

２．１　インドの概況

インドは，日本のおよそ9倍に相当する329万km2の国土に12億1019万人(2011)の人口を抱える巨大な国である．統治体制は連邦制であり，28の州および6つの連邦直轄地から成る．GDPは約2兆ドル，GDP成長率は7.4～7.9%と高い経済成長を達成している．

図-5は，2010年時点でのインドの人口の年齢構成と2025年の予測値を示しており，出生率の高さを反映して長期にわたりピラミッド型の人口構造が維持されることが読み取れる[1]．このことは，わが国や韓国，中国，また欧州諸国のように高齢化の進行に伴う交通事故リスクが増加する状況とは大きく異なり，当面は若年層を中心とした交通安全対策が求められる状況であることを示している．

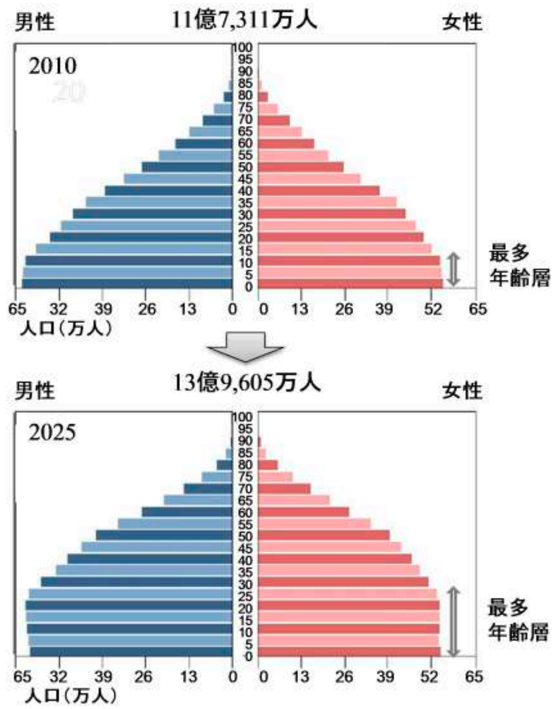

図-5　インドの人口構成とその将来予測[6]

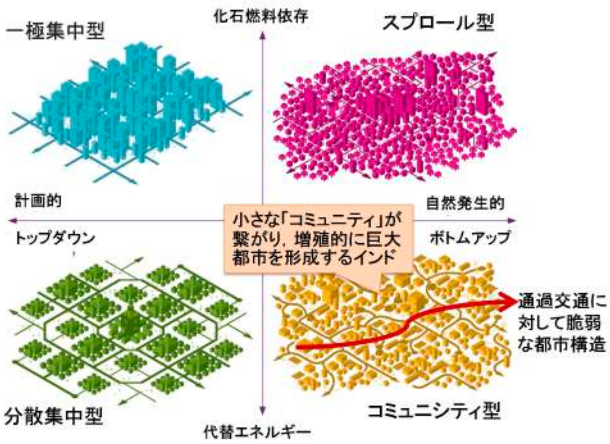

図-6　都市の類型とインド都市の特徴

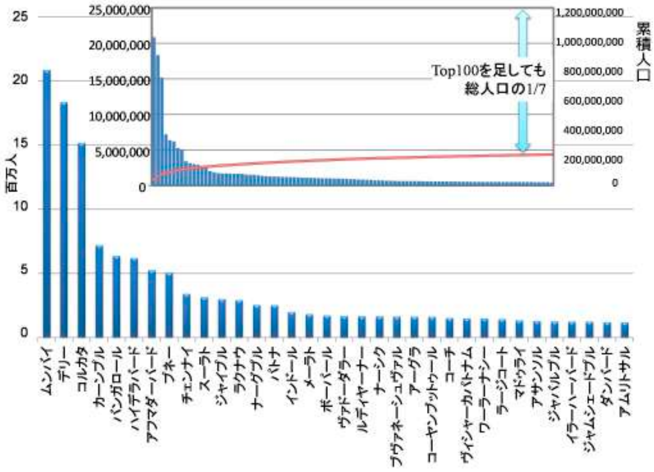

図-7　インドの都市別人口規模分布

写真-1　巨大なコミュニシティとしてのデリー

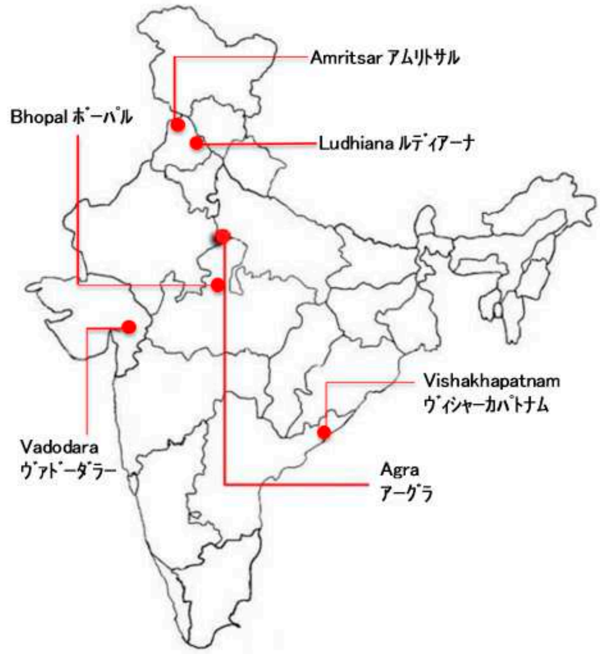

図-8　調査対象の6つの都市

2．2　インド都市の特徴と調査対象都市

世界の主要都市の形態を人口分布によって分類すると，ヨーロッパ型の「コンパクトシティ」，アメリカおよび東・東南アジアに見られる「スプロールシティ」，そしてスマートグリッドなどの次世代技術が生み出すであろう「ネットワーク型シティ」などに分類される．しかし，インドの都市のかたちはそうした分類には当てはまらない，いわば「コミュニシティ」（communi-city）と呼ばれる形態である．コミュニシティとは，小さな「コミュニティ」がつながり，増殖的に巨大都市を形成しているものである（写真-1参照）．

１章に示したように，インドにおいては今後メガシティの急増が予測される．しかしその一方で，分散型の国土構造を呈している．たとえば，図-7に示すように，人口規模トップ100の合計人口は国の総人口の7分の1にも及ばない．大多数の都市は数十万人～200万人程度の都市である．

本研究では，コミュニシティのなかでも比較的人口の多い100～200万人の中規模都市群に注目する．その上で，人口当たりの事故死亡率の異なる6つの都市を抽出して比較分析する．具体的には図-8に示すAmritsar（アムリトサル），Ludhiana（ルディアーナ），Agra（アーグラ），Bhopal（ボーパル），Vadodara（ヴァドーダラー）およびVishakhapatnam（ヴィシャーカパトナム）である．これらは人口規模においてTier-2と呼ばれるグループ（2011年時点で47都市）に属する都市群であり，今後さらに経済発展と都市化の進行が予測される地方都市群である．

2．3　対象都市におけるモータリゼーションの現況

インドにおいては急速なモータリゼーションが進行しているが，自家用車の普及率はまだまだ低い状況にある．その一方で，様々なモードの道路交通が存在し，市民の足を支えている．調査対象都市における2011年時点のモ

表-1　対象都市におけるモード別車両登録台数

モード	対象都市				
	Agra アーグラ	Bhopal ボーパル	Ludhiana ルディアーナ	Vadodara ヴァドーダラー	Vishakhapatnam ヴィシャーカパトナム
自動二輪車	568,470	497,735	866,392	817,379	453,847
オートリクショー		11,500	14,562	33,239	21,994
自動車	76,544	60,095	158,263	106,475	50,910
タクシー		13,635	1,701	7,116	6,331
バス	1,791	3,275	2,588	3,717	3,234
トラック	18,160	14,433	35,487	33,337	18,163
トラクター	37,121	14,977	48,571	4,779	3,001
合　計	702,086	616,578	1,127,564	1,008,679	558,704
人　口	1,574,542	1,756,718	1,706,069	1,516,108	1,057,146

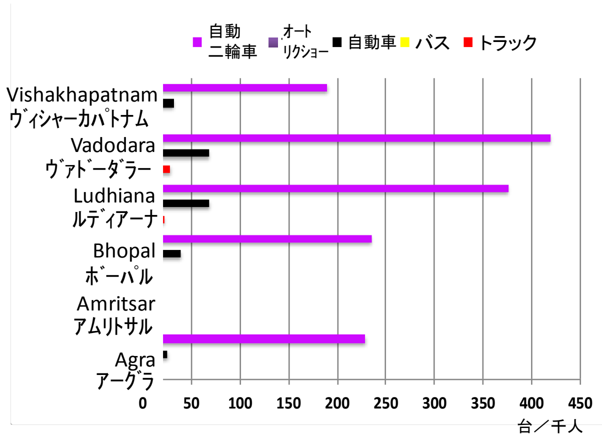

図-9　人口千人当たりのモード別車両登録台数

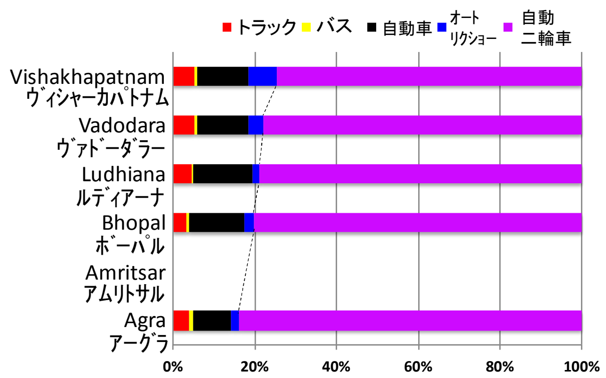

図-10　車両登録台数のモード別構成

ード別の車両登録台数を示したものが表-1である．また，図-9および図-10はそれぞれ人口千人当たりの車両登録台数およびモード別構成比を示している．いずれの都市においても自動二輪車の割合が圧倒的に高く，自動車の割合は1割強という水準である．公共交通としてのバスやオートリクショーの割合は，より低い水準にある．なお，これらの図表に示す数値は，自動二輪車については過去の登録累計値であり廃車分を考慮していないことから，過大評価の可能性があるとインド工科大（IITD）の専門家は指摘している．

表-2　対象都市における交通事故の概況

	対象都市					
都市名	Agra アーグラ	Amritsar アムリトサル	Bhopal ボーパル	Ludhiana ルディアーナ	Vadodara ヴァドーダラー	Vishakhapatnam ヴィシャーカパトナム
州名	ウッタル・プラデーシュ	パンジャーブ	マディア・プラデーシュ	パンジャーブ	グジャラート	アーンドラ・プラデーシュ
都市人口 2011 センサス	1,574,542	1,198,841	1,756,718	1,706,069	1,516,108	1,057,146
人口10万人当り交通事故件数	606	80	254	294	172	414
人口10万人当り交通事故死者数	38	7	14	18	11	24

２．４　対象都市における交通事故の概況

国家犯罪記録局（National Crime Records Bureau）の発行する2011年事故統計[5)]に基づき，対象都市における人口10万人当りの交通事故件数（事故率）および交通事故死者数（事故死亡率）を示したものが表-2である．これを見ると，人口規模が類似しているにも関わらず，事故率および事故死亡率が都市間で大きく異なっていることが読み取れる．事故率及び事故死亡率が最も高いのはアーグラであり，ヴィシャーカパトナムが続く．一方，これらの数値が最も低いのは，アムリトサルであり，ヴァドーダラー，ボーパルが続く．

都市間での事故率／事故死亡率の違いならびに各都市での交通死亡事故の特徴等については，我々が実施した独自の調査に基づき，次章で明らかにする．

３．　対象都市における交通死亡事故の詳細分析

３．１　都市別・モード別の交通事故死亡率

インドにおいては，交通事故に関するデータが，言語の異なる州に跨って統一的なフォーマットでは記録保存されていない状況にある．当然のことながらデータベース化やGIS化はなされてない．そこで6つの都市を対象に，警察署を回って，付録１に示す事故原票（FIR: First Information Report）を収集し，統一フォーム（付録２）でのデータベースの作成を実施した．収集したデータ数は下表に示す通りである．

表-3　対象都市における事故データの収集状況

都市名	記録期間	事故データ数
Agra　アーグラ	2007-11	674
Amritsar　アムリトサル	2007-11	265
Bhopal　ボーパル	2007-11	685
Ludhiana　ルディアーナ	2007-11	651
Vadodara　ヴァドーダラー	2005-10	684
Visakhapatnam　ヴィシャーカパトナム	2007-11	1164

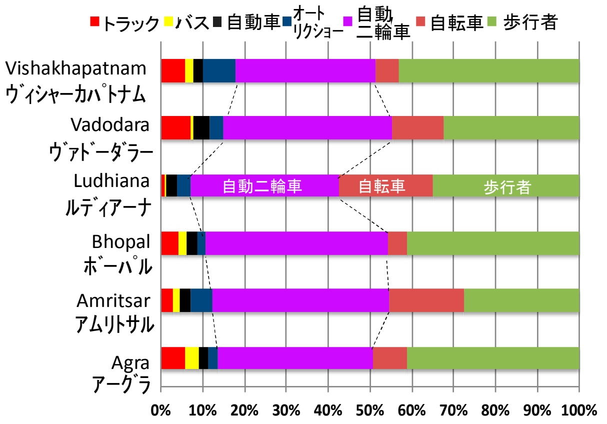

図-11　交通死亡事故のモード別（道路ユーザ別）の割合

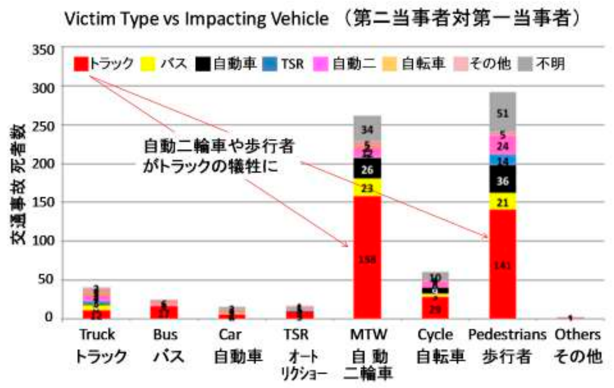

図-13　アーグラにおける交通死亡事故の類型

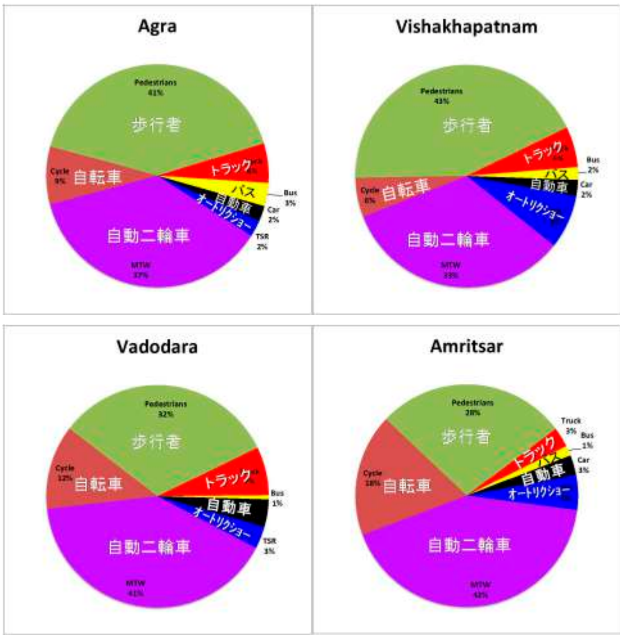

図-12　事故死亡率の異なる都市間の状態別割合の比較

（上段は事故死亡率の高い2都市，下段は低い2都市）

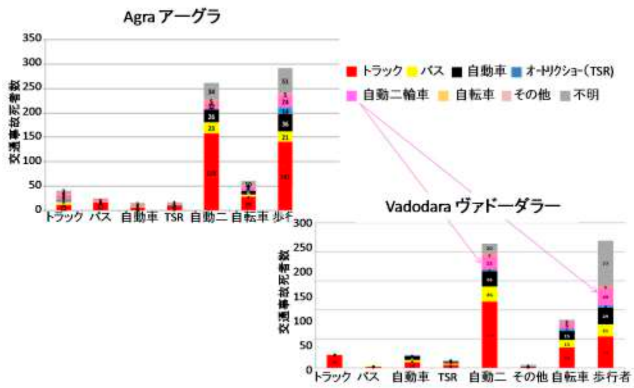

図-14　事故死亡率の異なる都市間の死亡類型の比較

IITD側が整備したデータベースに基づき，交通死亡事故のモード別（道路ユーザ別）の割合を示したものが図-11である．都市によって差異はあるものの，平均すると歩行中および自動二輪車乗用中の死亡事故はそれぞれ4割にのぼる．それに次いで自転車乗用中の死亡事故が多く，全体の1～2割を占めている．

３．２　事故類型から見た交通死亡事故の特徴

次に，調査対象の6都市より，交通事故死亡率の高い都市と低い都市をそれぞれ2都市ずつ抽出して，両者の違いを事故類型から捉えたものが図-12である．前二者はアーグラとヴィシャーカパトナムであり，後二者はアムリトサルとヴァドーダラーである．この比較で注目したいのは，歩行者と二輪車乗用中の死亡割合である．前二者においては歩行中の死亡割合が相対的に高く，後二者においては自動二輪車および自転車の乗用中の死亡割合が高い傾向が示されている．

さらに，交通死亡事故について第一当事者対第二当事者の組み合わせによって詳細に捉えたものが，図-13および図-14である．交通死亡事故率の最も高いアーグラを例とすれば，自動二輪車や歩行者がトラックの犠牲になるケースが突出して多い．

次に，アーグラと事故死亡率の低いヴァドーダラーの類型を比較すると，ヴァドーダラーにおいては歩行者がトラックの犠牲になるケースは少なく，その一方で自動二輪車同士の事故と，自動二輪車と歩行者の事故による死亡割合がアーグラに比べて多いことがわかる．

４．疫学的アプローチによる交通死亡事故の分析

４．１　交通死亡事故の時間変動の特徴

１章で示したように，疫学的アプローチとは，特定の集団内を対象に死亡率や疾病率など，健康に関わる事柄・事象の頻度，時間的変動などを調査し，健康に関わる事柄と，その要因と考えられるものの間に存在する関係を解明する研究手法である．こうしたアプローチを交

表-4　世界の疾病・傷害(DALYs)の被害順位の変化[7),8)]

1990		2020	
Rank	Disease or injury	Rank	Disease or injury
1	Lower respiratory infections	1	Ischaemic heart disease
2	Diarrhoeal diseases	2	Unipolar major depression
3	Perinatal conditions	3	Road traffic injuries
4	Unipolar major depression	4	Cerebrovascular disease
5	Ischaemic heart disease	5	Chronic obstructive pulmonary disease
6	Cerebrovascular disease	6	Lower respiratory infections
7	Tuberculosis	7	Tuberculosis
8	Measles	8	War
9	Road traffic injuries	9	Diarrhoeal diseases
10	Congenital abnormalities	10	HIV

DALY: Disability-adjusted life year. A health-gap measure that combines information on the number of years lost from premature death with the loss of health from disability.

