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## Protecting the vulnerable by design – a tribute to Dinesh Mohan(1945–2021)

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## Protecting the vulnerable by design – a tribute to Dinesh Mohan (1945–2021)

### 1. Was it a riot or was it a pogrom?

Dinesh was taking pictures of Sikh children with burn injuries, who were playing in one of the relief camps. The army had been deployed but not given any orders to act yet. Dinesh was hauled up by a soldier and accused of photographing an army tank. Then he was frog-marched to the superior officer with an automatic gun jabbed in his ribs and his arm in an armlock behind him, and he was lifted into the air. The soldier coolly asked "Isko udā dein?" (should we finish him off?) That is when Nandita pounced on him shouting: 'I am Nandita Haksar, Supreme Court lawyer! You can't do this! There is no martial law ...' Dinesh, not wanting to have his camera confiscated, opened it and exposed the roll of film as soon as they let him down. As the four drove away, Dinesh had to stop. His legs were trembling too much for him to drive. Peggy Mohan

Two days earlier, on 31 October 1984, Prime Minister Indira Gandhi (the 'Iron Lady of India') was assassinated by her two Sikh body guards in an act of revenge. Earlier that year she had ordered the military to remove separatist militants who had occupied the Golden Temple, the holiest Sikh shrine, severely damaging the site while killing hundreds, including pilgrims and civilians. Her assassination triggered a massacre in which Sikh boys and men were dragged out on the street, beaten up, doused in kerosene and set ablaze as their families were forced to stand and watch. The official death toll was 2700 deaths, but unofficial estimates ranged from 8,000–17,000 (Wikipedia Contributors).

Episodes of communal violence have been common in India's history. Invariably, the official description of what happened is that there was a provocation (eg a Sikh killed a beloved political figure), and the popular grief and anger led to a spontaneous eruption of madness and violence. However, a book titled 'Who are the Guilty', published by the People's Union for Civil Liberties (PUCL) and the People's Union for Democratic Rights (PUDR) in less than a month after the 1984 Anti-Sikh violence, was instrumental in creating a profound shift in this narrative (PUDR-PUCL, 1984). The report included testimonies and eyewitness accounts from interviews conducted with victims and their families in the refugee camps immediately after the events. The report concluded that the violence had 'a well-organised plan marked by acts of both deliberate commissions and omissions by important politicians of the Congress (I)<sup>1</sup> at the top and by authorities in the administration'. It documented vivid descriptions of how the ruling party used city buses to bring crowds of assailants from local villages, provided them with voter lists, school registration forms and ration lists, and, in many cases, local party leaders led the mobs

to Sikh houses and businesses. ('The shop signs are either in Hindi or English. How do you expect the illiterate arsonists to know whether these shops belonged to Hindus or Sikhs unless they were identified to them by someone who is either educated or a local person?'). It described numerous acts of omission (where the police and military stood aside while the state briefly abdicated its responsibility to protect citizens from violent mobs) and acts of active incitement and engineering of violence by functionaries of the state. In short, the report proved that what happened on those four fateful days in New Delhi was not a riot; it was a pogrom.

'Who are the Guilty' went further. It included a list of people identified by survivors (including 16 politicians, three of whom were senior leaders of the ruling party, 13 police personnel and 189 others), in many cases providing the only evidence that connected these individuals to their crimes. Therefore, the report was published with no named authors because of the obvious risk they faced. However, shortly after Dinesh Mohan's death on 21 May 2021, the PUCL-PUDR released a statement identifying him (see Box 1) as one of the four key authors of the report. His collaborators (who shared stories with us for this article) point out the critical role played by Dinesh Mohan especially in ensuring that the report was written in a style and used a standard of evidence that was more like an academic report than was common for human rights reports in India at the time. As one of his unnamed co-authors wrote to us, 'It was Dinesh's inputs that made our report foolproof and, as it was based on solid information, the government did not dare to challenge our findings'. These characteristics, and the broader framing of the root causes of the violence, are likely the reason why the report has been instrumental in helping to shift the academic understanding of communal violence in India away from a spontaneous outburst of crowds gone insane, to a much more complex understanding of how social groups that are in power use state authority to perpetrate violence (Das, 2003). Unfortunately, there have been many instances of large-scale communal violence in India since 1984 (eg 1993: Bombay, 2003: Gujarat, 2012: Assam, 2020: Delhi, to name a few). Yet, the more nuanced understanding of how dominant groups use the state apparatus to commit violence that emerged from 'Who are the Guilty' provides new ways for advocates to fight for human dignity and protections for the most vulnerable in society.