通事故分析に適用する背景には，近年，世界保健機構WHOが途上国で増加する交通事故による死傷を社会的な疾病と見なし，その抑制のための抜本的な対策の必要性を指摘していることなどが挙げられる．表–4は, Murray CJL and Lopez ADによる，疾病や障害の影響の大きさを「障がい調整生存年（DALY）」単位で評価したランキングを示しており, 1990年には9位であった道路交通事故の傷害が2020年には3位に高まると予測されている．

a)アーグラにおける交通死亡事故のモード別時間変動

交通事故死亡率の最も高いアーグラを対象として，死亡事故件数の時間変動をモード別に示したものが図-15および図-16である．このグラフは，2007年から2011年における交通死亡事故件数をその発生時間ごとに集計し, 1日24時間内の時間変動として表現したものである．

図-15中の破線で示す全死亡事故の変動には顕著な時間的傾向は見られないが，夜間の20時から23時および3時から5時にかけて無視できない頻度で死亡事故が発生していることが読み取れる．モード別に見る自動二輪車の寄与が突出して大きく，3時から5時の時間帯ではトラックの寄与も大きい．

一方, 図-16の自転車および歩行者の死亡事故の時間変動に着目すると，歩行者の死亡事故については夜間の23時前後に著しいピークが存在することがわかる．自転車については夜間よりも昼間の10時前後に集中している．

b)ルディアー―ナにおける交通死亡事故の時間変動

次に，対象都市の中では死亡事故率が中程度のルディアー―ナの変動を見ると, 図-17のように全死亡事故では朝の9時と夜間の21時から23時に二つのピークが見られる．朝のピークには自動二輪車および自転車の死亡事故が大きく寄与しており，夜間のピークにはこれらの二つのモードに加え歩行者の死亡事故が大きく寄与している．

c）ヴァドーダラーにおける交通死亡事故の時間変動

最も死亡事故率が低いグループのヴァドーダラーに着目すると, 図-18に示すように全死亡事故では21時前後にピークが存在する．歩行者においては，この傾向は顕著である．自動二輪車や自転車の死亡事故には，明確な時間的傾向は見られない．

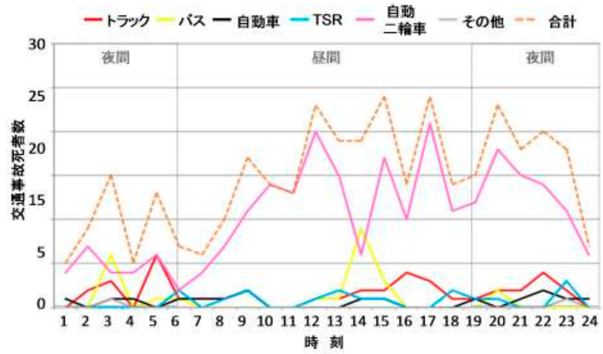

図-15　アーグラにおける交通死亡事故の時間変動

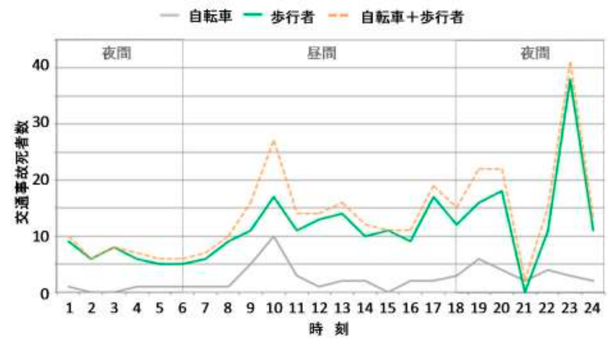

図-16　アーグラにおける交通死亡事故の時間変動

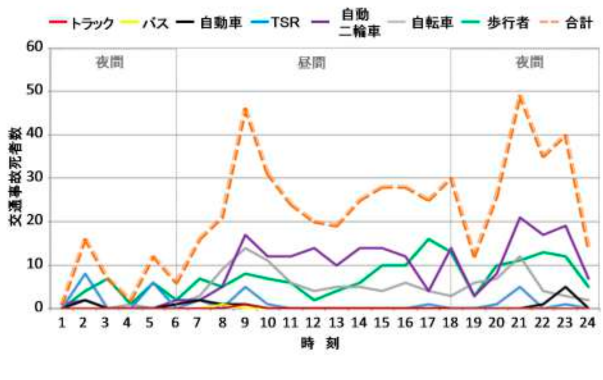

図-17　ルディアーナにおける交通死亡事故の時間変動

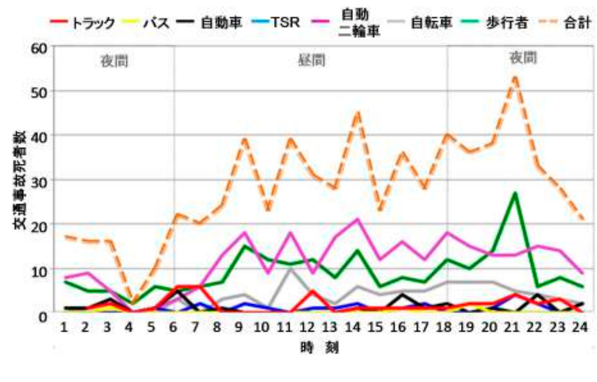

図-18　ヴァドーダラーにおける交通死亡事故の時間変動

アーグラ　　ルディアーナ　　ヴァドーダラー

図-19　3つの都市の道路ネットワーク

図-20　ルディアーナでの交通事故発生地点

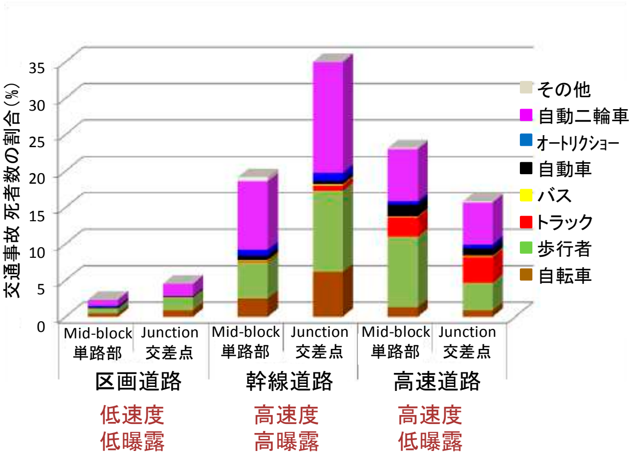

図-21　道路種別・形状別の交通死亡事故の発生割合

4．2　交通死亡事故発生地点の空間的特徴

まず，前節で取り上げた3つの都市の道路ネットワークの概要を示したものが図-19である．通過交通を処理するための放射・環状道路の組み合わせという観点から見ると，アーグラでは高規格の環状道路を備えておらず，東西および南北方向に走る幹線道路や高速道路を通じて通過交通が市街地に流入する状況を生み出している．また，歴史的な市街地や河川などの存在により，幹線道路や高速道路の線形もいびつなものとなっている．これに対して，ルディアーナやヴァドーダラーでは，環状道路が未完成ながらも，放射・環状の体系的整備が進められつつあり，通過交通の迂回を促すネットワーク構造となっている．アーグラの事故率とルディアーナ，ヴァドーダラーの事故率の大きな違いは，一つにはこうした道路ネットワーク構造の違いに起因するものと考えられる．

しかしながら，図-20に示すように環状方向のバイパイ道路を備えたルディアーナにおいても，中心市街地を貫く幹線道路上での事故が多発しており，ネットワーク対策のみでは十分な効果が上がっていないことが読み取れる．また，図-21は二重の環状道路（外環は整備途中）を有し，最もネットワーク対策が進んでいると思われるヴァドーダラーに着目し，道路種別・形状別の交通死亡事故の発生割合を示している．これを見ると，最も死亡事故の多発しているのは幹線道路の交差点であり，自動二輪車，歩行者および自転車の死亡事故が大多数を占める．道路種別に見れば，幹線道路に次いで高速道路での死亡事故割合が高く，区画道路での割合は非常に低い．高速道路においては，幹線道路に比べてトラックや自動車の死亡事故割合が高いという特徴がみられる．

なお，図中においては交通死亡事故のリスクを，速度と曝露時間（道路空間内の滞在時間）の2つの要因の組み合わせで整理し，区画道路を「低速度×低曝露」，幹線道路を「高速度×高曝露」，幹線道路を「高速度×低曝露」と位置付けている．こうした整理に基づき，幹線道路における交通事故死亡の発生割合の高さを高速度×高曝露の複合リスクの結果と解釈している．

図-22は，ヴァドーダラーの道路ネットワーク上における交通事故多発地点の位置とその風景を示している．図

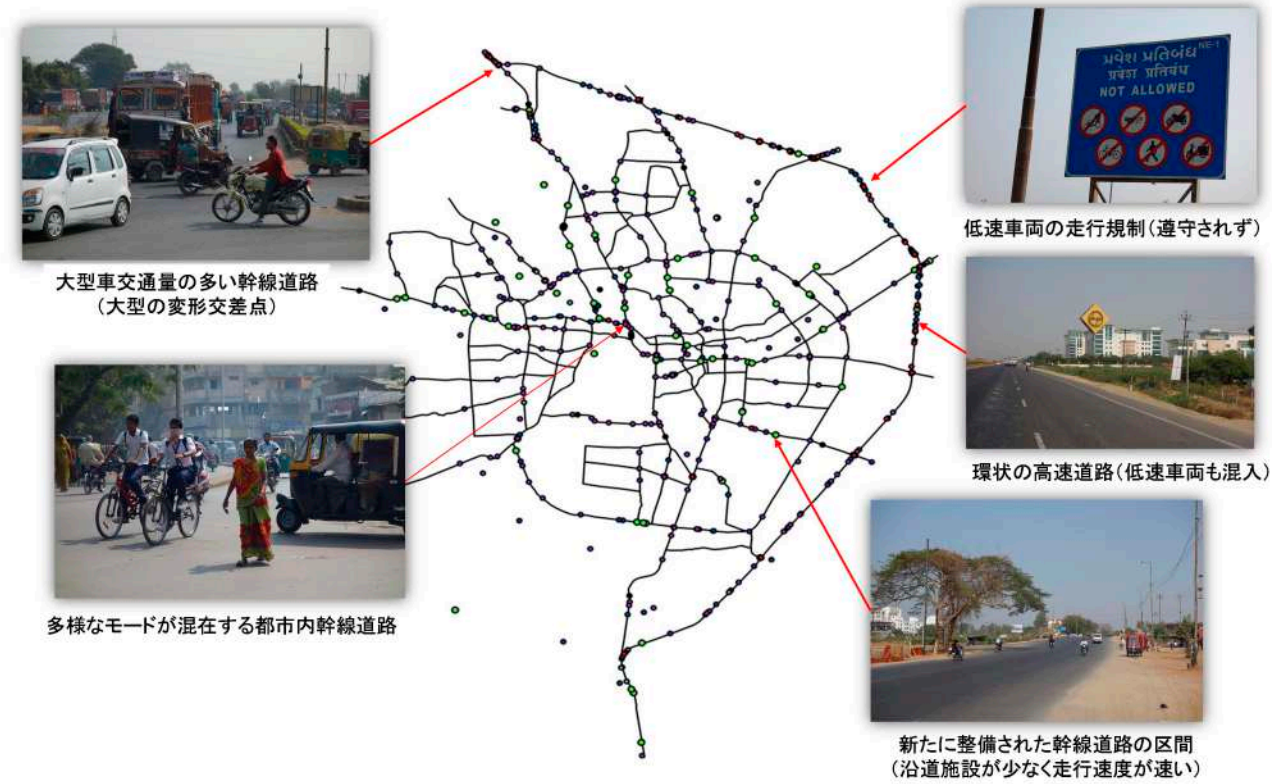

図-22　ヴァドーダラーの道路ネットワーク上における交通事故多発地点の位置と状況

中の5つの写真は,幹線道路および高速道路上の多発地点の状況を映したものであり，高速度×高曝露の複合リスクを抱える問題箇所である.

４．３　モード別の交通死亡事故リスク

交通死亡事故のリスクは，場としての道路空間のリスクだけでなく車両側のリスクにも依存すると考えるべきであろう．そこで，本節では車両（モード）の利用に関わる次の二種のリスク[9]を定義し，その定量化を試みる.

①パーソナルリスク：利用者一人トリップ当たり

$$\mathrm{PR} = \frac{\text{各モードの交通事故死者数}}{\text{各モードのトリップ数} \times \text{平均乗員数}} \qquad (1)$$

②社会的リスク（曝露を考慮）：一台キロ当たり

$$\mathrm{SRE} = \frac{\text{各モードに絡む交通事故死者数}}{\text{各モードの走行台キロ}} \qquad (2)$$

アーグラ，ヴァドーダラーに加え，ボーパルおよびヴィシャーカパトナムの4都市での交通事故データに基づき，パーソナルリスクおよび社会的リスクをモード別に評価した結果が図-23および図-24である.

パーソナルリスク（personal risk: PR）については，自動二輪車のリスクが突出して高い値を示し，特にアーグ

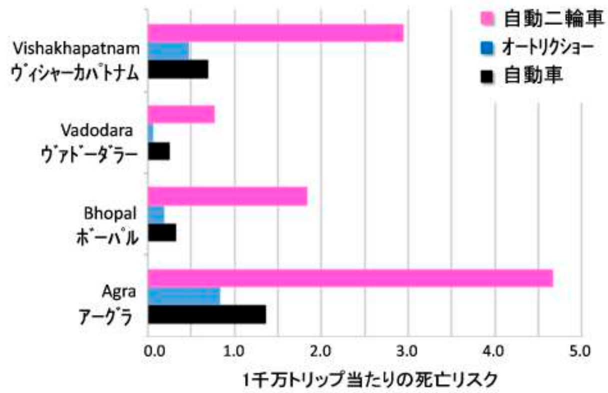

図-23　モード別のパーソナルリスクの評価結果

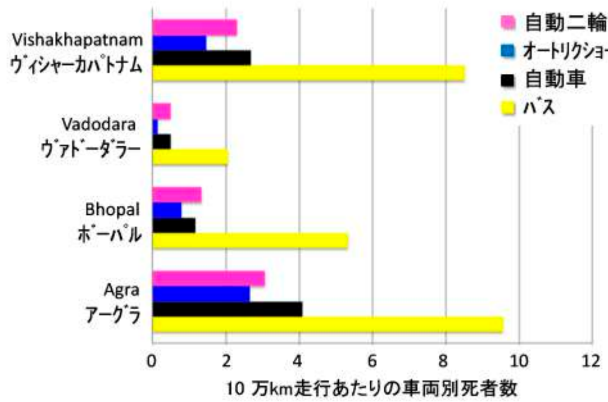

図-24　モード別の社会的リスクの評価結果

写真-2　乗員率の高いオートリクショー

ラにおいて高い結果となった．最もリスクの小さいモードはオートリクショーである．なお，オートリクショーは写真-2 に示すように小型ながら乗員率の高い中量輸送機関（パラトランジット）として利用されている．

社会的リスク（societal risk exposed: SRE）については，公共交通であるバスが最も高い値を示し，自動車，自動二輪車が続く．一方，オートリクショーは社会的リスクにおいても最も低い値を示している．なお，自動二輪車について二つのリスクが大きく異なる傾向を示している理由は，パーソナルリスクでは平均乗車人員を考慮して利用者一人当たりのリスクを評価しているためである．評価においては，調査結果に基づき，一日当たりの平均乗員数を自動二輪車では４人，自動車では７人，オートリクショーでは 60 名と設定している．一方，一台当たりの加害側・被害側の両者を含むリスクに着目した社会的リスクにおいては，輸送力の大きなバスのリスクが高く評価される結果となっている．

5．まとめ～分析に基づく事故削減方策の整理～

５．１　都市と道路の視点から

本研究調査を通して，都市内の広幅員の幹線道路では，高い死亡率が認められた．このような道路においては，高速度×高曝露時間の複合的なリスクが高いことから，まず速度コントロールの必要があると考えられる．また，バイパス道路（高速道路を含む）においても，法制度上は認められていない自動二輪車，自転車，歩行者などの中低速モードの混入による死亡事故が多発していることから，高架化などにより走行速度や車両サイズの異なるモードの混在を整理することも必要であると思われる．都市内の幹線道路においては，歩行者・自転車と自動二輪車・オートリクショー間のコンフリクトを軽減するための歩道施設，分離された自転車レーンが交通死亡事故抑制には有効である．あわせて，夜間に集中する歩行者の交通死亡事故の抑制には，街路照明の改善，街路・区画道路（生活道路）の交通静穏化も求められるところである．

５．２　モード別のリスクの視点から

車両については，パーソナルリスクは自動二輪車，自動車，オートリクショーの順に高いことが明らかにされた．一方，社会的リスクについては，バスが最も高く，次いで自動車，自動二輪車，オートリクショーの順となる．このことを鑑みると，パーソナルリスクの観点からはヘルメットの着用による自動二輪車走行の安全性向上，社会的リスクの観点からは，バス，トラックの速度抑制および衝突時の衝撃を軽減するためのバス車両のフロントのソフト化などの対策が重要と考えられる．

５．３　社会・コミュニティの視点から

社会・コミュニティの視点からは，特に夜間の歩行者・自動二輪車・トラック間の事故が大きな問題であることが認められた．一つには，夜間の暗さによる視認性の悪さが原因と指摘される．都市を覆う森林と，街灯照明の不足がこのような状況を招いていると考えられ，実態把握のための詳細調査は平成25年度に実施するものとする．一方で，飲酒人口の急増も大きな要因と推察される．ここ10年で，デリーで7倍，ムンバイで16倍の飲酒人口が増加し，現地新聞報道によると，全交通死亡事故のうち7割が飲酒運転であったという．厳格な禁酒都市（州）であるヴァドーダラーのようなセーフコミュニティ化が求められる．

コミュニティによる交通の静穏化の推進という視点からは，市街地を通過する幹線・高速道路の建設を市民の声により抑制するなどの取り組みが待たれる．また，リスク評価の観点から，パーソナルおよび社会的なリスクの低い安全かつ効率的なパラトランジットの賢い活用が重要と考えられる．また，オートリクショーや自動二輪車の事故に巻き込まれる歩行者と自転車の死亡事故を抑制するための施策も必要である．

これら「都市環境デザイン」「道路・車両デザイン」「コミュニティデザイン」の3つの視点は，どれか一つが達成できればよいものではなく，モビリティ社会のトータルデザインとして，相互に働きかけながらともに機能しあうものである．コミュニティデザインは，その有機的なつながりの一端を担うものである．部分解を追求するのではなく，常に3つの観点で全体最適をめざすなかに，インドにおける交通死亡事故の抑制が実現できるものと思われる．

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付録１　インドにおける既存の事故記録原票の例

FIRST INFORMATION REPORT

CIPA-R1.11 00

(Under Section 154 Cr.P.C.)

1. District: AMRITSAR CITY P.S.: Maqboolpura Year: 2011 FIR No.: 68 Date: 26-12-2011

2. Act(s): Section(s):
   (i) IPC 1860 304A/279
   (ii)
   (iii)
   (iv)

3. Occurrence of Offence:
   (a) Day: Monday Date From: 26-12-2011 Date To: 26-12-2011
   Time Period: Time From: 18:30 hrs Time To:
   (b) Information received at P.S: Date: 26-12-2011 Time: 20:05 hrs
   (c) General Diary Reference: Entry No.: 29 Time: 20:05 hrs

4. Type of information: WRITTEN

5. Place of Occurrence:
   (a) Direction and Distance from P.S: West/1.0 Km. Beat No.: 01
   (b) Address: RAM TALAI CHOWK, AMRITSAR
   (c) In case, Outside the limit of the Police Station:
   Name of P.S: District:

6. Complainant/Informant:
   (a) Name: RAJAN SHARMA (S/O) ASHWANI KUMAR
   (b) Birth Year: Nationality: INDIA
   (c) Passport No. Date of Issue: Place of Issue:
   (d) Occupation:
   (e) P R/o ,
   C R/o H.NO 33 GALI NO 3 PAWAN NAGAR BATALA ROAD ASR.