This description of Dinesh Mohan's contribution to a pivotal moment in human rights work in India will be surprising to most readers. It is a history that most of his injury prevention colleagues would be largely unfamiliar

**Box 1 Statement from the People's Union For Civil Liberties.**

332, Patpar Ganj, Opposite Anand Lok Apartments, Mayur Vihar I, Delhi, 110091

Founder: Jayaprakash Narayan; Founding President: V. M. Tarkunde

President: Ravi Kiran Jain; General Secretary: Dr. V. Suresh  
25th May 2021

**CONDOLENCE MESSAGE**

PUCL feels a deep sense of loss over the sad demise of Prof. Dinesh Mohan on 21st May. Prof. Dinesh Mohan's passing away marks the loss of a multifaceted personality: an outstanding academician, a visionary thinker, pioneer in the field of traffic studies and sustainable infrastructure development and a staunch champion of human rights.

Prof. Dinesh Mohan was a member of People's Union for Civil Liberties (PUCL) from its inception in 1980 and took active part in its activities. While he participated in numerous PUCL activities in the 1980–1990s, his greatest contribution was as one of the four-member citizen's Fact Finding and Investigative Team (FFT) formed jointly by People's Union For Democratic Rights (PUDR) and People's Union For Civil Liberties (PUCL) to enquire into the anti-Sikh riots which swept across Delhi in the wake of Indira Gandhi's assassination.

Participating on behalf of the PUCL, Prof. Mohan played a key role in drafting the report, 'Who are the guilty? -A Report of a Joint Inquiry into the Causes and Impact of the Riots in Delhi from 31st October to 10th November 1984'. The FFT studied the outbreak of violence in which around 3000 innocent Sikhs were brutally killed.

The FFT Report was historically very important for it exposed how the violent mobs which killed several thousand Sikhs were actually egged on and led by key leaders of the Congress party, which was ruling at that time, in connivance with the Police, and the impunity they enjoyed. That report is a monumental contribution to the field of investigative reports on communal violence and Dinesh Mohan had played a significant part along with the other colleagues in the inquiry.

PUCL has cherished memories of contributions made over the years by Prof. Dinesh Mohan, in defense of human rights and democratic processes. He represented the best combination of an academician – activist and never hesitated to lend a helping hand to any campaign seeking his help to bolster their Report with sound factual details. Apart from making immense and significant contribution to areas relating to road safety and transportation, his contribution to other public policy spheres such as sustainable human development, water issues and environment and ecological movements is noteworthy.

The human rights movement has lost a stalwart of outstanding academic and professional experience who was also a genial, warm and empathetic human being. The loss is great and irreparable.

PUCL offers its heartfelt condolences to the bereaved family.

Ravi Kiran Jain, President, PUCL

N. D. Panchoi, Vice-President, PUCL

Dr. V. Suresh, National General Secretary, PUCL

with. Readers may even be wondering what, if anything, links this with the themes of violence and unintentional injuries that are typically covered in the International Journal of Injury Control and Safety Promotion. Is the connection that the PUCL-PUDR Report reframed the discussion about communal violence in terms of the structural determinants of injuries? It certainly is that. However, that was not what allowed Dinesh's entry on to the human rights stage in India. In 1984, Dinesh was relatively unknown to the Indian human rights community. As a graduate student in the USA, Dinesh had been an active member of the Students for a Democratic Society (SDS) in the late 1960s and had participated in the anti-war struggles against US interventions in Vietnam. But the USA and its politics are