7. Details of Known/Suspect/Unknown accused with full particulars(attach separate sheet if necessary):
   (i) KASHMIR SINGH (S/O) NIRANJAN SINGH
   P R/o ,
   C R/o VILL BHINDER PS KHALCHIAN ASR (R).
   (ii)
   (iii)

8. Reason for delay in reporting by the complainant/informant: NO DELAY

9. Particulars of the properties stolen/involved(attach separate sheet if necessary):

Sl.No.	Property Type(Description)	Est. Value(Rs.)	Status
(i)			
(ii)			
(iii)			

-- 1 --

District: AMRITSAR CITY P.S.: Maqboolpura Year: 2011 FIR No.: 69 Date: 26-12-2011

10 - Total value of property stolen:

11 - Inquest Report/U.D Case No., if any:

12 - F.I.R Contents(attach separate sheet,if required):

ਬਿਆਨ ਅਜਾਨੇ ਸ੍ਰੀ ਰਾਜਨ ਸ਼ਰਮਾ S/o ਸ੍ਰੀ ਅਸ਼ਵਨੀ ਕੁਮਾਰ ਕੌਮ ਬ੍ਰਾਹਮਣ ਵਾਸੀ H.no 33 ਗਲੀ ਨੰ 3 ਪਵਨ ਨਗਰ ਬਟਾਲਾ ਰੋਡ ਅੰਮ੍ਰਿਤਸਰ ਉਮਰ ਕ੍ਰੀਬ 27 ਸਾਲ ਬਿਆਨ ਕੀਤਾ ਕਿ ਮੈ ਉਕਤ ਪਤੇ ਦਾ ਰਹਿਣ ਵਾਲਾ ਹਾਂ ਅਤੇ ਮੈ ਨਗਰ ਨਿਗਮ ਅੰਮ੍ਰਿਤਸਰ ਵਿਚ ਠੇਕੇਦਾਰੀ ਦਾ ਕੰਮ ਕਰਦਾ ਹਾਂ ਅਤੇ ਅੱਜ ਵਕਤ ਕ੍ਰੀਬ 6.30 ਵਜੇ ਸ਼ਾਮ ਨੂੰ ਆਪਣੀ ਮਾਰੂਤੀ ਕਾਰ ਨੰਬਰੀ CH01-L-1380 ਸਵਾਰ ਹੋ ਕੇ ਬੱਸ ਸਟੈਂਡ ਅੰਮ੍ਰਿਤਸਰ ਤੋਂ ਆਪਣੇ ਘਰ ਨੂੰ ਜਾ ਰਿਹਾ ਸੀ ਅਤੇ ਮੇਰੇ ਪਿਤਾ ਅਸ਼ਵਨੀ ਕੁਮਾਰ ਆਪਣੇ ਮੋਟਰਸਾਈਕਲ ਨੰਬਰੀ ਟੈਂਪਰੇਰੀ PB02-BM-4236 ਹੀਰੋ ਹਾਂਡਾ ਸਪਲੈਂਡਰ ਰੰਗ ਕਾਲਾ ਤੇ ਸਵਾਰ ਹੋ ਕੇ ਮੇਰੇ ਅੱਗੇ ਅੱਗੇ ਜਾ ਰਹੇ ਸੀ ਜਦੋਂ ਮੇਰੇ ਪਿਤਾ ਅਸ਼ਵਨੀ ਕੁਮਾਰ ਰਾਮਤਲਾਈ ਚੌਕ ਤੇਹਰਾਂ ਵਾਲਾ ਤੇ ਤੇਹਰਾਂ ਵਾਲੀ ਸਾਈਡ ਪਹੁੰਚੇ ਤਾਂ ਮਗਰੋਂ ਬੱਸ ਸਟੈਂਡ ਅੰਮ੍ਰਿਤਸਰ ਵਲੋਂ ਇਕ ਬੱਸ ਬਹੁਤ ਤੇਜ਼ ਸਪੀਡ ਆਈ ਜਿਸ ਨੂੰ ਇਕ ਸਰਦਾਰ ਡਰਾਈਵਰ ਚਲਾ ਰਿਹਾ ਸੀ ਜਿਸ ਨੇ ਮੇਰੇ ਪਿਤਾ ਤੋਂ ਥੋੜੀ ਅੱਗੇ ਬੱਸ ਕੱਢੀ ਤੇ ਮੇਰੇ ਪਿਤਾ ਨੂੰ ਬੱਸ ਦੀ ਸਾਈਡ ਮਾਰੀ ਜੋ ਮੇਰੇ ਪਿਤਾ ਦਾ ਮੋਟਰਸਾਈਕਲ ਸੜਕ ਤੇ ਡਿੱਗ ਪਿਆ ਅਤੇ ਮੇਰੇ ਪਿਤਾ ਦਾ ਸਿਰ ਸੜਕ ਤੇ ਵੱਜਾ ਤੇ ਖੂਨ ਲੱਥ ਪੱਥ ਹੋ ਗਿਆ ਤੇ ਮੈਂ ਆਪਣੀ ਕਾਰ ਖੜੀ ਕਰਕੇ ਰੌਲਾ ਪਾਇਆ ਅਤੇ ਬੱਸ ਦਾ ਨੰਬਰ PB09-8125 ਜਿਸ ਦੀ ਸਾਈਡ ਤੇ ਪਿਆਰ ਬੱਸ ਸਰਵਿਸ ਲਿਖਿਆ ਸੀ ਜਿਸ ਦੇ ਡਰਾਈਵਰ ਦਾ ਨਾਮ ਬਾਅਦ ਵਿਚ ਪਤਾ ਲੱਗਾ ਕੇ ਕਸ਼ਮੀਰ ਸਿੰਘ S/oਨਿਰੰਜਣ ਸਿੰਘ ਕੌਮ ਜੱਟ ਸਿੱਖ ਵਾਸੀ ਪਿੰਡਰ ਥਾਣਾ ਘਰਿੰਡਾ ASR ਦਿਹਾਤੀ ਚਲਾ ਰਿਹਾ ਸੀ ਜੋ ਮੇਰੇ ਪਿਤਾ ਦੇ ਤੇਜ਼ ਰਫਤਾਰ ਉਕਤ ਡਰਾਈਵਰ ਨੇ ਉਕਤ ਬੱਸ ਦੀ ਸਾਈਡ ਮਾਰੀ ਤਾਂ ਮੇਰੇ ਪਿਤਾ ਦੇ ਸੜਕ ਵਿਚ ਡਿੱਗ ਕੇ ਸਿਰ ਵਿਚ ਗੰਭੀਰ ਸੱਟ ਲਗਣ ਕਾਰਨ ਮੌਕੇ ਤੇ ਮੌਤ ਹੋ ਗਈ ਤੇ ਮੈਂ ਆਪਣੇ ਰਿਸ਼ਤੇਦਾਰ ਨੂੰ ਫੋਨ ਕਰਕੇ ਮੌਕਾ ਤੇ ਬੁਲਾਇਆ ਸੜਕ ਤੇ ਲੋਕਾਂ ਦੀ ਭੀੜ ਹੋਣ ਕਰਕੇ ਡਰਾਈਵਰ ਕਸ਼ਮੀਰ ਸਿੰਘ ਉਕਤ ਮੌਕਾ ਤੋਂ ਬੱਸ ਛੱਡ ਕੇ ਭੱਜ ਗਿਆ ਮੈਂ ਆਪਣੇ ਪਿਤਾ ਦੀ ਲਾਸ਼ ਕੋਲ ਮੰਨੀ ਸ਼ਰਮਾ S/o ਸ੍ਰੀ ਵਿਨੋਦ ਕੁਮਾਰ ਕੌਮ ਬ੍ਰਾਹਮਣ ਵਾਸੀ H,no 33 ਗਲੀ ਨੰਬਰ 3 ਪਵਨ ਨਗਰ ਬਟਾਲਾ ਰੋਡ ਅੰਮ੍ਰਿਤਸਰ ਛੱਡ ਕੇ ਆਪ ਪਾਸ ਇਤਲਾਹ ਦੇਣ ਜਾ ਰਿਹਾ ਸੀ ਆਪ ਮਿਲ ਗਏ ਹੋ ਕਾਰਵਾਈ ਕੀਤੀ ਜਾਵੇ ਬਿਆਨ ਸੁਣ ਲਿਆ ਠੀਕ ਹੈ Sd/- Rajan Sharm ਤਸਦੀਕ ਪਰਮਜੀਤ ਸਿੰਘ ASI PS ਮਕਬੂਲਪੁਰਾ ਅੰਮ੍ਰਿਤਸਰ ਮਿਤੀ 26-12-11 ਕਾਰਵਾਈ ਪੁਲਿਸ:- ਅੱਜ ਮਨ ASI ਸਮੇਤ HC ਸਤਨਾਮ ਸਿੰਘ 2976 HC ਜੋਗਿੰਦਰ ਸਿੰਘ 2528 SPO ਅਨੂਪਾਲ 1068 ਬਾਏ ਗਸ਼ਤ ਅਤੇ ਤਲਾਸ਼ ਭੈੜੇ ਪੁਰਸ਼ਾਂ ਦੇ ਸਬੰਧ ਵਿਚ ਪ੍ਰਾਈਵੇਟ ਵਹੀਕਲਾਂ ਦੇ ਸਬੰਧ ਵਿਚ ਥਾਣਾ ਮਕਬੂਲਪੁਰਾ ਤੋਂ ਗੋਲਡਨ ਐਵੀਨਿਊ ਅੰਮ੍ਰਿਤਸਰ ਨੂੰ ਜਾ ਰਹੇ ਸੀ ਜਦ ਮੋੜ ਗੋਲਡਨ ਐਵੀਨਿਊ ਪੁੱਜੇ ਤਾਂ ਸ੍ਰੀ ਰਾਜਨ ਕੁਮਾਰ S/o ਅਸ਼ਵਨੀ ਕੁਮਾਰ ਉਕਤ ਨੇ ਮੇਰੇ ਪਾਸ ਹਾਜ਼ਰ ਆ ਕੇ ਆਪਣਾ ਉਕਤ ਬਿਆਨ ਤਹਿਰੀਰ ਕਰਾਇਆ ਬਿਆਨ ਲਿਖ ਕੇ ਪੜ੍ਹ ਕੇ ਸੁਣਾਇਆ ਗਿਆ ਜਿਸ ਨੇ ਆਪਣਾ ਬਿਆਨ ਠੀਕ ਮੰਨ ਕੇ ਆਪਣੇ ਬਿਆਨ ਹੇਠ ਅੰਗਰੇਜ਼ੀ ਵਿਚ ਦਸਖਤ ਕੀਤੇ ਜਿਸ ਦੀ ਮੈਂ ਤਸਦੀਕ ਕੀਤੀ ਬਿਆਨ ਬਾਲਾ ਤੋਂ ਸੂਰਤ ਜੁਰਮ 304A/279 IPC ਦਾ ਹੋਣਾ ਪਾਇਆ ਜਾਂਦਾ ਹੈ ਕੰਟਰੋਲ ਰੂਮ ਪਰ ਇਤਲਾਹ ਦਿਤੀ ਜਾਵੇ ਬਿਆਨ ਹੱਥੀ SPO ਅਨੂਪਾਲ 1068 ਥਾਣੇ ਭੇਜਿਆ ਜਾਂਦਾ ਹੈ ਮੁਕੱਦਮਾ ਦਰਜ ਕਰਕੇ ਨੰਬਰ ਮੁਕਦਮਾ ਤੋਂ ਜਾਣੂ ਕੀਤਾ ਜਾਵੇ ਮੈਂ ਸਮੇਤ ਸਾਥੀ ਕਰਮਚਾਰੀਆ ਮੌਕਾ ਪਰ ਮਸਰੂਫ ਤਫਤੀਸ਼ ਹਾਂ Sd/- ਪਰਮਜੀਤ ਸਿੰਘ ASI PS ਮਕਬੂਲਪੁਰਾ ASR 26-12-11 ਅੱਜ ਬਰਦ '- ਮੋੜ ਗੋਲਡਨ ਐਵੀਨਿਊ at 7.00 pmਅੱਜ ਥਾਣਾ ':- ਇਸ ਵਕਤ ਉਕਤ ਫਰਦ ਬਿਆਨ ਮੌਸੂਲ ਥਾਣਾ ਹੋਣ ਤੇ ਮੁਕੱਦਮਾ ਉਕਤ ਬਾ ਜੁਰਮ ਉਕਤ ਦਰਜ ਰਜਿਸਟਰ ਕਰਕੇ ਅਸਲ ਫਰਦ ਬਿਆਨ ਮਏ ਨਕਲ FIR ਹੱਥੀ ਅਹਿਦਾ ਕਰਮਚਾਰੀ ਨਿਯਦ ASI ਪਾਸ ਮੌਕਾ ਪਰ ਭੇਜਿਆ ਜਾਂਦਾ ਹੈ ਕੰਟਰੋਲ ਰੂਮ ਤੇ ਮੁੱਖ ਅਫਸਰ ਥਾਣਾ ਬਜ਼ਰੀਆ ਟੈਲੀਫੋਨ ਇਤਲਾਹ ਦਿਤੀ ਗਈ ਪੂਰਤੀ ਰਪਟ ਨੰਬਰ 31 ਸਮਾਂ 9.05 PM

13 - Action Taken(Since the above information reveals commission of offence(s)u/s as mentioned at Item No.2:

(i) Registered the case and took up the investigation OR

(ii) Directed(Name of the I.O): PARAMJIT SINGH Rank: ASI
No.: 1146 to take up the investigation, O

(iii) Refused investigation due to:
OR

(iv) Transferred to P.S(name): District:
on point of jurisdiction.

F.I.R read over to the complainant/informant, admitted to be correctly recorded and a copy given to the complainant/informant, free of cost:

R.O.A.C:

14 -

Signature / Thumb Impression of The Complainant/Informant:

Signature of Officer
Name: PRITAM PAL
Rank: SI No.: 783

15 - Date and Time of despatch to the court:

付録２　H2429 プロジェクトにおいて作成した統一的な事故記録票

Road Accident Recording Form

Accident Information

Form No.		
Filled By	Date filled (dd/mm/yyyy)	/ /
Police Report Available	0=No 1=Yes	If yes, FIR No.
City/Town/Village Name		
Time of Accident		
Date	(DD) (MM) (YYYY)	
Day	01=Monday 02=Tuesday 03=Wednesday 04=Thursday 05=Friday 06=Saturday 07=Sunday 08=Unknown	
Holiday	0 = No 1 = Yes 9=Unknown	
Hit and Run	0 = No 1 = Yes 9=Unknown	
Accident Severity	1=Damage Only 2= Injury 3=Fatal 9= Unknown	
No. of Fatalities		
No. of Injured		
No. of Vehicles Involved		
Collision Type		

01 = Hit pedestrian	02 = Vehicles head on	03 = Vehicle hit from back
04 = Vehicle hit from side at right angle	05 = Sideswipe (same direction)	06= Vehicle Sideswipe (opposite direction)
07 = Overturn	08 = Vehicle hit fixed object	09 = Run off the road
10= Others	99 = Unknown	

Collision Spot	01 = On straight road 02 = Road junction 03 = Other 09 = Unknown	
Type of Road	0= Un-metalled 01=Metalled (Black topped/Concrete) 02=Others 09=Unknown	

Divider 1=Two-Way without median 2= Two-way with median 3= One-way 9= Unknown

Location 1=Urban 2=Rural 3=Semi-Urban 4=Other 9=Unknown

Light Condition 1=Day light 2=Dark 3= Dark but lighted 4= Dawn 5= Dusk 9= Unknown

Road Category **RURAL:** 1= State Highway 2= National Highway 3= PMGSY

URBAN: 4=Arterial 5= Sub-Arterial 6= Local Street 7= Local 8= Other 9= Unknown

Distance Km post. In the absence of Km post - from the nearest urban centre ((m)

From

Global Position (latitude) (longitude)

Road 1 **Road 2**

Road 3 **Land**

Brief Description of Accident

Vehicle Information

Form No. **Vehicle**

Type

01 = Multi-Axle Heavy Goods vehicle 02 = 2-Axle Heavy Goods vehicle 03=Light Goods Vehicle 04 =Mini Bus

05= Bus 06 = Car/van/jeep/taxi 07= Ambulance 08= Fire Fighting Vehicle

09= Three Wheeler Passenger 10=Three Wheeler Goods 11 =Thela 12=Electric Cycle

13 = Tractor without Trailor 14= Tractor with Trailor 15 = Cycle Rickshaw 16 = Motorcycle/Scooter/Moped

17 = Animal drawn vehicle 18=Bicycle 19=Pedestrian 20=Others 99=Unknown

Maneuver of Vehicle at Crash Time

01 = Proceeding straight 02 = Turning 03 = Reversing 04 = Overtaking 05=Parked/Stopped

06 = Other 07= Going wrong way 08= Making U turn 09 = Unknown

Loading 1=Normal 2= Overloaded 3= Others 9= Unknown

Disposition 0=Not Roadworthy (needs to be towed away) 1= Roadworthy (can drive away) 9 = Unknown

Mechanical Failure 0=No 1=Yes 9=Unknown

Hazardous Cargo 0=No 1=Yes 9=Unknown

Fire 0=No 1=Yes 9=Unknown

Impact-Vehicle/Object

Vehicle type (If another vehicle impacted this vehicle) 11=Pedestrian 12=Tree

13=Kerb/Median 14= Pole 15= Other 99=Unknown

Make-Model

Model-Year

Form No. **Vehicle**

Type

01 = Multi-Axle Heavy Goods vehicle 02 = 2-Axle Heavy Goods vehicle 03=Light Goods Vehicle 04 =Mini Bus

05= Bus 06 = Car/van/jeep/taxi 07= Ambulance 08= Fire Fighting Vehicle

09= Three Wheeler Passenger 10=Three Wheeler Goods 11 =Thela 12=Electric Cycle

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17 = Animal drawn vehicle 18=Bicycle 19=Pedestrian 20=Others 21=Unknown

Manoeuvre of Vehicle at Crash Time

01 = Proceeding straight   02 = Turning   03 = Reversing   04 = Overtaking   05=Parked/Stopped

06 = Other   07= Going wrong way   08= Making U turn   09 = Unknown

Loading

1=Normal   2= Overloaded   3= Others   9= Unknown

Disposition

0=Not Roadworthy (needs to be towed away)   1= Roadworthy (can drive away)   9 = Unknown

Mechanical Failure

0=No   1=Yes   9=Unknown

Hazardous Cargo

0=No   1=Yes   9=Unknown

Fire

0=No   1=Yes   9=Unknown

Impact-Vehicle/Object

Vehicle type (If another vehicle impacted this vehicle)   11=Pedestrian   12=Tree

13=Kerb/Median   14= Pole   15= Other   99=Unknown

Make-Model

Model-Year

Victim Information

Road User

1= Passenger, 2= Driver, 3= Pedestrian, 4=Cyclist, 9= Unknown

Occupant Vehicle

01 = Multi-Axle Heavy Goods vehicle   02 = 2-Axle Heavy Goods vehicle   03=Light Goods Vehicle   04 =Mini Bus

05= Bus   06 = Car/van/jeep/taxi   07= Ambulance   08= Fire Fighting Vehicle

09= Three Wheeler Passenger   10=Three Wheeler Goods   11 =Thela   12=Electric Cycle

13 = Tractor without Trailor   14= Tractor with Trailor   15 = Cycle Rickshaw   16 = Motorcycle/Scooter/Moped

17 = Animal drawn vehicle   18=Bicycle   19=Pedestrian   20=Others   21=Unknown

Seating Position

01= Front   02= Back   03= Other   09= Not Applicable for Cyclist/Pedestrian

Location of Non-occupant

Age

In years, 99 if unknown

Sex

1 = Male   2 = Female

Injury

0 = No injury   1= Injured   2 = Fatal   9 = Unknown

Pedestrian/Vehicle Impact

Mode of Treatment

0=None 01=First aid only 02=Discharge after casualty ward treatment 03=Admitted to hospital 08=Others 09=Unknown

No. of Days in Hospital Days, Unknown- 999

Injury 1							**Injury Severity 1**	
Injury 2							**Injury Severity 2**	
Injury 3							**Injury Severity 3**	
Injury 4							**Injury Severity 4**	
Injury 5							**Injury Severity 5**	
Injury 6							**Injury Severity 6**	
Most Severe Injury							**ISS**	

A STUDY ON COMMUNITY DESIGN FOR TRAFFIC SAFETY

OBJECTIVE

1. To study the epidemiology of road traffic injury (fatal) patterns in six cities of India differentiated by population size and high and low rates of fatalities per unit population.
2. To understand the modal share of victims and vehicles involved in crashes and to estimate risk functions associated with different road users.
3. To obtain a preliminary understanding of road design from an engineering perspective, design of the built environment from a land-use perspective, and community design in a broader sense for control of road traffic fatalities in urban areas.
4. To suggest areas of detailed research in future studies.

RESEARCH TEAM – TRIPP IIT DELHI

Indian Institute of Technology Delhi

1. Professor Dinesh Mohan. Ph.D. in Bioengineering, University of Michigan, Ann Arbor, Michigan, USA.

2. Professor Geetam Tiwari. Ph. D. In Transportation Planning, University of Illinois, Chicago, Illinois, USA

3. Professor Sudipto Mukherjee. Ph.D. in Mechanical Engineering, Ohio State University, Columbus, Ohio, USA.

TIME FRAME

One year: 1 APRIL 2012 – 31 MARCH 2013

RESEARCH DESIGN AND METHODS

Selection of study sample

Six cities were selected in India for the study (Figure 1).

Figure 1. Cities selected for the study.

Table 1. Population and road traffic fatality data for six cities selected for the study.

	CITY					
	Agra	**Amritsar**	**Bhopal**	**Ludhiana**	**Vadodara**	**Vishakhapatnam**
Population 2011 Census	1,574,542	1,132,761	1,795,648	1,613,878	1,666,703	1,730,320
Fatalities in 2011	653	70	254	294	172	416
Fatalities per 100,000 persons	41	6	14	18	10	24

Table 1 shows the population and road traffic fatality data for the six cities selected for the present study (Census of India, 2012, NCRB, 2012).

It was decided to select 6 cities to get a proper representation of the situation in India. Travel patterns can vary from city to city in the use of bicycles, paratransit modes, mopeds and official public transport. The six cities have very different fatality rates per 100,000 persons. These cities represent the growing urban agglomerations of India where high growth rates are expected in the next decade. An analysis for these cities would be useful as our findings may influence future directions for road safety policies in high growth cities in India.

Sources of data

Data were collected from different police stations in each city, transportation departments, and municipalities of the selected cities.

Collection and coding of Data

Research assistants specially employed for the project were sent to Agra, Amritsar, Bhopal, Ludhiana, Vadodara and Vishakhapatnam to obtain primary data on vehicle registration and road traffic fatality cases and other data available in the city from secondary sources (e.g.: transportation and city development plan studies commissioned by respective city governments).

Different police stations in each city were visited and a request placed for obtaining copies of First Information Reports (FIRs) of fatal road traffic crashes for the previous five years (example in Appendix 1). The data from the records so obtained were coded on to a special accident recording form (Appendix 2). The data from these forms were then entered in spread sheets for computer analysis.

Data Analysis Strategies

The data recoded into the IITD form and vehicle registration data are expected to give us information on the following variables:

- Age (not for all) and sex of victims
- Month, day and time of crashes
- Road user type and type of associated crash vehicles
- Type of road where crash occurred
- Crash at junction or mid-block
- Vehicle manoeuvre
- Proportions of vehicles in use in the city

a. The above data have been used to prepare cross-tabulations for all variables to develop an understanding of the epidemiology and spatial distribution of traffic crashes in these six cities. These data have been used to determine significant differences in these cities that might be leading to the differences in crash rates.

b. In addition, a risk-based method for modelling traffic fatalities will also be attempted for each one of the cities. This method has been described by Bhalla et al (2007). In this method it is assumed that crash rates between different road users are proportional to their roadway use and this can be used to estimate case fatality ratios (CFRs) for the different vehicle-vehicle and vehicle-pedestrian combinations. The CFR, the probability of fatality in the event of a crash, depends on precrash variables that describe the characteristics of vehicles and victims, the crash variables, and the postcrash victim care. These include:

- Vehicle characteristics (e.g., size, mass, and shape) and safety design technology (e.g. availability and use of seat belts and airbags);
- Victim attributes including age, sex, height, and weight;
- Crash conditions including vehicle speed, direction of vehicle travel, crash avoidance manoeuvres, weather conditions, and roadway infrastructure;
- Post crash medical care including response time of emergency medical services, and quality of on-site and trauma care.

In our study all the details may not be available, and therefore, we might have to make some educated assumptions establish pairwise CFRs in for different road users, represented as a matrix with the threats (impacting vehicles) listed in columns and the victims listed in rows. We will establish a CFR Matrix using for each city using a methodology similar to that employed by Bhalla et al (2007).

Detailed analysis

The following analyses were conducted:

1. Vehicle registration comparison
2. Vehicle ownership patterns for each city
3. Fatalities by road user type
4. Fatalities by road user type and struck vehicle
5. Road traffic victims by estimated age groups (Vadodara only)

6. Road traffic fatalities by time of day and road user type
7. Road traffic fatalities by road user type and location (junction or mid block) – Ludhiana and Vadodara only.
8. Occupant risk per vehicle (Agra, Bhopal, Vadodara, Vishakhapatnam)
9. Fatalities associated with different vehicle types (Agra, Bhopal, Vadodara, Vishakhapatnam)
10. Estimate of fatalities associated with different vehicle types per 100,000 km (Agra, Bhopal, Vadodara, Vishakhapatnam)
11. Estimate of personal fatality risk per 100 million trips
12. Road users killed based on type of road and location (Vadodara)
13. Actual location of fatalities in Agra, Ludhiana, and Vadodara.

Ethics and Human Subjects Issues

1. No human subjects are involved.

2. Names and addresses of all road traffic crash victims will be not be included in any of the data files maintained at TRIPP to maintain the confidentiality of the victims.

Results

Background information on cities[1]

Agra

Agra (27°12' N and 78°12' E) is located on the banks of the river Yamuna in the northern state of Uttar Pradesh, India, 363 km west of state capital, Lucknow and 200 km south of the national capital Delhi.

Being centrally located on the national map traffic by rail and road going south passes through Agra thus making it a major transport node at the regional level as well as at the national level.

Year	Population	Decadal growth rate
1961	462,000	-
1971	591,000	28%
1981	781,000	32%
1991	978,000	25%
2001	1,275,000	30%
2011	1,574,000	23%

The population of Agra city was 1,574,000 persons in 2011 with a decadal growth rate ranging from 25% to 32% in the last five decades. The growth rate was lowest in the last decade. The present density of the city is 84 persons per hectare. Sex ratio in urban region of Agra district is 857 as per 2011 census data. Child population (0-6 years) of Agra district is 13 % of total urban population and average literacy rate 73%.The city is divided into 80 wards but the distribution of population is non-uniform in the city. Wards 26, 43, 50 and 66 have high concentration of population whereas the wards 36, 40 and 47 have lower population

The economy of Agra city is based on small scale industries, commerce, trade and tourism. Major crops are Wheat, Paddy, Bajra, Mustard, Patato etc. Over 7,200 small scale industrial units are spared all over the district. Agra city is also known for leather goods, handicrafts, stone carving and inlay work.

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[1] All data for cities has been obtained from the respective City Development reports prepared in the period 2006-2008, and Census of India 2011. Definitions for road lengths may differ across cities and city boundaries may have changed in the 1961-2011 period.

Amritsar

Amritsar (31.63° and 74.85° E) is located on the north-west corner of the sate of Punjab 28 km for the border of India with Pakistan. National Highway (NH) 1 connects the city to Jallandhar through Beas towards the Eastern side and NH 15 links the region with Tarn Taran District towards Southern side. These two national highways connect the city to other nearby urban centres. The city also has a good linkage to Lahore, Pakistan through Wagha Border towards the west direction.

Year	Population	Decadal growth rate
1961	390,055	16%
1971	454,805	17%
1981	594,844	31%
1991	708,835	19%
2001	1,011,327	42%
2011	1,132,761	12%

The population of Amritsar city was 1,132,761 persons in 2011 with a decadal growth rate ranging from 26% to 42% in the last five decades. The growth rate was lowest in the last decade. The present density of the city is 81 persons per hectare.

Female to male sex ratio in urban region of Amritsar district is 880 as per 2011 census data. Child population (0-6 years) of Amritsar is 10 % of total urban population and average literacy rate 85%.

The road network of the Amritsar City is radial-cum- circumferential covering an area of 139 sq. km. The total road length is about 525 km. According to an estimate about 50,000 people visit Golden temple every day. All these have impact over the socio-economic context of the city.

Trading sector absorbs 59% of the workforce. The major commodities for trade include various silk products, woollens, traditional embroidery, blankets, carpet, copper, brass utensils, dry fruit and tea. Apart from textile manufacturing, Amritsar is also one of the biggest grain markets in Punjab. The important items include wheat, maize, gram, rice .

Bhopal

Bhopal (23.25° N, 77.42° E) is the capital of the Indian state of Madhya Pradesh and the administrative headquarters of Bhopal District and Bhopal Division. The major regional Road network comprises of NH 12 connecting Hosangabad and Narsingarh and a number of State Highways linking Indore, Sagar, and Jabalpur.

Year	Population	Decadal growth rate
1961	222,000	-
1971	384,000	73%
1981	671,000	75%
1991	1,062,000	58%
2001	1,433,000	35%
2011	1,796,000	25%

The population of Bhopal city was 1,796,000 persons in 2011 with a decadal growth rate ranging from 25% to 75% in the last five decades. The growth rate was lowest in the last decade. The present density of the city is 86 persons per hectare.

Female to male sex ratio in urban region of Bhopal is 911 as per 2011 census data. Child population (0-6 years) of Bhopal is 12 % of total urban population and average literacy rate 85%.

Bhopal is located on hilly terrain within the Malwa Plateau and the National Highway 12 (Beora – Jabalpur road), which links the city to many large cities in the north – west and the south – east. State Highways connect Indore and Sagar.

The economic base of Bhopal City mainly depends on industrial sector, while the service sector is becoming increasingly important which provides the majority of employment in Bhopal because it being capital of state. The sectors that reported to be growing fast in Bhopal are housing, banking & insurance and education.

The total road length of the city is 1,020 km. The city is distinctly divided into two parts, the old city housing most of the trading and commercial activities and the newly developed area with mainly administrative, institutional and residential activities.

Ludhiana

Ludhiana (30.91° N, 75.85° E) is the largest city in Punjab, both in terms of area and population. The city is spread over an area of 159 sqkm. It is one of the prime industrial and educational centres of northern India

The population of Ludhiana city was 1,615,000 persons in 2011 with a decadal growth rate ranging from 26% to 67% in the last five decades. The growth rate was lowest in the last decade. The present density of the city is 88 persons per hectare.

Year	Population	Decadal growth rate
1961	251,000	26%
1971	401,000	60%
1981	606,000	51%
1991	1,042,000	67%
2001	1,395,000	38%
2011	1,615,000	16%

Female to male sex ratio in urban region of Ludhiana is 845 as per 2011 census data. Child population (0-6 years) of Ludhiana is 11 % of total urban population and average literacy rate 85%.

The city is very well connected in terms of roadways and railways. NH1-Grand Trunk road passes through the city, which connects it to Indian capital city Delhi and to other important cities of Punjab like Jalandhar, Amritsar, Wagha Border etc. NH95 connects the city to Chandigarh in southeast direction and Ferozpur in southwest direction. Other important State highways and major roads also connect the city to various towns of Punjab.

The economy of the city is based on various areas of manufacturing industry including bicycles, sewing machines, textile and other industries. Others include commercial establishments, financial and banking services, public services and places of religious importance.

A total of 1356 km of road network exists. The city has built 2.3 km long elevated road cutting across the city to facilitate through traffic movement. Traffic problems are severe, especially in major commercial areas. At present no city bus services are being operated in the city.

Vadodara

Vadodara (22.30° N, 73.19° E), formerly known as Baroda, is the third largest and most populated city in the Indian State of Gujarat, after Ahmedabad and Surat. The city is spread over an area of 149 sqkm. The city is on the major rail and road arteries joining Mumbai with Delhi and Mumbai with Ahmedabad. National Highway No. 8 passes through the city.

The population of Vadodara was 1,666,700 persons in 2011 with a decadal growth rate ranging from 27% to 77% in the last five decades. The growth rate was lowest in the last two decades. The present density of the city is 99 persons per hectare.

Year	Population	Decadal growth rate
1961	298,000	-
1971	468,000	57%
1981	735,000	57%
1991	1,031,000	40%
2001	1,306,000	27%
2011	1,666,700	28%

Female to male sex ratio in urban region of Vadodara is 923 as per 2011 census data. Child population (0-6 years) of Vadodara is 9% of total urban population and average literacy rate 92%.

The State Road Transport (STC) of Vadodara links it with a number of towns in Gujarat. The STC buses connect Vadodara with the different destinations in Gujarat, northern part of Maharashtra and western region of Madhya Pradesh.

Vadodara is one of India's foremost industrial centres with dominant groups of chemicals and pharmaceuticals, cotton textiles and machine tools. The city witnessed a sudden spurt in industrial activity with the establishment of the Gujarat refinery in 1962. Various large-scale industries such as Gujarat State Fertilizers and Chemicals (GSFC), Indian petrochemicals Corporation Limited (IPCL) and Gujarat Alkalis and Chemicals Limited (GACL) have come up in the vicinity of the Gujarat Refinery.

Vishakhapatnam

Vishakhapatnam (17.00° N, 83.00° E) is a port city on the southeast coast of India. It is the second-largest city in the state of Andhra Pradesh and the third-largest city on the east coast. The city is spread over an area of 530 sqkm. It is one of the prime industrial and educational centres of northern India

The population of Vishakhapatnam city was 1,6730,320 persons in 2011 with a decadal growth rate ranging from 26% to 67% in the last five decades. The growth rate was lowest in the last decade. The present average density of the city is 33 persons per hectare.

Year	Population	Decadal growth rate
1961	251,000	95&
1971	401,000	72%
1981	606,000	66%
1991	1,050,000	74%
2001	1,320,000	26%
2011	1,615,000	30%

Female to male sex ratio in urban region of Vishakhapatnam is 977 as per 2011 census data. Child population (0-6 years) of Vishakhapatnam is 9 % of total urban population and average literacy rate 83%.

The city has 1,220 km of roads dominated by three major arteries, one along beachfront, another along the Northern Hill flank and the third which runs through the city. NH- 5 and NH – 43 of the National Highway (NH) network and the State Highways connect the city area to the vast hinterland. Around 8 % of the total area is covered by roads.

The sectors contributing to city's economic growth are agriculture and fishing, large, medium and small scale industries and services that include trade and commerce, transport, education, etc. It has experienced rapid industrialization with the onset of major industries: oil refinery, fertilizer factory, Hindustan Zinc Smelter and Visakhapatnam Steel Plant. The construction of the outer harbour and steel plant have considerably changed the character of the city.

Transportation data

1. Vehicle ownership data has been obtained from four cities:

- Agra
- Bhopal
- Vadodara
- Vishakhapatnam

We were not successful in sourcing reliable and accurate data from Ludhiana, and none from Amritsar. Based on the limited data available from Ludhiana we have made some estimates of vehicle populations.

2. The official vehicle registration numbers are overestimated for private vehicles, as they are not required to pay any taxes annually. Private vehicles pay a lifetime registration tax at time of purchase, and therefore the official number represents a cumulative total over a number of years. The actual numbers of vehicles on the road are estimated to be approximately 65% of the official number (CRRI, 2007; Expert Committee, 2002). This fact may be kept in mind when examining the numbers presented in this section.

Vehicle registration

Table 2 shows the official vehicle registration figures for the five study cities. Statistics for Amritsar are not available and Ludhiana is estimated. It is expected that they will be available before the end of November.

Table 2. Vehicle registered in Agra, Bhopal, Ludhiana (estimated), Vadodara, and Vishakhapatnam in 2010.

Vehicle	City				
	Agra	Bhopal	Ludhiana	Vadodara	Vishakhapatnam
MTW*	568,470	497,735	866,392	817,379	453,847
TSR+		11,500	14,562	33,239	21,994
Car	76,544	60,095	158,263	106,475	50,910
Taxi		13,635	1,701	7,116	6,331
Bus	1,791	3,275	2,588	3,717	3,234
Truck	18,160	14,433	35,487	33,337	18,163
Tractor	37,121	14,977	48,571	4,779	3,001
Total	**702,086**	**616,578**	**1,127,564**	**1,008,679**	**558,704**
Population	1,574,000	1,796,000	1,615,000	1,666,000	1,615,000

** Motorised two-wheelers* *+ Three-wheeled scooter rickshas*

Figure 2. Examples of three-wheeled scooter rickshas which serve as para-tarnsit transport modes in all six cities.

Figure 2 shows examples of three-wheeled scooter rickshas. Figure 3 shows the proportions of vehicles registered in 5 study cities. In relative terms, Agra has a larger proportion of motorized two-wheelers, and Vishakhapatnam a greater proportion of three-wheeled scooter rickshas. Ludhiana and Vadodara seem to be similar in their vehicle proportions. Vehicle ownership pattern for 5 cities is shown in Figure 4. Relative to other cities, Vadodara and Ludhiana have a higher proportion of car and motorised two-wheeler ownership.

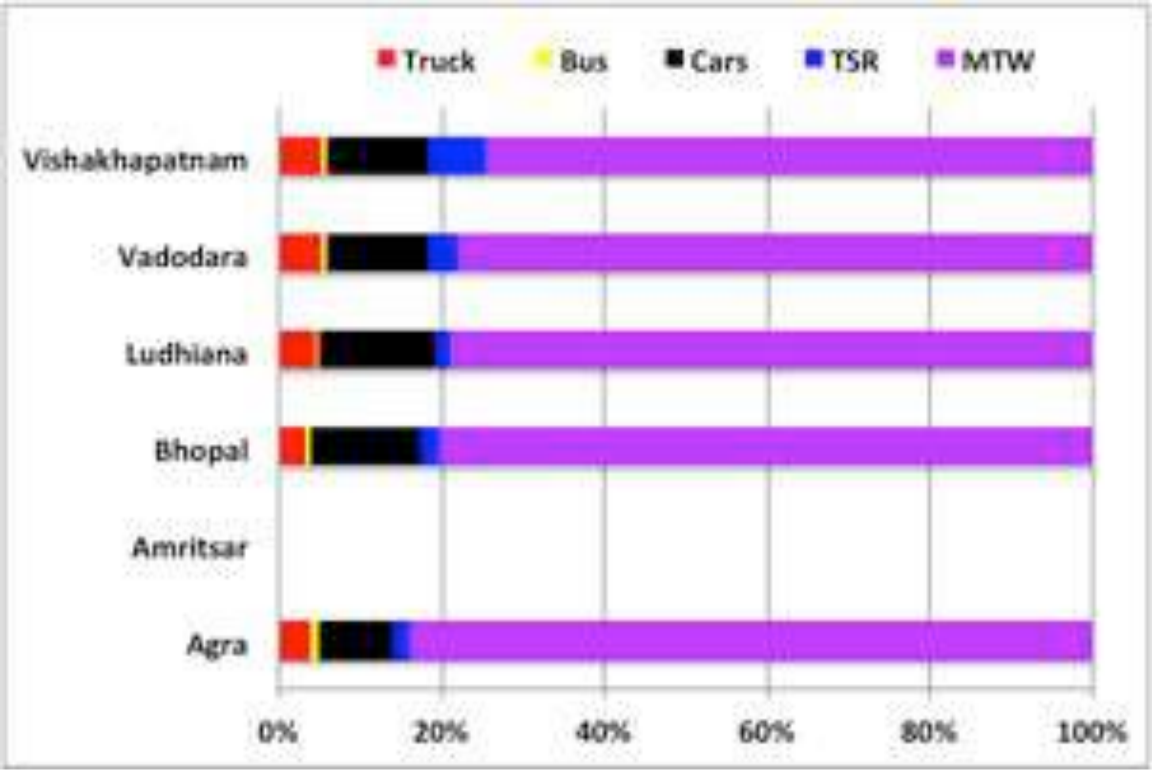


Figure 3. Official vehicle registration data for 5 study cities, vehicle proportions of total in each city (MTW - Motorised two-wheelers, TSR - Three-wheeled scooter rickshas).