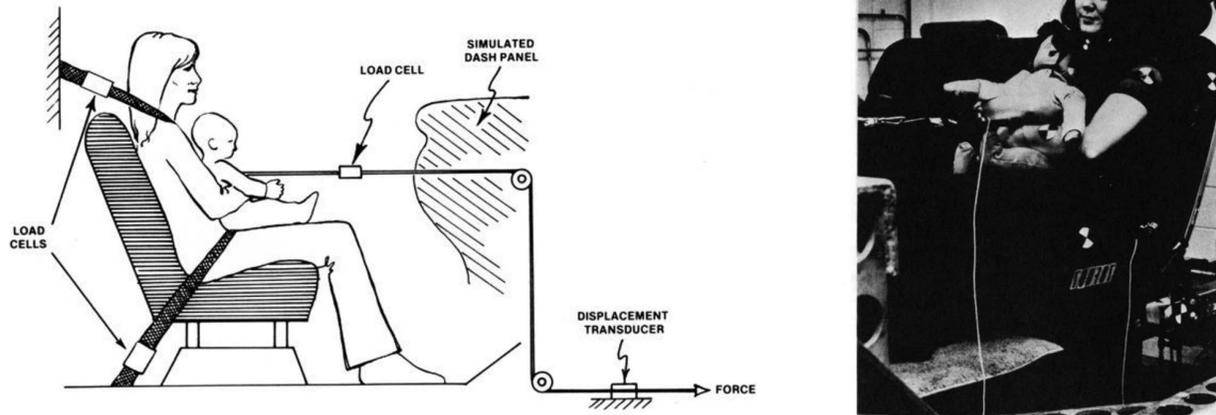
a far cry from the struggles for rights and civil liberties in India. What Dinesh offered the Indian human rights community, was his expertise in assessing the external causes of traumatic injuries. His PhD thesis research at the University of Michigan had focused on the mechanical properties of human tissues, and the mechanisms of head and chest injuries. There was likely nobody in India who was better trained to speculate on the potential causes of injuries of victims of violence. This was the primary reason he was initially included in human rights work in India. Although he may not have been considered politically savvy by this community at first, the experience with their 1984 investigations made it rapidly clear that Dinesh would be more than just a technical expert and would play an important role in shaping the political dialogue in this field.

**2. The influence of William Haddon and the insurance institute for highway safety**

In 1971 .... I drove to the Highway Safety Research Institute (now University of Michigan Transport Research Institute) and met Professor McElhaney. Fifteen minutes later I was a research assistant in the Biomechanics Department and was put to work on head impacts with Richard Stalnaker. This was a completely unexpected development, as I had primed myself to work on aids for the disabled with orthopaedic surgeons. I knew nothing about human tolerance to impact. It was also fun being involved in the process that decided (USDOT FMVSS) standards. Some of those standards remain unchanged. (Mohan, 2001)

After finishing his PhD, Dinesh Mohan worked for three years at the Insurance Institute for Highway Safety (IIHS) in Washington, DC, as a biomechanical engineer. IIHS is a US non-profit organization whose president at the time was William Haddon, the first administrator of the National Highway Safety Bureau (later the National Highway Traffic Safety Administration, NHTSA). Haddon is arguably among the most important figures in injury prevention. The Haddon's Matrix (Haddon, 1970) shifted focus from individual behavioural factors to the broader structural determinants of road safety (design of roads, vehicles, trauma systems). This new paradigm and the use of a more evidence-based regulatory approach is credited with the long-run declines in traffic crashes that have occurred in the USA since the 1970s (Bhalla et al., 2020; O'Neill & Mohan, 2020). Under Haddon's leadership, NHTSA set the first national motor vehicle safety standards. Haddon was hired by IIHS in 1970 to transform it from an organization advocating high-school driver education into a research group. At the time, IIHS was undergoing a transformation from folklore to science that was initiated by Haddon. Dinesh became part of the original small research group at IIHS.

Haddon quickly recognized that Dinesh could be much more than a bioengineer and took him under his wing and spent time mentoring Dinesh on the broader issues involved in vehicle and highway safety. This was the beginning of Dinesh's lifetime commitment to the field. In his words:



**Figure 1.** Experiments to assess whether parents can hold on to infants during a crash.(Mohan & Schneider, 1979)

Spurred on by Haddon, we worked with a missionary zeal. Haddon also took it upon himself to “educate” me. He would call me into his office, give tutorials on the principles of injury control, and quiz me on chapters from his book *Accident Research* (Haddon, Suchman and Klein, 1964). On afternoons when he was in a more pensive mood, he would discuss the American Constitution, ways the Senate and the Congress worked, and the complexities of rulemaking. Many of those interchanges were unpleasant, heated and irritating. But they left an impact. I was no more just a bioengineer but began to understand that the traffic crash was part and parcel of the wider socio-economic system of a society. (Mohan, 2001)

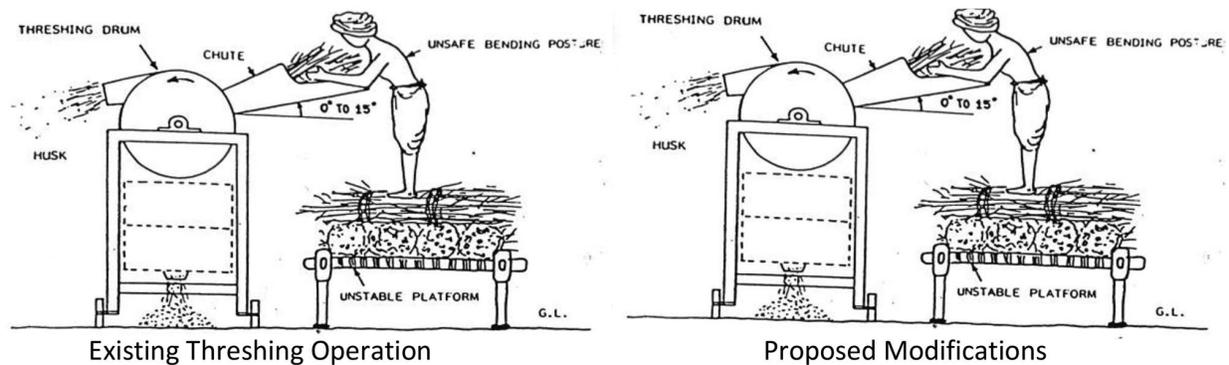
While the field of vehicle safety was undergoing a transformation, there were still many adherents who strongly believed, with no evidence, that educating drivers to prevent crashes should be the focus of all prevention efforts. For instance, it was widely believed that seatbelt use could be increased by advertising campaigns. IIHS research demonstrated that these campaigns did not work, leading to the idea of passing laws to make seat belt use compulsory<sup>2</sup>. During these early debates it was argued, with no evidence, that belted mothers could hold their infants in their arms protecting them from crash injuries. Dinesh was able to quickly organize a research project in which female volunteers in lap/shoulder belts held child dummies as tightly as possible and were then subjected to forces comparable to those in moderate speed crashes (Mohan & Schneider, 1979) (Figure 1). Not surprisingly, these volunteers were unable to keep hold of the child surrogates. The dramatic images from these tests fairly quickly led to this option being dropped from the proposed laws.

In this climate, Haddon was the leading advocate for passive protection (ie requiring no action by vehicle occupants) vs. protection that required action by the occupants. This resulted in the very long US debate about the benefits of airbags vs. seat belts, which started in the 1970s and did not end until the US Supreme Court ruled in a unanimous decision in 1983 that an earlier decision by NHTSA to rescind a proposed rule requiring automatic crash protection was ‘arbitrary and capricious’. Dinesh played an active role

in the early debates and published a paper ‘that presents the most thorough and up to date scientific analysis available of the comparative performance of lap/shoulder belts and airbags in reducing injuries in frontal crashes...’<sup>3</sup> (Mohan et al., 1976). The results of this study indicated that ‘in frontal crashes, even compared to 100 percent belt use<sup>4</sup>, more lives could be saved and severe injuries reduced by the use of airbags’. Thus, it is clear that Dinesh was not just doing good scientific studies, but was doing so in the context of very heated public debates about restraint systems in cars. As the US Supreme Court noted in its ruling on automatic restraints, the car companies had ‘waged the regulatory equivalent of war against airbags’ and lost. IIHS research, including Dinesh’s work, contributed to that loss.