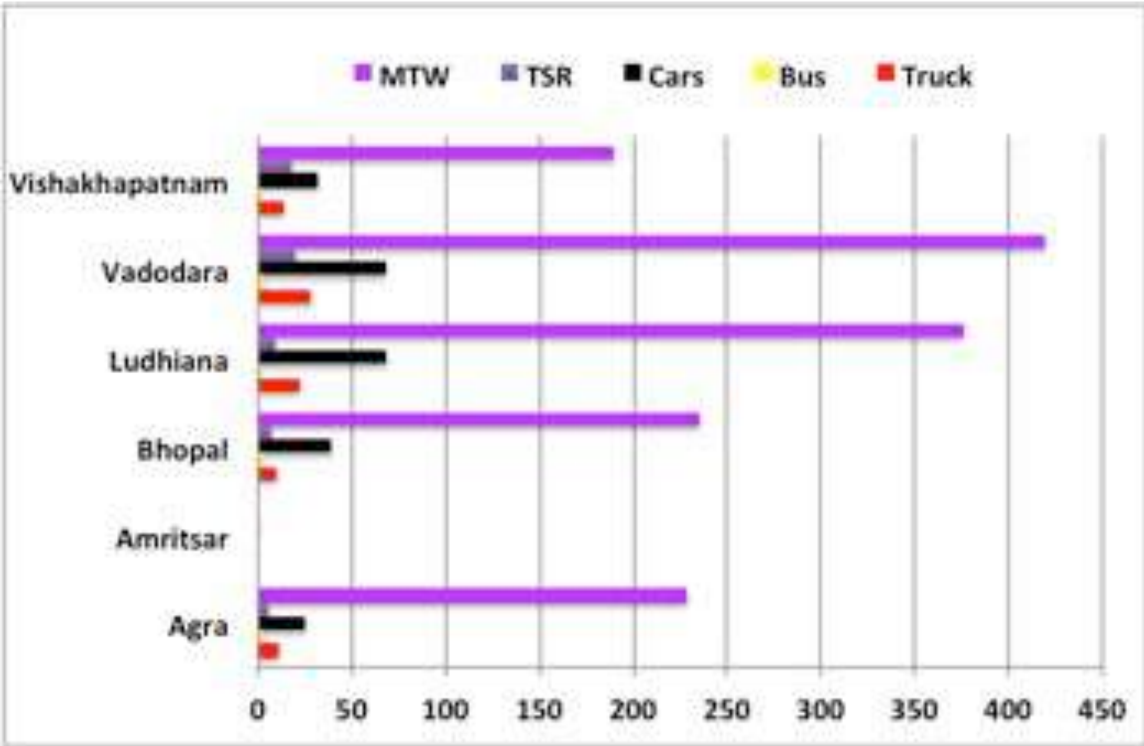


Figure 4. Official vehicle registration per 1,000 persons data for 5 study cities.

Road traffic injury (RTI) fatality data

Progress

Table 3. Details of records collected, coded and analysed for road traffic fatal crash data from six study cities in India.

City	Fatal crash records obtained	Data coding	Data analysis
Agra	674	Completed	Completed
Amritsar	265	Completed	Completed
Bhopal	685	Completed	Completed
Ludhiana	651	Completed	Completed
Vadodara	684	Completed	Completed
Vishakhapatnam	1164	Completed	Completed

Table 3 shows the summary of progress on the field study of fatal road traffic crash patterns in 6 study cities in India. The following may be noted:

1. A total of 4,23 hard copies of fatal accident police records (FIR, see example in Appendix 1) were obtained from six cities and brought to Delhi for coding and analysis.
2. The details from these records were translated and coded into a special form developed for this project (Appendix 2) and the same transferred into computer spreadsheets for analysis.
3. As decided in the First Interim Meeting in Delhi, we selected two cities for a more detailed analysis – Ludhiana and Vadodara.

Fatalities by road user type

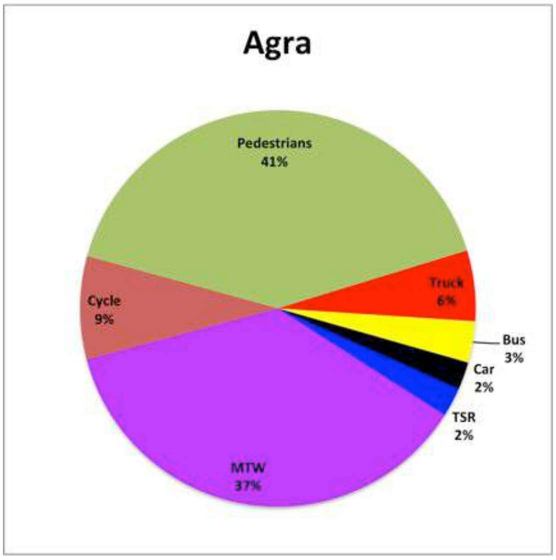


Figure 5. . Road traffic fatalities by road user type – Agra.

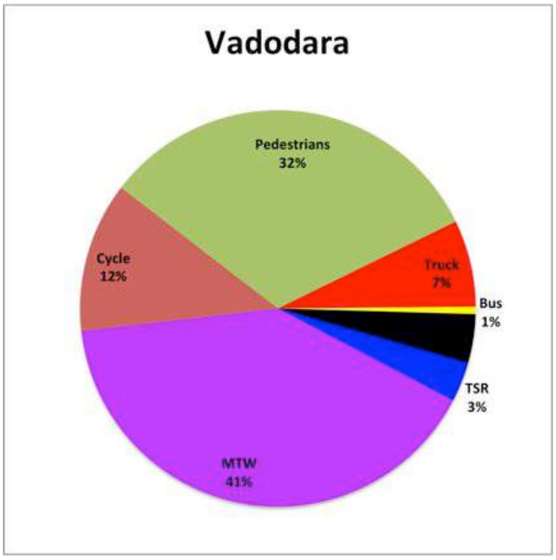


Figure 6. Road traffic fatalities by road user type – Vadodara.

(MTW - Motorised two-wheelers, TSR - Three-wheeled scooter rickshas)

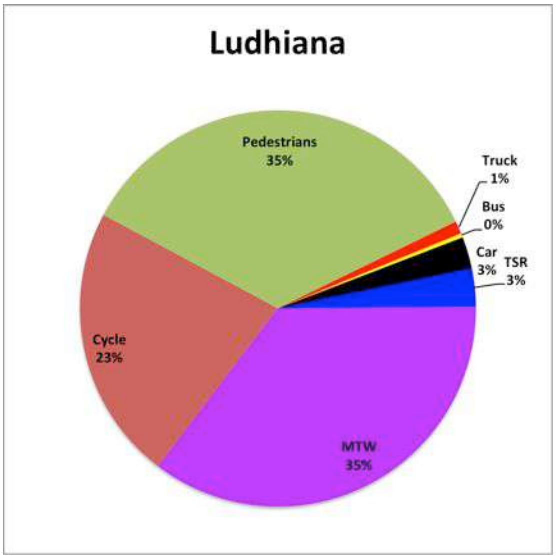


Figure 7. Road traffic fatalities by road user type – Ludhiana.

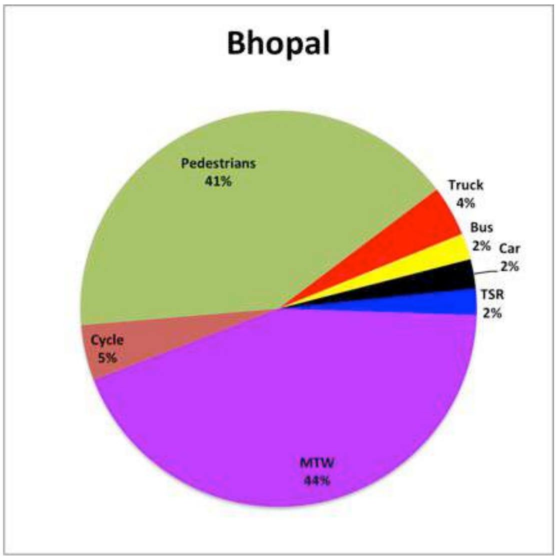


Figure 8. Road traffic fatalities by road user type – Bhopal.

Figures 5-10 show the distribution of fatalities by road user type in the six study cities. Agra and Vadodara have similar populations with a RTI fatality rate higher in Agra (41 per 100,000 persons) compared to Vadodara (10 per 100,000 persons). Agra, which is a major tourist destination, has a higher proportion and a higher number of bus and pedestrian fatalities than Vadodara.

Ludhiana and Bhopal have similar populations but Ludhiana (18 fatalities per 100,000

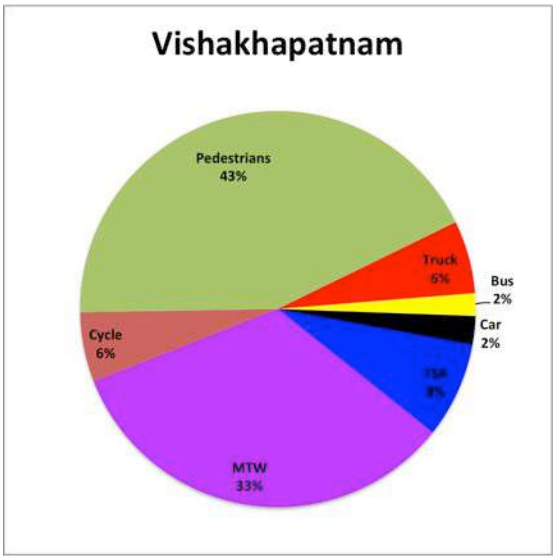


Figure 9. Road traffic fatalities by road user type – Vishakhapatnam.

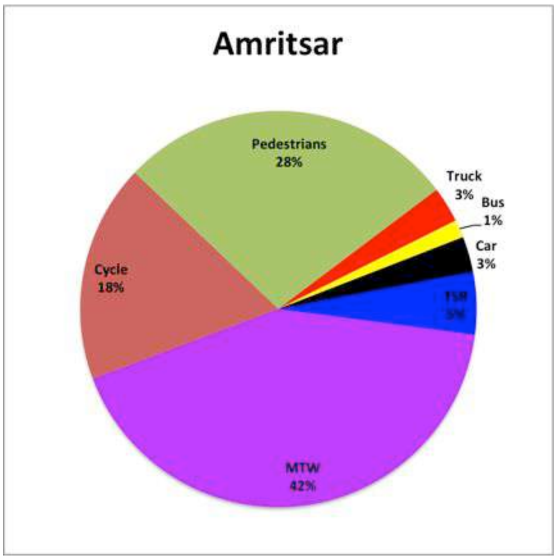


Figure 10. Road traffic fatalities by road user type – Amritsar.

persons) has a slightly higher RTI fatality rate than Bhopal (14 fatalities per 100,000 persons). Ludhiana has a much higher rate for bicyclists and Bhopal is higher for MTWs

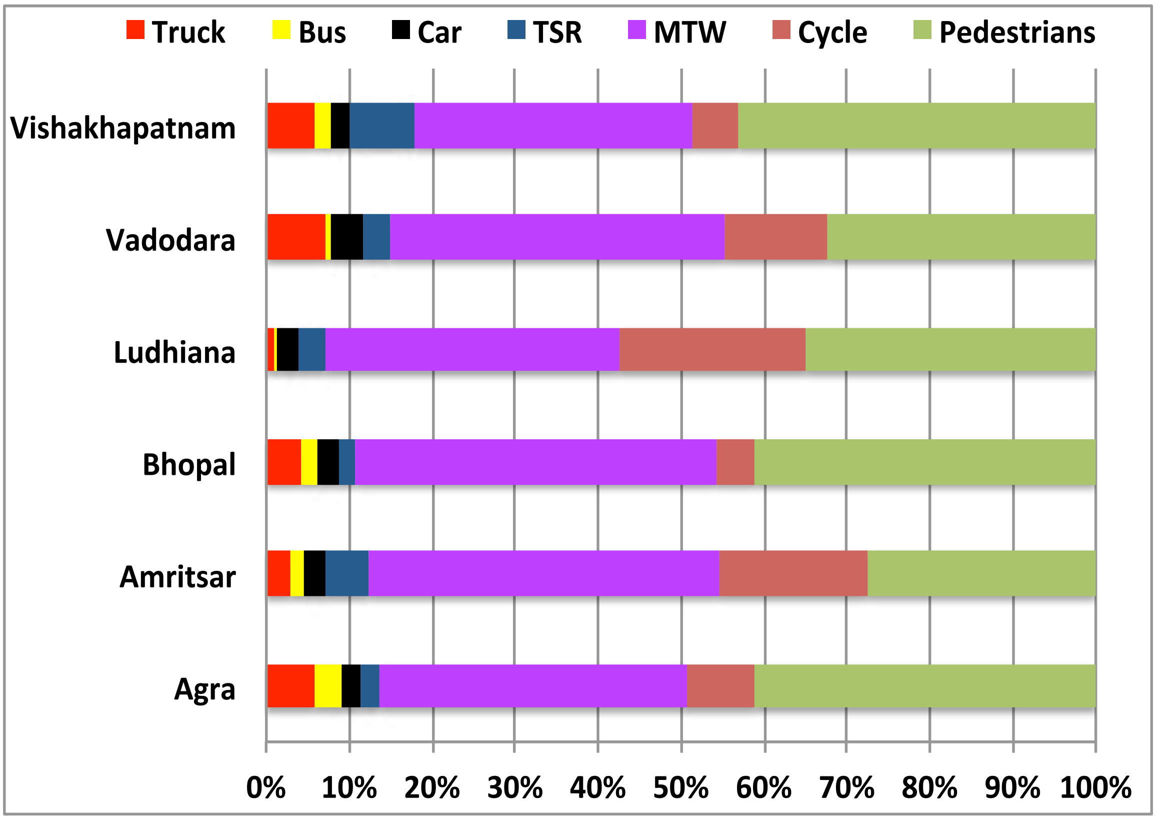


Figure 11. Proportion of RTI fatalities by road user type in six study cities (MTW - Motorised two-wheelers, TSR - Three-wheeled scooter rickshas).

The RTI fatality rate in Vishakhapatnam (24 per 100,000 persons) is much higher than Amritsar (6 per 100,000 persons), and the former has a higher proportion of pedestrian and three-wheeled scooter ricksha deaths. In all the cities vulnerable road users (VRU - pedestrians, bicyclists, and motorised two-wheeler occupants constitute more then 80 per cent of all fatalities irrespective of the overall death rate. Car occupants less constitute than 4 per cent of fatalities in all cities and TSR occupants less than 5 per cent, except in Vishakhapatam where the proportion for the latter is 8 per cent. Cycler occupants have the highest proportions in Ludhiana and Amritsar (23 per cent and 18 per cent respectively).

Traffic fatalities: victim type vs impacting vehicle/object

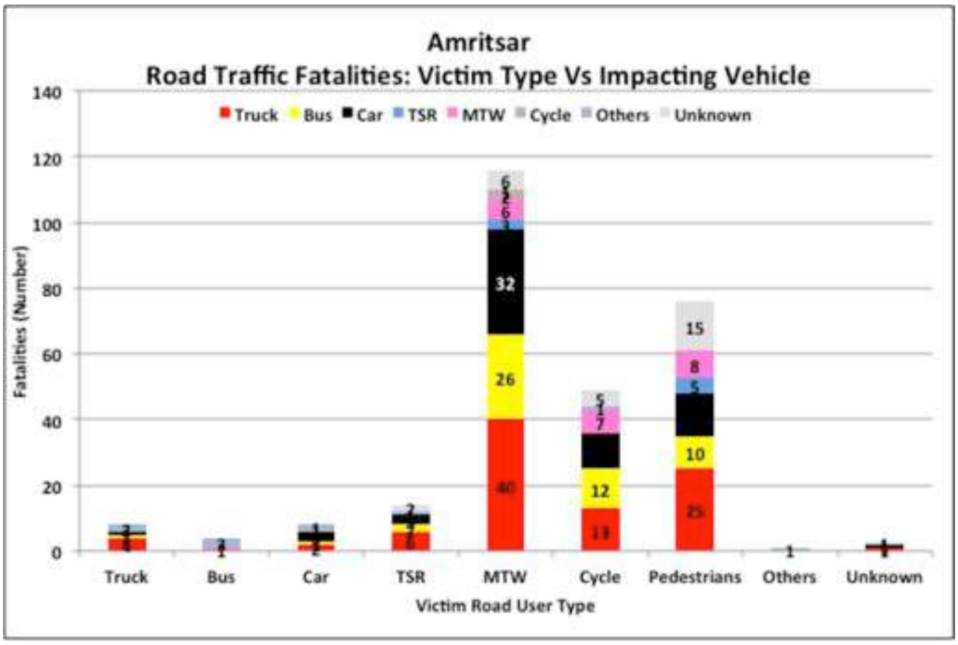


Figure 12. Traffic fatalities: victim type vs impacting vehicle/object in Amritsar (MTW - Motorised two-wheelers, TSR - Three-wheeled scooter rickshas).

Figures 12-17 show the distribution of road traffic fatalities by road user category versus the respective impacting vehicles/objects for all the six study cites. In all the cities the largest proportion of fatalities for all road user categories are associated with impacts with trucks

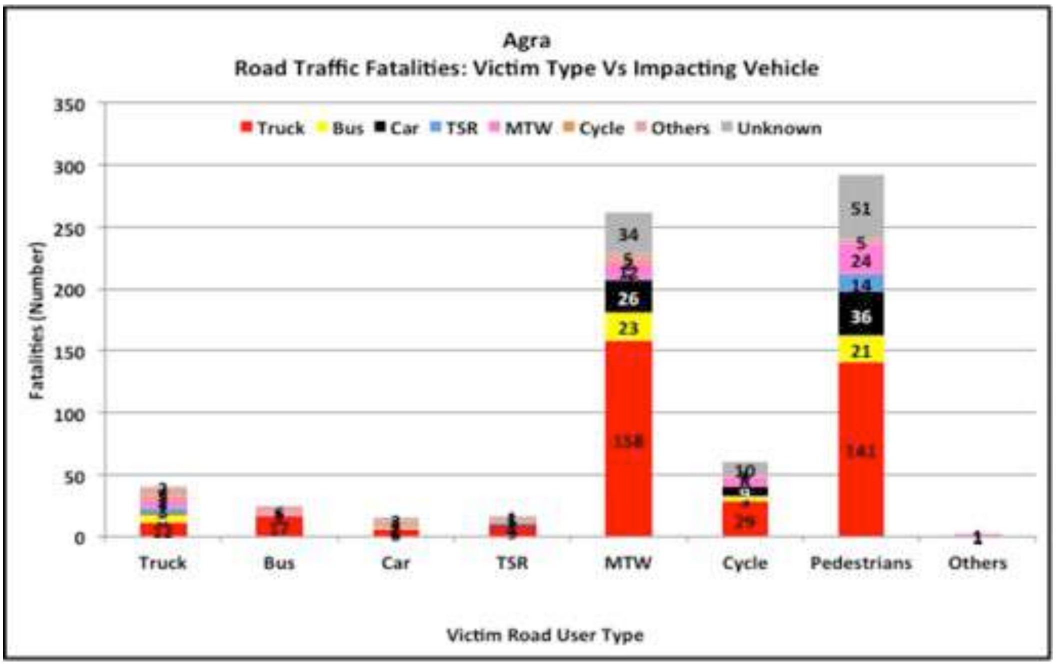


Figure 13. Traffic fatalities: victim type vs impacting vehicle/object in Agra.

and then cars. Amritsar has the highest proportion of fatalities involving buses as impacting vehicles. The reason for this is not clear. The most interesting feature emerging from this analysis is the involvement of motorised two-wheelers as impacting vehicles in VRU in all the six cities. The proportion of pedestrian fatalities associated with MTW impacts ranges from 8 to 25 per cent of the total. The highest proportion was observed in Bhopal. The involvement of MTWs as impacting vehicles in VRU fatalities may due to the fact that pedestrians and bicyclists do not have adequate facilities on arterial roads of these cities and they have to share the road space (the curb side lane) with MTW riders.

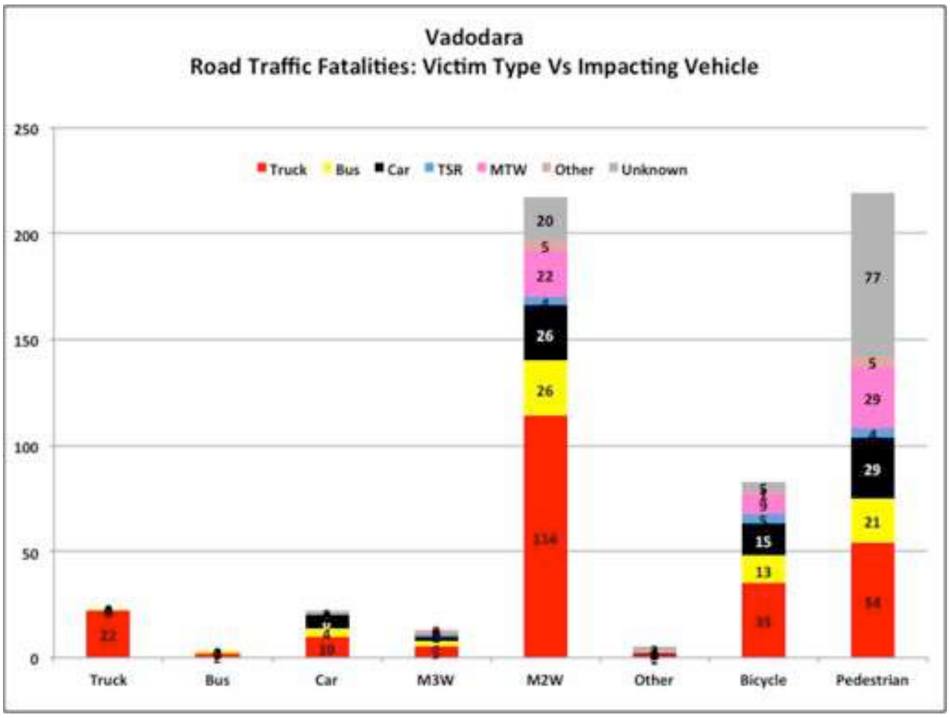


Figure 14. Traffic fatalities: victim type vs impacting vehicle/object in Vadodara (MTW - Motorised two-wheelers, TSR - Three-wheeled scooter rickshas).

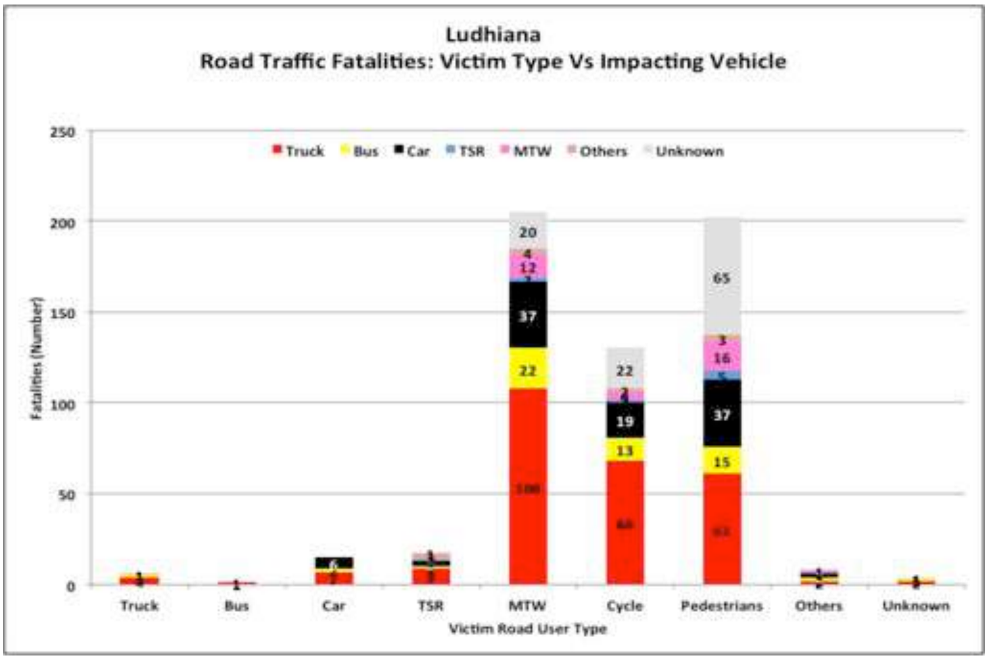


Figure 15. Traffic fatalities: victim type vs impacting vehicle/object in Ludhiana.

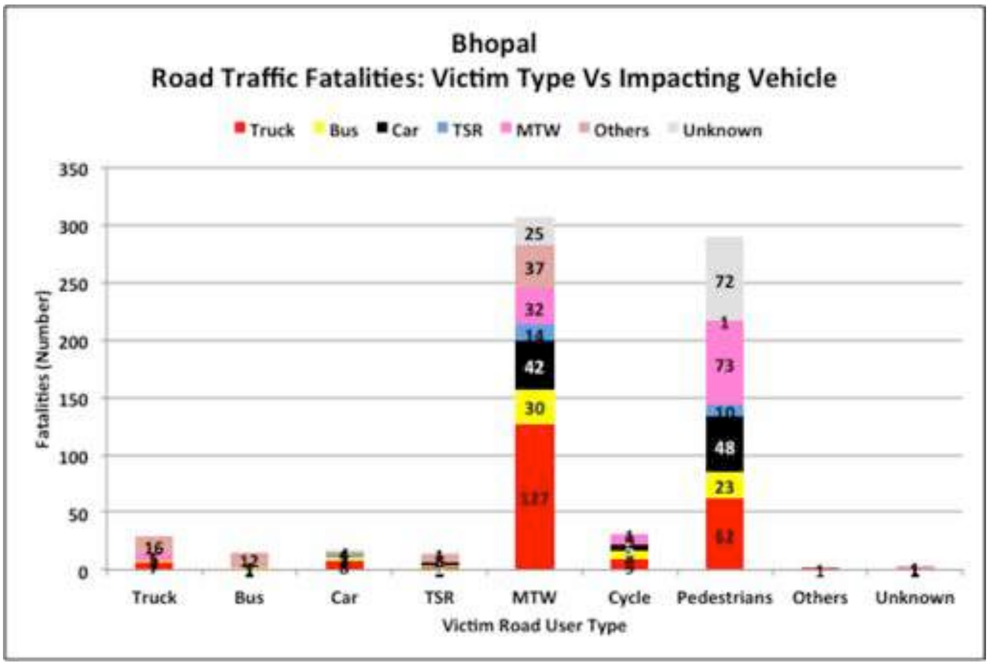


Figure 16. Traffic fatalities: victim type vs impacting vehicle/object in Bhopal (MTW - Motorised two-wheelers, TSR - Three-wheeled scooter rickshas).

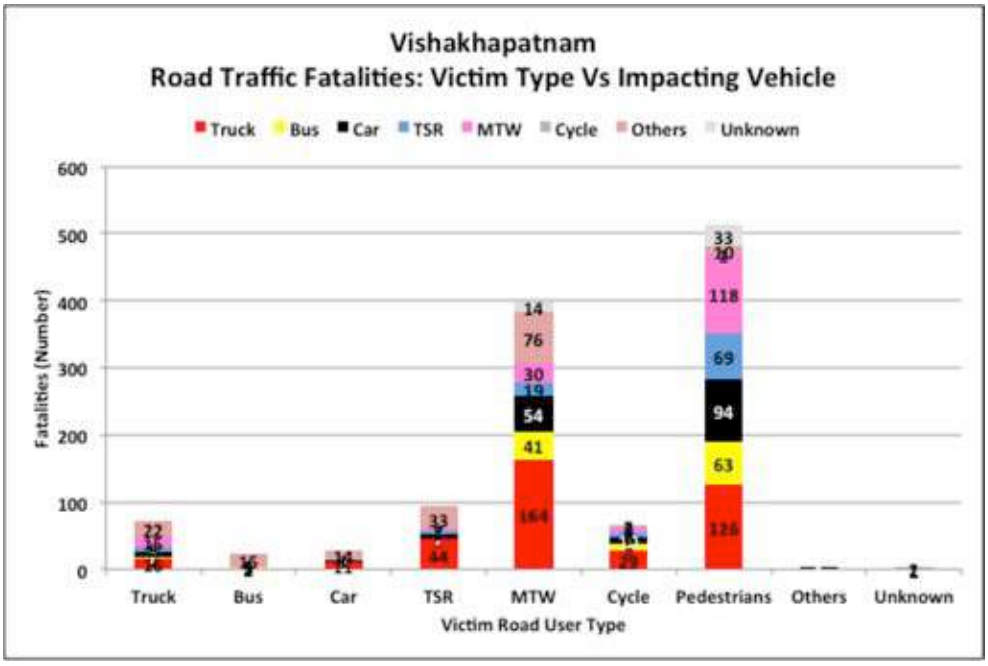
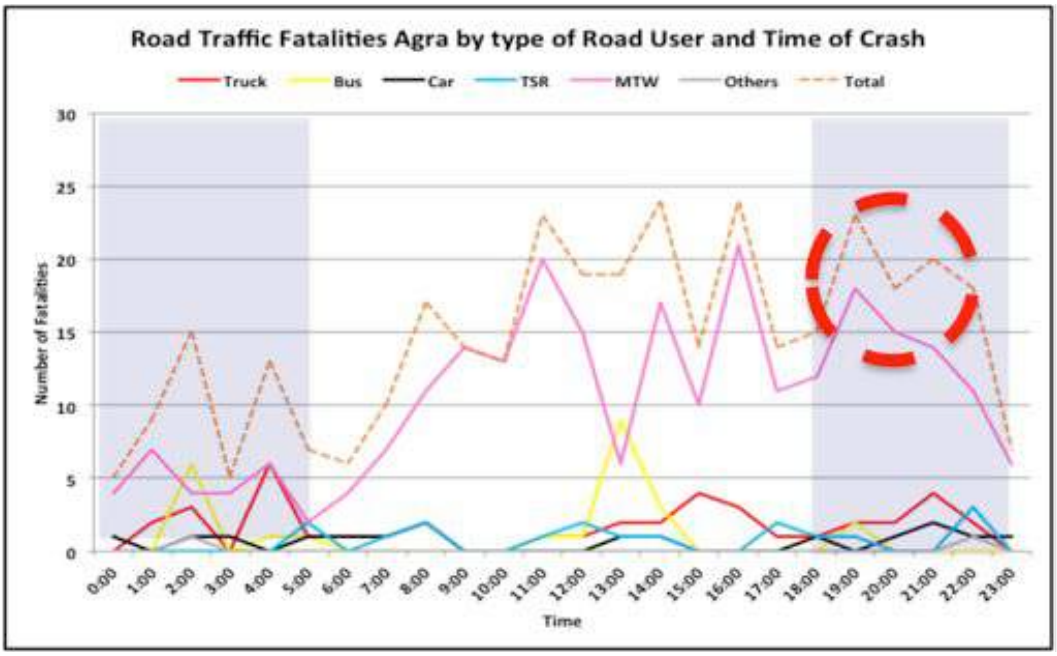


Figure 15. Traffic fatalities: victim type vs impacting vehicle/object in Vishakhapatnam.

Road traffic fatalities by type of road user and time of crash



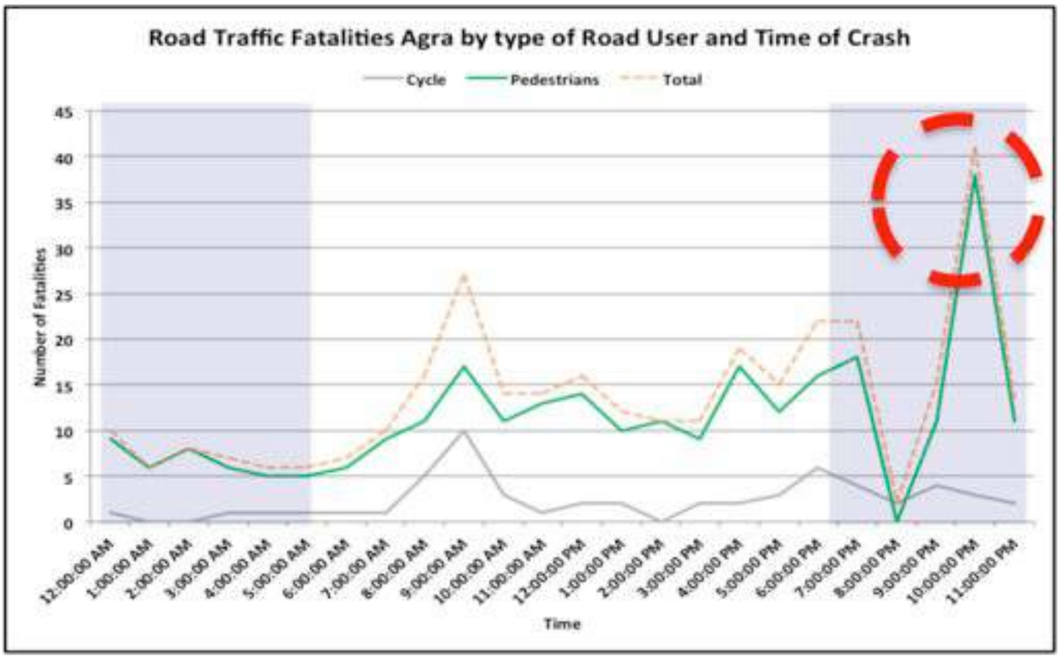


Figure 16. Road traffic fatalities in Agra by time of crash.

Figure 18 shows the fatalities by road user category and time of day in Agra. Pedestrian and bicycle fatalities peak somewhat earlier in the morning than the motor vehicle fatalities. This may be because this class of road users start for work earlier than those using motorised transport. The total fatality rate remains somewhat similar between the hours of 10:00 and 18:00 and a strong bimodal distribution is not observed. This could be because school and working timings are reasonably staggered. Schools start around 08:00 in the morning and close at 14:00 and some of them have a second shift, private offices open between 08:00-09:00, government offices between 09:00-10:00 and shops around 11:00. Most shops stay open up to 21:00 and restaurants up to 23:00. The data also show that MTW and pedestrian deaths are relatively high at 22:00-23:00 when we would expect traffic volumes to be low. Details regarding the associated causes for these crashes are not

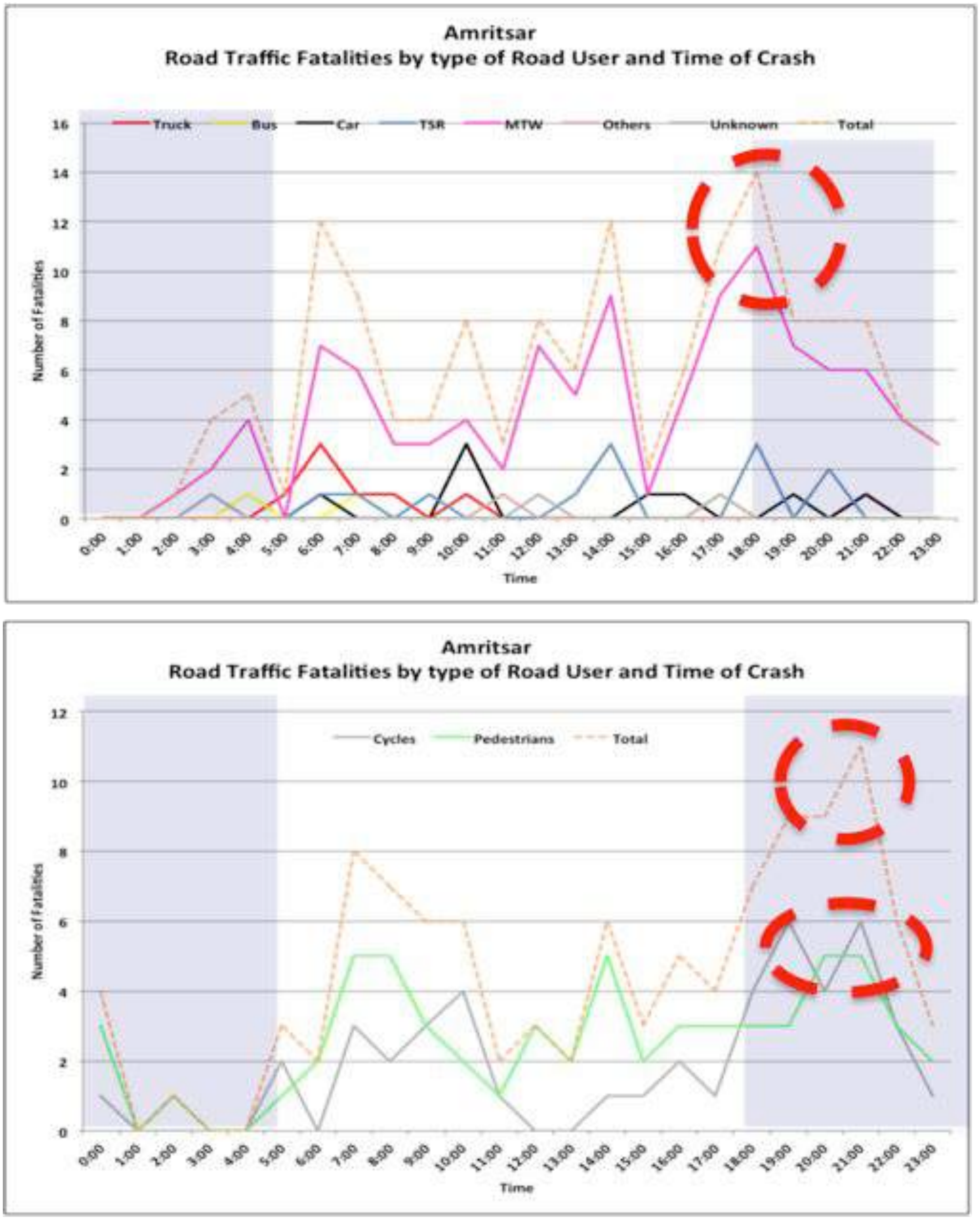


Figure 17. Road traffic fatalities in Amritsar by time of crash.

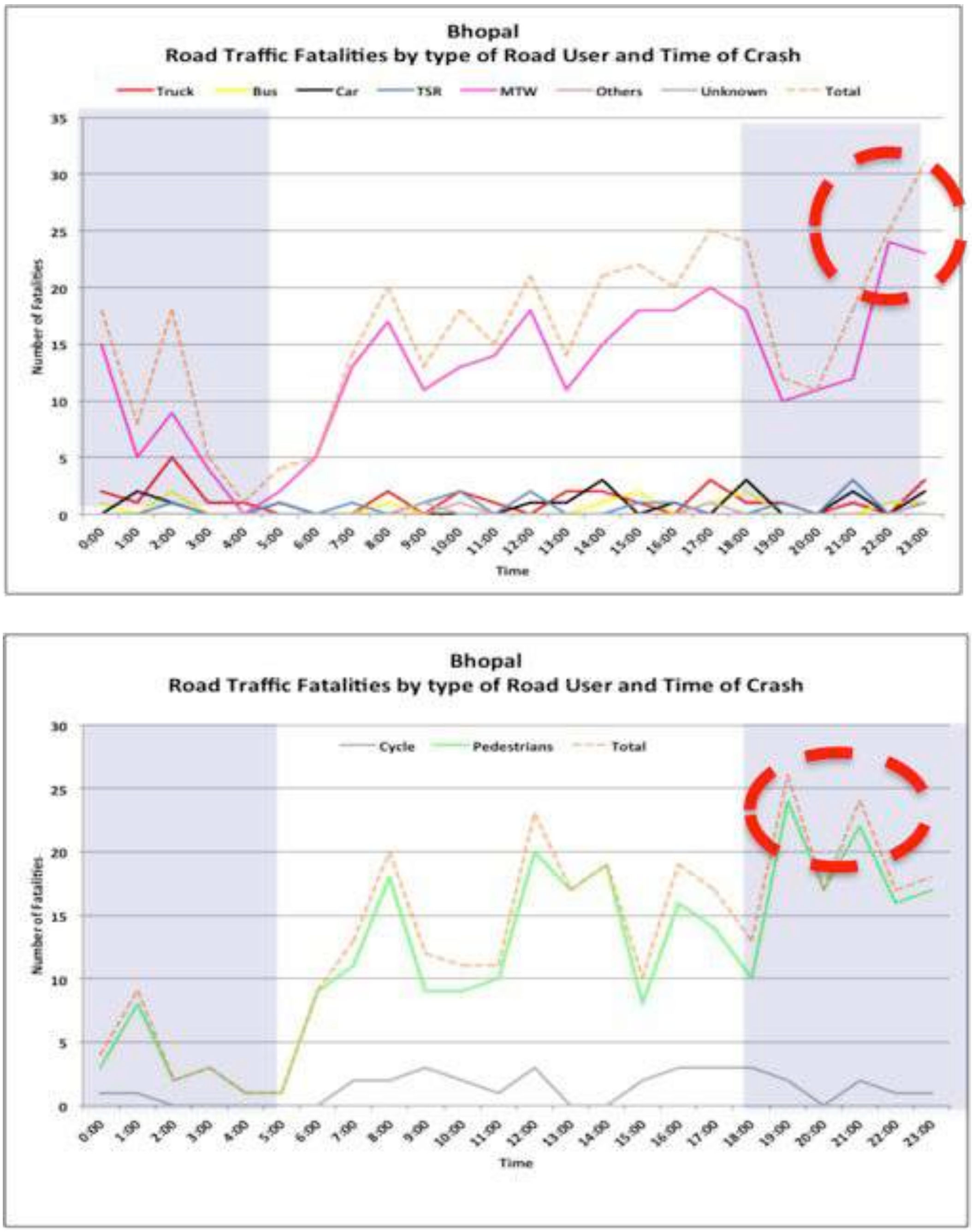


Figure 18. Road traffic fatalities in Bhopal by time of crash.

available but the risk factors could include high speeds, driving under the influence of alcohol, and limited visibility. Figure 19 shows road traffic fatalities by time of day in Amritsar. The pattern is similar to that observed in Agra in the previous figure.