Nevertheless, it was not all work and no play at IIHS in those days, and Dinesh had his share of fun. For example, the 1976 Annual Meeting of the American Association of Automotive Medicine (AAAM) in Atlanta took place at the same time as the presidential election that Jimmy Carter won. Dinesh had discovered that Carter’s expected election victory party was scheduled to take place at a nearby hotel, so three people from IIHS led by Dinesh decided to see if they could crash that party. There was a long line to get in, and it seemed that everyone had tickets, but Dinesh and a colleague persevered and succeeded in crashing the party without tickets and enjoyed celebrating with President-Elect Jimmy Carter who was there – a clear failure of the US Secret Service.

As another example, Haddon read a lot of scientific papers, some of which he circulated to the research staff. One such paper addressed the question (May et al., 1976), why don’t woodpeckers get brain damage? An interesting question because a typical woodpecker does about 12,000 violent pecks a day. Dinesh decided to have some fun and sent a response to Haddon, suggesting that motorcycle helmets could be redesigned with a woodpecker-like beak to allow injured motorcyclists to forage for food until they are rescued. He ended with the thought that maybe woodpeckers do get brain damage on their first peck, which explains why they continue to peck forever!



**Figure 2.** Safer thresher design, including modifications to chute, and height and stability of standing platform (Mohan & Qadeer, 1990).

Dinesh only stayed at IIHS for a few years and not long after he joined the organization, it helped him apply for a US Green Card, which would have allowed him to become a permanent resident. However, the day he learned that his Green Card had been approved, Dinesh resigned saying that he *'didn't want to be seduced by the card'*, and not long after returned to India and took a faculty position at the Indian Institute of Technology, (IIT) Delhi. Although his stay at IIHS was relatively short, there is no question that his interactions at IIHS, especially with Haddon, had a strong influence on his lifetime commitment to vehicle and highway safety.

### 3. Protecting the vulnerable by design: influence on injury prevention in India

When I moved to the Indian Institute of Technology in 1979, I thought I was well equipped to change the road safety situation in India! Twenty-one years later, I can quite humbly admit that all my training and efforts have had little impact on actual policies and road traffic crash rates in India. In 1980, there were approximately 28,000 road traffic fatalities in India. Last year there were more than 80,000. (Mohan, 2001)

In 1979, Dinesh moved to India and joined the faculty of IIT-Delhi and set about reframing the principles of injury prevention so that they would be appropriate for a more global context rather than the Western focus in which they were originally developed. The main ideas were presented in a series of books and edited collections, with contributions from the leading figures in the field of injury prevention (Mohan & Berger, 1996; Barss et al., 1998; Mohan & Tiwari, 2000; Peden et al., 2004; Tiwari et al., 2005; Mohan, 2013a; Tiwari & Mohan, 2016). Using available epidemiological data from India and other low- and middle-income countries (LMICs) as well as his own observations, these articles presented the broad swath of injuries that are common in LMIC settings and provided a sketch of how these could be mitigated using the basic principles of the injury prevention field (Mohan, 1986a, 1986b) (Figure 2). For instance, Dinesh described unique risk factors for falls that were common in India but not in high-income countries (HICs), including flying kites from roofs, sleeping on roofs

and unguarded windows. For poisonings, he described how kerosene ingestion is the most common accidental poisoning for children because of its common use in stoves and lamps, and because it is colourless and often sold and stored in empty soft drink bottles.

Similarly, he described a wide range of risk factors for kitchen burns due to a cluster of risk factors that are uncommon in HICs, including open flames, pressurized kerosene stoves, flowing garments made of flammable materials (eg cotton saris and night gowns) and floor-level cooking surfaces (which are often within reach of young children). Always pointing to the need for addressing such issues by design rather than blaming victims, Dinesh wrote, *'Most studies mention carelessness of adults and older children ... but this is in spite of the fact that responsible persons were present at the time of the mishap in a large number of cases ... but there is little information on how product or environment design may have contributed to the problem'* (Mohan, 1986b). In the 1990s, Dinesh led several epidemiological studies on risk factors and experimental studies on the flammability of fabrics and garments commonly used in India (Bhalla et al., 2000), making insightful and impactful recommendations. After extensive media coverage of his work on firecracker injuries during the festival of Diwali, the use of cold water increased from 5% of burn victims in 1983 to 51% in 1987 (Mohan & Varghese, 1990). In fact, doctors reported that it became common for parents to bring children to the hospitals with their injured hands still immersed in a bucket of cold water. In contrast, a concurrent media campaign aimed at discouraging people from buying dangerous conical fireworks had no effect.