Figure 20 shows road traffic fatalities by time of day in Bhopal. The pattern is similar to the previous two cities, except that pedestrian and bicycle crashes do not show as high a rate at 22:00-23:00 hours. However, the pattern of MTW fatality rates at night are similar to the previous two cities.

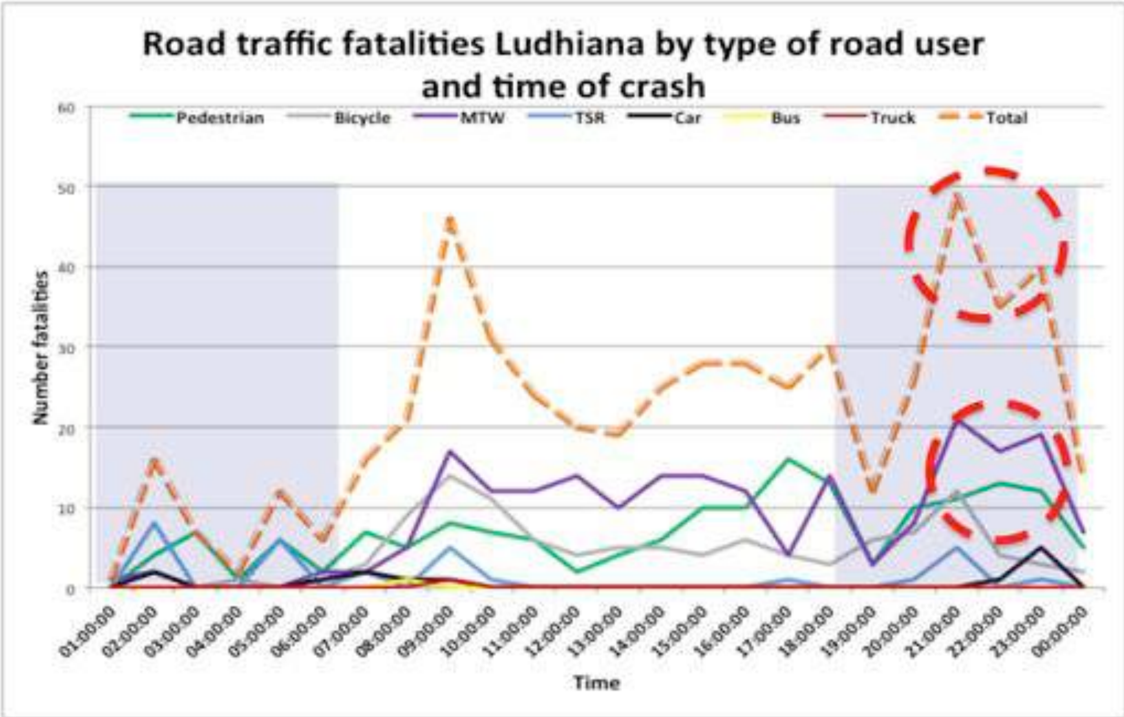


Figure 19. Road traffic fatalities in Ludhiana by time of crash.

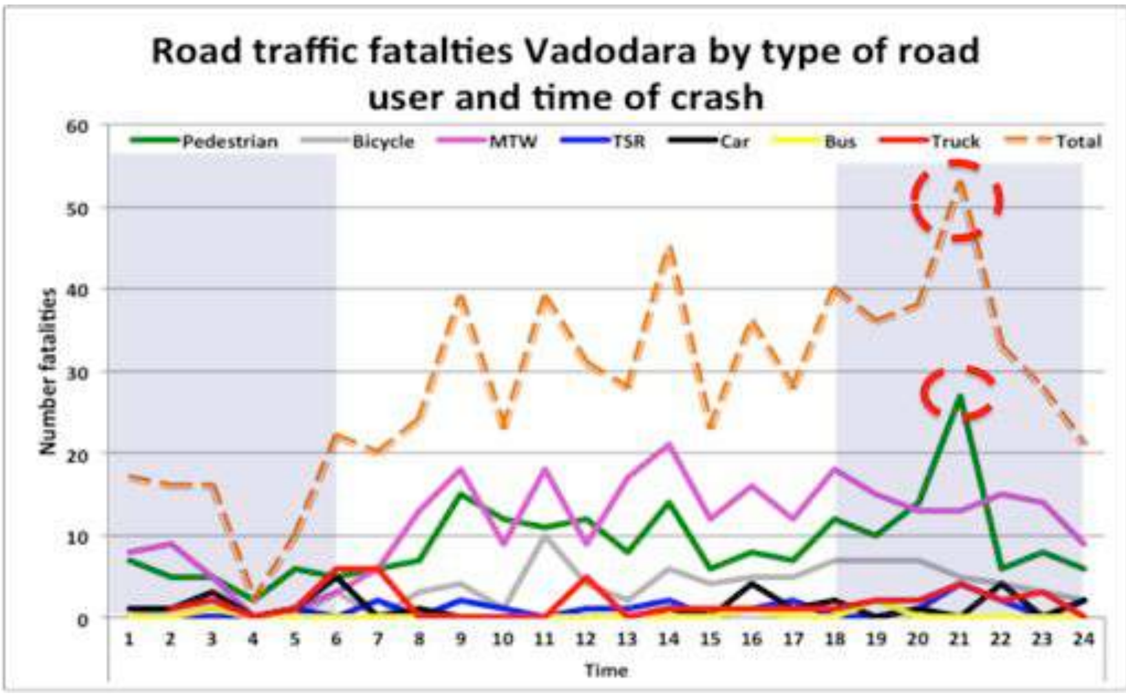


Figure 20. Road traffic fatalities in Vadodara by time of crash.

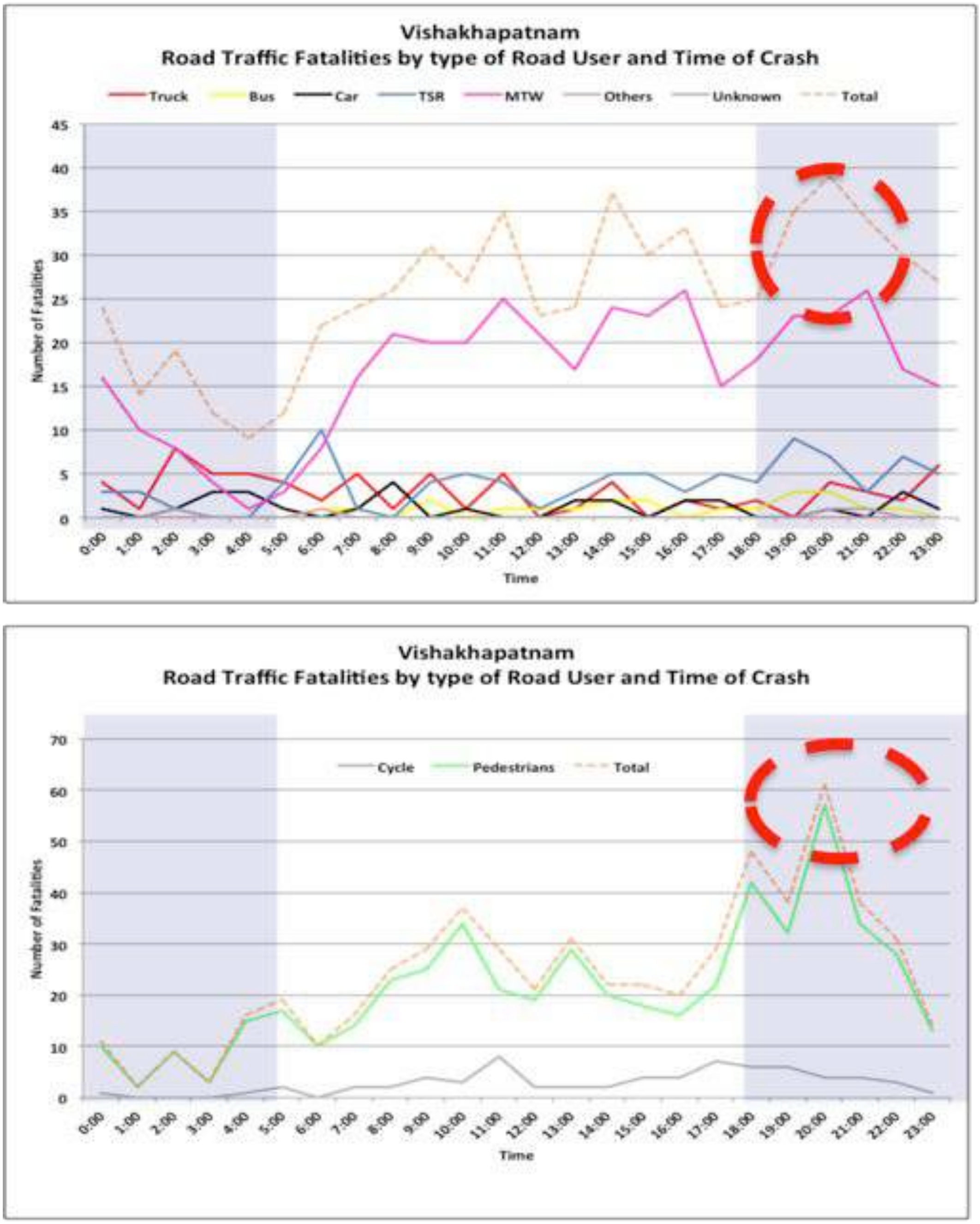


Figure 21. Road traffic fatalities in Vishakhapatnam by time of crash.

The crash patterns by time of day in Ludhiana are similar to the previous cities (Figure 21), but those in Vadodara seem to have a slight difference in night-time crashes. Pedestrian and MTW peaks are not seen at 22:00-23:00 hours. This could be because Vadodara is located in the sate of Gujarat, which is a dry state by law, and sale of alcohol is prohibited. However, we do not have the necessary epidemiological data to verify this.

The general pattern of crashes by time of day in Vishakhapatnam is similar to the previous five cities, except that the relative increase in pedestrian deaths at night appears to be higher than the other cities. The details available with us do not permit us to offer any reliable explanation for this.

In summary, the data from the six cities indicate that crashes rates between 20:00-23:00 hours are relatively high in all the cities when traffic volumes would be relatively lower. This points to risk factors including high velocities, alcohol involvement and lack of visibility.

Age of victims

Age of victims was not recorded in the First Information Reports (FIR) made available to us for a vast majority of the cases. However, for the city of Vadodara, we made estimated the age of the victims in 3 broad groups: 0-19 (young adults and children), 20-59 (working age), and ≥ 60 years (elderly). The estimates are shown in Figure 24. These data indicate the proportion of young individuals involved in fatal road traffic crashes is relatively small. Anecdotal evidence suggests that a large proportion of young individuals walk and bicycle to school, and many are transported as passengers on motorised two-wheelers. Figure 25 shows the age distribution of fatal road traffic crash victims for the country as reported by the police. These data also indicate that the 0-14 age group is under represented in proportion to their share in the population. Lower exposure rates may account for this, however, this explanation does not seem to be adequate enough to explain these very low rates, especially children on motorcycles. This phenomenon needs further study.

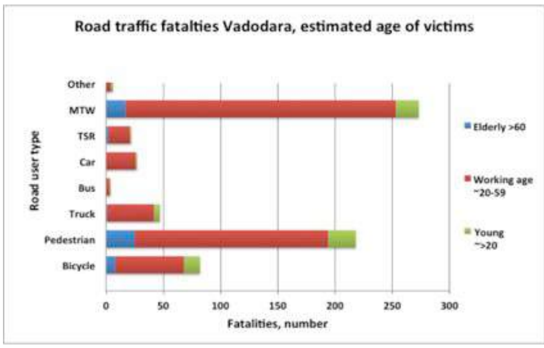


Figure 22. Estimated age distribution of road traffic crash fatalities in Vadodara.

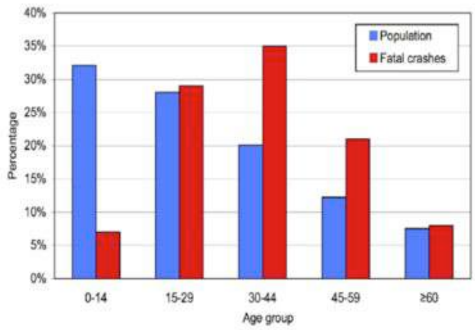


Figure 23. Age distribution of road traffic crash fatalities in India (NCRB, 2012).

Road traffic fatalities by type of road user and location of crash

Figure 26 shows the distribution of road traffic fatalities in Vadodara and Ludhiana at junctions and mid-blocks. In the case of Vadodara, the junction definition included a distance of 50 m upstream of all the roads meeting at the junction. For Ludhiana the location was recorded as mentioned in the police FIR/. These data indicate that a majority of the fatal crashes take place mid-block rather than at junctions. The Vadodara data shows a higher proportion at junctions as compared to Ludhiana. This could be because of the more inclusive definition adopted for Vadodara. A vast majority of the fatal crash victims comprise VRUs. In the absence of adequate pedestrian and bicycle facilities on arterial roads of all six cities studied, the left side of the road (curb side lane) has to be shared by pedestrians, bicyclists, MTWs, buses and trucks. In addition, vehicle speeds would tend to be higher in mid block locations. This may be one reason why a majority of fatalities take place mid-block.

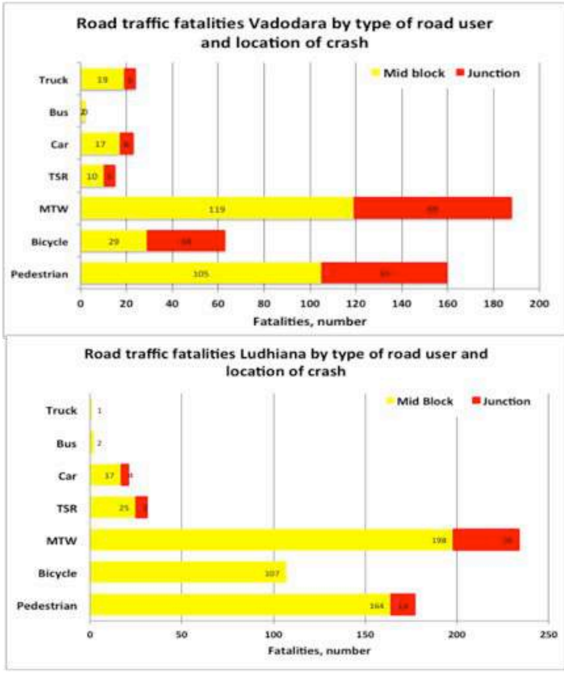


Figure 24. Road traffic fatalities by location of crash.

City structure, arterial roads and location of crashes

The city structure and location of main arterial roads and highways passing through the city was studied by examining the map of each study city. In addition, all fatal crashes were plotted (for cases where location details could be identified) for two cities: Ludhiana and Vadodara. In the case of Agra, we were able tom plot cases for one year. The results of this study are included below.

a. AGRA (high crash rate)

Figure 25. Fatal crash locations (one year) identified in Agra city.

Figure 26. Traffic on road C-C in Agra.

Figure 27 shows the fatal crash locations in Agra city. A majority of the fatal crashes are located on the arterial roads of the city and not on the local and connector roads. Some of the highest concentrations take place on three highways passing through the city: (a) A-A is a six lane national highway, which runs east-west and seems to have the higher velocities; (b) B-B is a state highway also running east-west, which is 2- 4 lanes; (c) C-C is a state highway running north-south, which connects to cities south of Agra (Figure 28). The road has heavy mixed traffic including with very inadequate pedestrian/bicycle facilities. All these roads have heavy traffic throughout the day, and velocities can be above 50 km/h at night. Figure 29 shows traffic on the National Highway (A-A) in Agra. This is major highway

Figure 29. Traffic on national highway A-A in Agra.

constructed through the city over the past decade. This highway is a major east-west corridor for inter city traffic and is used by large proportion of buses and trucks. There are almost no convenient faculties for VRUs to cross this highway. In addition, a very large number of workshops, trading and transport companies, and shops are located on both sides of the highway. A highway like this constructed through the city seems to result in high crash rates along its length.

b. AMRITSAR (low crash rate)

Amritsar is a city in the north-west of India about 30 km from the border with Pakistan. As a result there are no major national highways that have to carry intercity traffic through the city. Most of the roads in the city are congested. Crash locations were not identified for Amritsar. According to official statistics the city has the lowest road traffic fatality rate among the six studies included in this project.

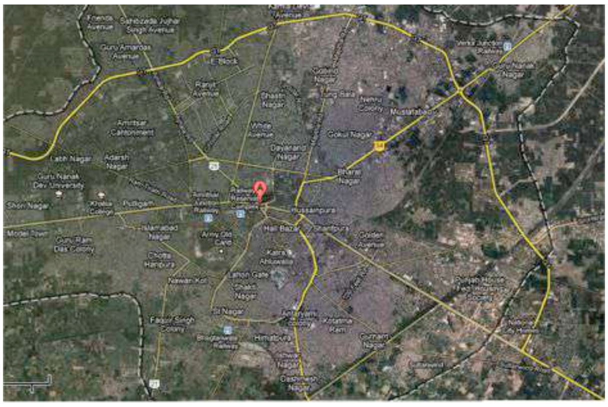


Figure 27. Arterial roads in Amritsar.

c. BHOPAL (low crash rate)

Crash locations have not been identified for Bhopal. The city has no major highways crisscrossing the city. In addition the city has a large lake within the city and a hilly residential area. Most of the arterial roads in the city are congested in the daytime hours with mixed traffic. Bhopal has a lower fatality rate as compared with Agra, Vishakhapatnam and Ludhiana.

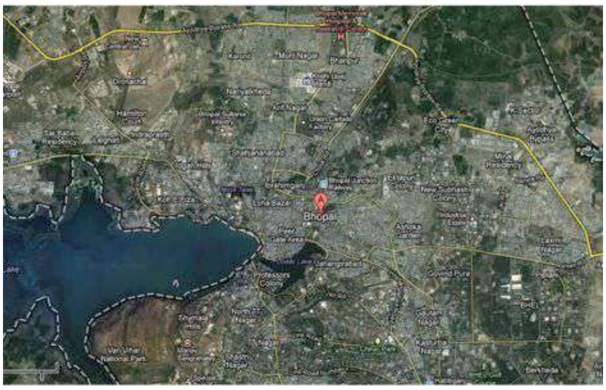


Figure 28. Arterial roads in Bhopal.

d. LUDHIANA (high rate)

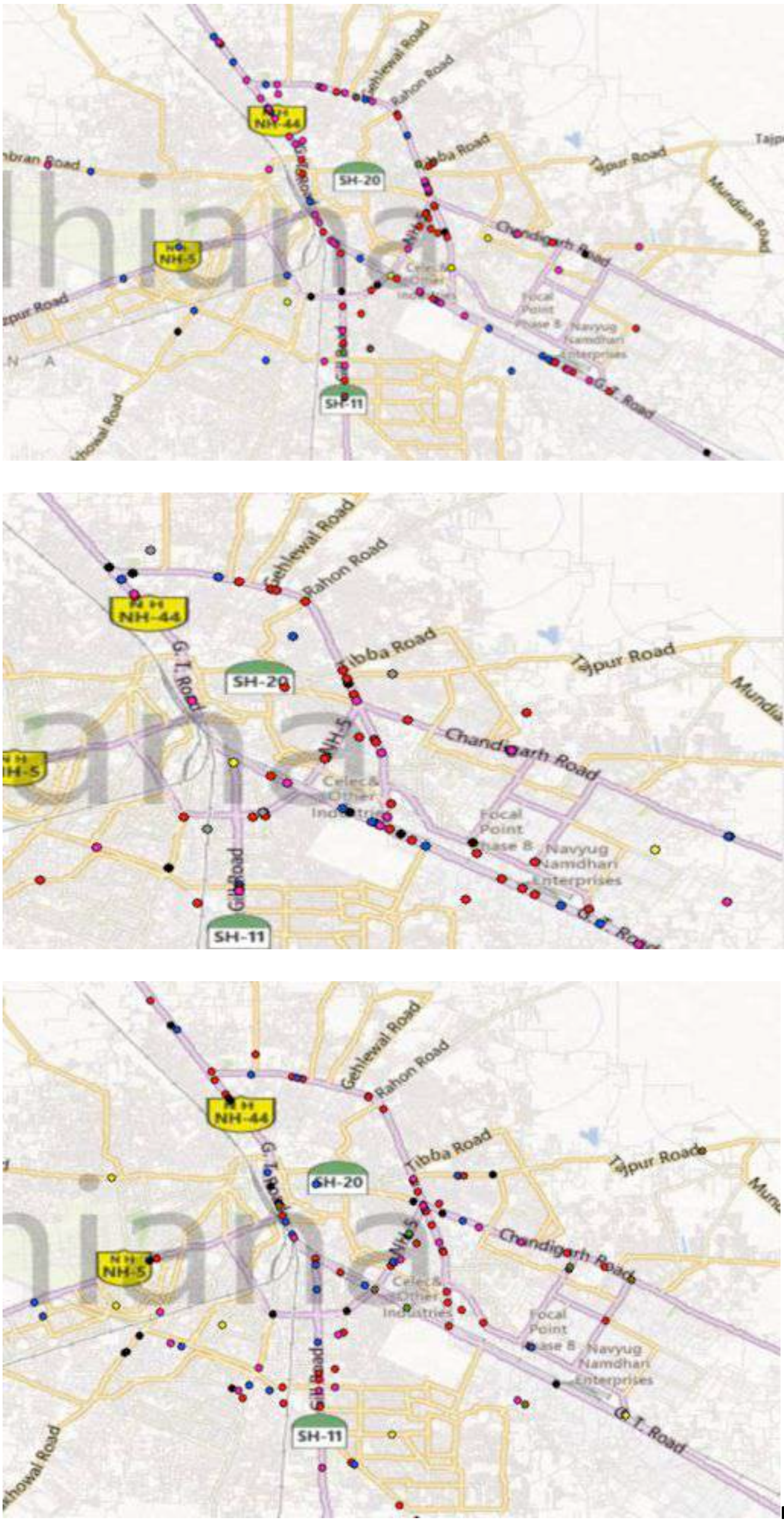
Figure 32. Arterial roads and highways in Ludhiana.

Figure 32 shows the arterial roads and highways passing through Ludhiana. An important National Highway that connects the capital Delhi with the border city Amritsar passes through Ludhiana, going from the southeast side to the northwest. Another national highway comes into the city form the southwest and a state highway from the south. A bypass has been constructed connecting these highways encircling the city in the north, east and the south sides.

Figure 33. Traffic on highways passing through the city in Ludhiana.

The highways passing through the city also serve as arterial roads of the city. The type of mixed traffic including trucks operating on these roads is shown in Figure 33. Bicyclists and pedestrians in large numbers also use these roads but adequate and safe facilities for them do not exist in these roads.

The location of pedestrian, bicycle and MTW fatalities is shown in Figure 34. As in Agra, a large proportion of fatalities take place on the highways and major arterials. The red dots represent impacts by trucks, blue dots impact by buses and red dots impacts by cars. Truck impacts are the most frequent on the highways.



Pedestrian fatalities

Bicycle fatalities

MTW fatalities

Figure 34. Location of pedestrian, bicyclist and MTW fatalities in Ludhiana.

e. VADODARA (low rate)

Figure 35 shows the arterial and highway layout in Vadodara. There is no major highway that goes through Vadodara, there is bypass for intercity traffic which skirts the western side of the city from the north ton the south. Arterial roads connect the central parts of the city to this bypass.

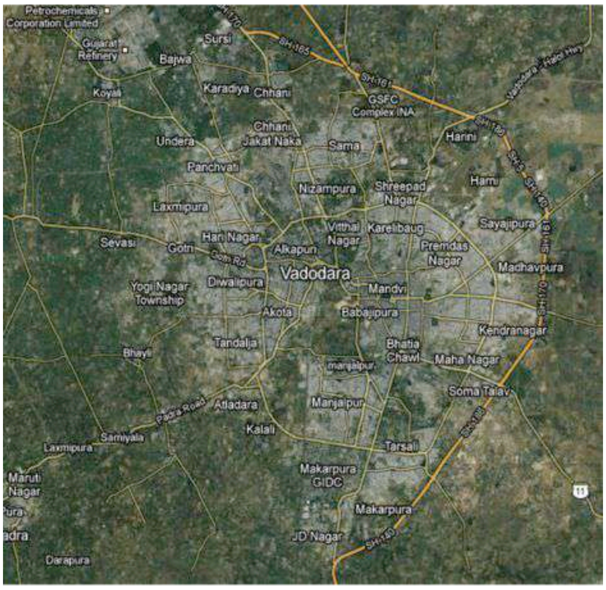


Figure 35. Arterial roads and highways in Vadodara.

Figure 36 shows the locations of the fatal crashes in the city. All the main arterials leading out from the city and the circular road inside the bypass have a concentration of crashes.

The western bypass also has a higher concentration and crashes are located all through its length. Type of traffic operation on the bypass is shown in Figure 37.

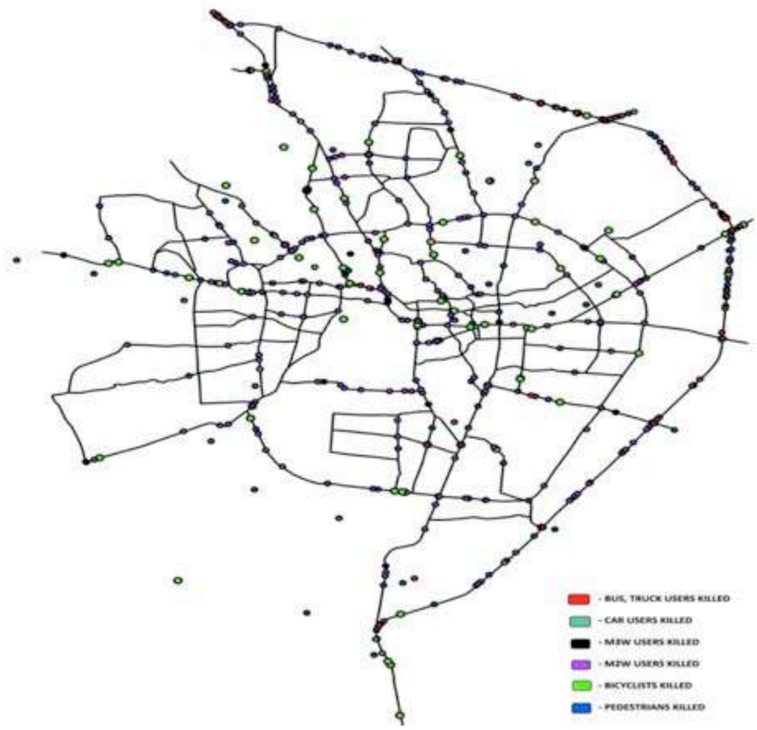


Figure 36. Location of fatal crashes in Vadodara.

Figure 37. Traffic on the bypass in Vadodara.

Mixed modes, relatively high speeds and sharing of the road by VRUs with heavy vehicles results in high crash rates. However, the overall fatality rate in Vadodara is less than that in Agra, Ludhiana and Vishakhapatnam as the main roads inside the city are congested.

f. VISHAKHAPATNAM (high rate)

Vishakapatnam is a port city with the eastern headquarters of the Indian Navy, and it hosts heavy industry factories in different locations of the city. National highways lead out of the city and different sectors of the city are connected with roads that can have relatively high speeds. The city has a high fatality rate.

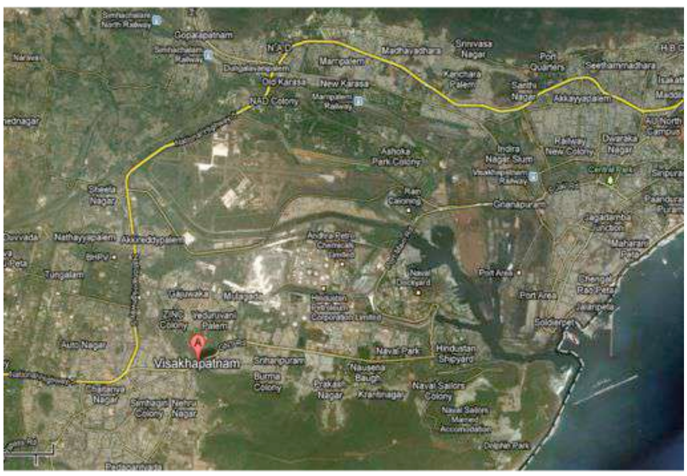


Figure 38. Highways and arterial roads in Vishakhaptnam.

Figure 39. Traffic on the main arterials of Vishakhaptnam.

Fatality locations have not been identified in Vishakhapatnam. Figure 39 shows the traffic on main arterials of the city. Existence of wide roads and flyovers with mixed traffic may be one of the factors associated with high road traffic fatality rates in the city.

Road user risk analysis

Risk of fatality has been calculated using different indices to understand the role of different motor vehicles, personal risk per trip by different modes and the risk different vehicles present to society.

Occupant risk per 100,000 vehicles

Figure 40 shows the number of motor vehicle occupant fatalities per 100,000 vehicles. This has been obtained by dividing the total number of occupant fatalities for each vehicle type divided by the specific number of that vehicle type registered in the city (corrected for overestimates). These data show that occupant fatalities per vehicle decrease in the following order – bus:truck:TSR:MTW:car. It is difficult to account for the bus and truck figures, as the total number of fatalities is divided by the number of these vehicles registered in the specific cities only. However, the

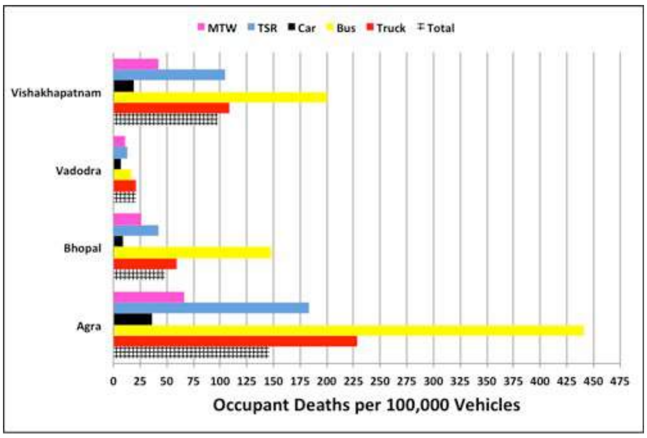


Figure 40. Motor vehicle occupant fatalities per 100,000 vehicles.

actual number of trucks and buses operating in the cities would include those passing through these cities but not registered there. If these extra vehicles were accounted for, then the indices for occupant fatality rates for buses and trucks would be lower.

Occupant fatality rates for MTW and TSR occupants are 2-3 and 3-5 times higher that for cars respectively. The high rates per vehicle for TSRs would also be because they carry a much larger number of passengers in the day as compared to MTWs and cars. This effect is accounted for in the section on personal risk in a following section.

Fatalities associated with each vehicle type

Figure 41 shows all the fatalities that each vehicle type is associated with. This includes fatalities of road users other than the vehicle occupant. For example, if a motorcycle hits a pedestrian and the pedestrian dies, then the pedestrian death will also be associated with the motorcycle. This index gives a rough idea of the total number of fatalities you can expect for each vehicle type given the present traffic conditions and mode shares.

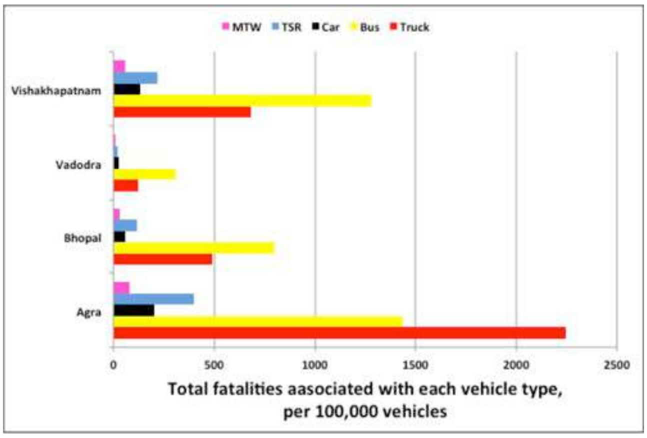


Figure 41. Fatalities associated with specific vehicle types per 100,000 vehicles.

These indices again show that buses and trucks have the highest rates in all the cities. The usual caveat applies that the actual number of buses on the roads in these cities would be higher than the number registered in the city. This would mean that the absolute index for buses and trucks would be lower than that shown in Figure 41. In all cities except Agra, buses appear to have a higher number than trucks. Whatever, the real index for these vehicles, the data in figure 41 does point to the fact that buses and trucks have a disproportionate involvement in urban fatal crashes. Since a majority of the victims associated with these crashes are VRUs, these figures strengthen the need for much better facilities for VRUs so that they do not have to share the curbside lanes with these heavy vehicles. If buses and trucks were designed to have safer fronts for impacts with pedestrians, then this number would reduce. At present there are no pedestrian impact standards for buses and trucks.

These data also show that each TSW is associated with more fatalities than the car and each car is associated with more fatalities than a MTW. However, the differences between the car and MTW are not very large. What these data tell us is that at the city societal level a motorcycle does not do as much harm, though it is more hazardous for its own occupant than the car or TSR. This index also points us to the need for improvement in TSR designs and need for crashworthiness standards. These numbers give us an indication of the situation at present operating levels and exposure has not been taken into account. This is done in the next section.

Fatalities associated with each vehicle type accounting for exposure

Figure 42 shows us the estimates for all fatalities associated with specific vehicle types per 100,000-vehicle km per day. The following values have been assumed for distances travelled per day.

Bus: 150 km
Car: 50 km
TSR: 150 km
MTW: 25 km

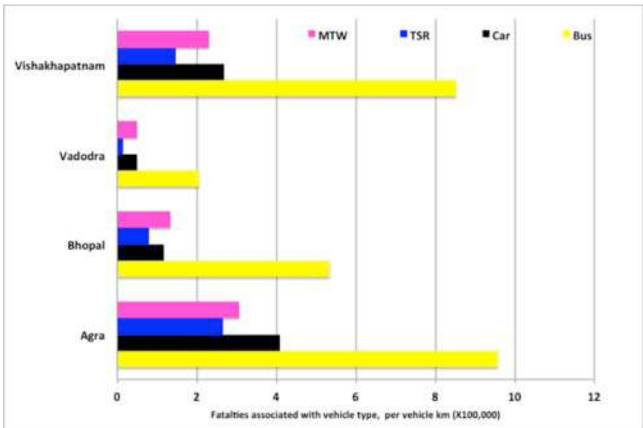


Figure 42. Fatalities associated with specific vehicle types per 100,000-vehicle km.

These figures basically indicate that the relative higher rate for TSRs as compared to cars as shown in the previous section was due to the higher exposure of TSRs. These indices appear to indicate that per km of travel TSRs, MTWs and cars are very roughly equally harmful for society under present conditions. Out of these three vehicles it is very important to improve the safety performance the MTW for its occupants (helmet use and daytime running lights). TSRs need improvement for safety of occupants as well as the VRUs it impacts. The fatalities associated with the can be decreased mainly by speed control and reduction in drinking and driving.

Personal fatality risk per 10 million trips

The personal fatality risk has been calculated by dividing the vehicle specific occupant fatality rate by estimates of average number of occupants carried by each vehicle per day. The numbers assumed are: MTW – 4, TSR – 60, Car – 7. The results of these calculations are shown in Figure 43.

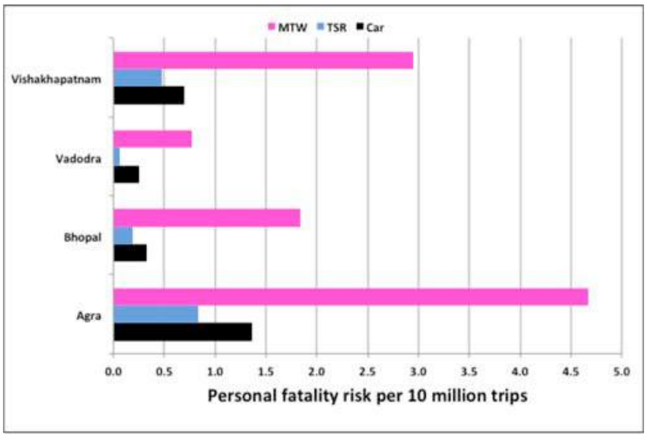


Figure 43. Vehicle specific personal fatality risk per 10 million trips.

It is clear that given the present trip lengths for each vehicle type, the MTW rider is 3-6 times more at risk than a car occupant. The MTW fatality rates per trip in Agra and Vishakhapatnam are much higher than the other three cities. The reasons for this are not known at present. At a personal level, risk per trip seems to be lowest for TSR occupants in all the cities. These estimates are true for present modal shares and assumed trip rates.

Helmet use and daytime running lights are not mandatory for MTW riders in any of the cities studies. The implementation of just these two measures is likely to reduce the personal fatality risk by about 50%.

Summary and conclusions

City and roads

- The six cities studied vary considerably in the total number of fatalities per unit population and rates of fatalities per 100,000 vehicles. This is in spite of the fact that the population sizes are not very different.
- For the two cities where more detailed work has been done (Ludhiana and Vadodara), and for one city where locations of crashes were plotted for a one-year period, it appears that wide arterial roads, highways passing through the city and bypasses have high crash rates.
- The above observation suggests that all methods available for speed control (road design, traffic calming, and enforcement) need to be employed on arterial roads and highways crisscrossing the city. It would also be advisable to review the design criteria for provision of bypasses around the city for trough intercity traffic. It is possible that these highways need to be on elevated sections to reduce the possibility of interaction with local traffic.
- The high association of buses and trucks, and a surprisingly significant involvement of MTWs in VRU fatalities suggests that this is partly due to the fact that pedestrians and cyclists have to share the curbside lane with these vehicles in the absence of adequate sidewalks and bicycle lanes. This makes a clear case for the establishment of standards and laws that require all arterial roads to be outfitted with adequate pedestrian paths and bicycle lanes within a specified time frame.
- The detailed work in Vadodara and Ludhiana indicates that some fatalities do occur on non-arterial roads also. This implies that there would be a significant number of non-fatal crashes on these roads also. These can be reduced significantly with provision of appropriate traffic calming measures.
- The data indicate that there is an increase in the number of fatal crashes in the period 20:00-22:00 when traffic volumes are likely to be lower than those in the daytime. This suggests that there may be a need for improving visibility and lighting conditions on urban roads.

Vehicle design issues

- One of the very significant findings in this study is the discovery of the relatively high association of motorcycles in pedestrian and bicycle crashes. A detailed analysis needs to be done to ascertain whether vehicle design changes can reduce the probability of serious injury in these crashes.
- Personal risk of motorcycle riders is the highest compared to occupants of other vehicles. This could be reduced significantly by enforcement of helmet use and daytime running light laws. Since motorcycles far outnumber cars in Indian cities, it is necessary to focus on further improvements in motorcycle design (eg. braking systems, conspicuity, signaling systems).
- High association of buses and trucks with VRU crashes in all cities studied strengthens the argument for development of a pedestrian impact standard for these vehicles.
- TSRs are not safe enough either for their own occupants or the VRUs they impact. Crashworthiness standards including pedestrian impact standards specifically for these small and light vehicles need to be developed.

Community and enforcement issues

- The police departments need to focus on
    - Speed control, especially at night
    - Enforcement of helmet use laws
    - Control of drinking and driving
- Community involvement and pressure needed for
    - Rethinking urban road design issues so that wide high-speed roads do not go through cities
    - Provision of facilities for pedestrians and bicyclists
    - Introduction of traffic calming measures
    - Improving design of para-transit vehicles.

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非売品

H2429 プロジェクト

インドにおける交通安全のためのコミュニティデザインに関する研究調査

報告書

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