In the area of transportation safety, Dinesh started by explaining why society had an obligation to provide a safe environment (Mohan & Tiwari, 2000). Dinesh argued that in a modern society, almost everybody is forced to be on the road every day, whether it is for going to work, to school, or the myriad other daily activities that require road travel. However, operating a motor vehicle, or walking or bicycling among motor vehicles is complex task that requires good sensorimotor function. He estimated that at any given time, one-fourth of the people on the roads may have a cognitive or physical impairment that compromises their ability to conduct such activities safely, because of

their age (ie they are children or elderly), physical disabilities, psychoactive medications or psychological disturbances from having had a difficult dispute in a personal relationship earlier in the day. However, most of these people are not on the streets because of their choice, but because of the demands and compulsions on daily life created by a modern society. Furthermore, the poorest have the fewest choices and are therefore the most vulnerable. Since society is what forces people to be exposed to such risks, he reasoned, it is the ethical and moral responsibility of the state and civil society to ensure the safety of all by regulating products and environments.

Dinesh pointed out that although there had been extensive research in HICs on how to mitigate transportation risks, much of the findings of this body of work had little external validity except for some general theoretical principles (Mohan & Tiwari, 2000; Tiwari et al., 2005) (Box 2). This is primarily because of the large differences in the road environment between HICs and most LMICs, which tend to have a much higher share of non-motorized and two-wheeler trips, extensive use of locally designed para-transit vehicles (autorickshaws, tuk-tuks, tempos, jeepneys, etc.), much higher density living, higher proportions of non-motorized road users and more mixed land-use patterns. Furthermore, not only are the traffic patterns in LMICs different today, HICs have never experienced such traffic environments historically. Therefore, he argued that *'international consultants do not possess adequate insights'* and what needed were LMIC-based research programmes capable of understanding the local context and developing meaningful solutions.

### Box 2. On why safety-by-design is a societal responsibility.

In our modern ways of living we have to use products and do things at places and at times which are determined by someone else or by the society at large. The same holds true for activity at the work place or even at home. A large number of us have little choice in the design of the home we live in, the design of the tools we use, or the work place where we spend a major part of the day. .... Therefore, we have a societal and moral responsibility to design our products, environments and laws so that people find it easy and convenient to behave in a safe manner without sacrificing their needs to earn a living and fulfill their other societal obligations. The systems must be such that they are safe not only for 'normal' people but also for individuals who might belong to any of the groups of people having problems.

...

We know that drinking water should be purified at its source; it is unreasonable to expect everyone to boil water before drinking it. ... Ironically, it is quite common to create a product or environment which is likely to cause injury, warn the user to be careful, and then blame the user if a mishap occurs. We would never tolerate a person who introduced cholera germs in the city water supply and then 'educated' every citizen to boil water before drinking it .... (but) we put in place hazardous roads, vehicles and driving rules, and then expect road users to be safe by behaving in some ideal manner.

...

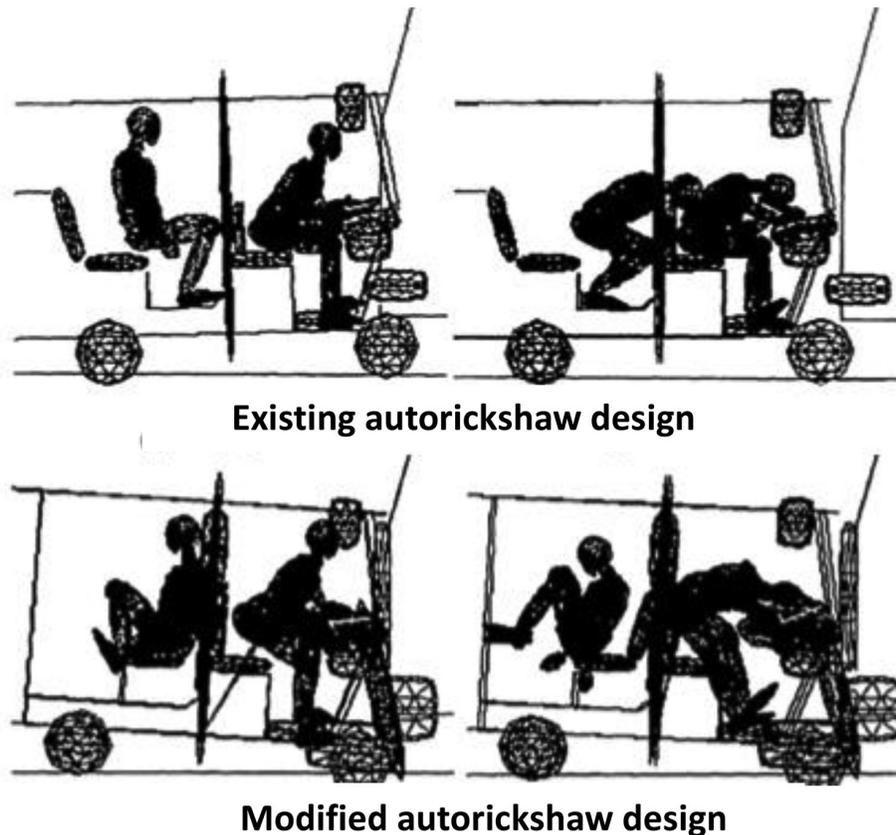
What needs to be understood is that the theoretical basis of injury control counter-measures may have international applicability, but the actual physical solutions may not. There is clearly a poverty of theory for work around the globe.

Dinesh Mohan (Mohan & Tiwari, 2000)

Addressing this *'poverty of theory'* in LMICs, Dinesh argued, requires large investments in research programmes based in LMICs, and focused on what works (and doesn't work) in the local transport environment (Mohan, 2001, 2002). Speaking at a memorial event shortly after his death, several of his friends pointed to the chutzpah it took for Dinesh to envision and maintain a fully grant-supported injury prevention programme based in an LMIC. In 2002, his research group, which was initially based at the Center for Biomedical Engineering at IIT-Delhi, became the Transportation Research and Injury Prevention Programme (TRIPP), a prolific source of inter-disciplinary scholarship aimed at addressing the adverse health effects of road transport. In private conversations, Dinesh often pointed to the neglect of the fields of injury prevention and transportation safety in academia, pointing out how difficult it had proven for even the stalwarts in the field in the USA and Europe to find an academic home from where they could pursue scholarly work in the long term. In 2021, just days before his death, IIT-Delhi announced that TRIPP would be a new academic centre (TRIP-C). The ability to hire faculty and offer academic programmes in the field of transportation safety makes TRIP-C a unique institution that has the potential to deliver Dinesh's long-held vision for advanced scholarship in theoretical and applied transportation safety research.

Starting from his earliest writings on road safety in LMICs in the early 1980s, Dinesh identified numerous priorities for road safety research that still remain largely underfunded and understudied other than notable studies that were conducted by him and his collaborators. Some specific examples of such issues that he highlighted include the fact that roads and intersections in LMICs are designed largely for the movement of cars and heavy vehicles following the design principles laid out in HICs where the roads are primarily used by these vehicles. In LMICs, there was a need for designs that work for a traffic environment dominated by pedestrians, motorcycles, human powered vehicles and locally designed vehicles (Mohan, 2001, 2002). Similarly, he pointed out that limited access expressways were an HIC solution to moving people between cities that worked poorly in LMICs where country sides are often heavily populated. While the issue of highways dividing populated landscapes receives some attention in HICs, the situation in LMICs is much more severe because the rural populations are usually too poor to own motor vehicles and thus may have no legal ways to cross a highway regulated for use only by motor vehicles. Among other design issues, he identified providing crossings for local traffic on highways as an issue of high importance.

In the area of vehicle crashworthiness design, Dinesh shone a spotlight on the need for safer designs for bus and truck fronts that reduce injuries caused to pedestrians, bicyclists and other vulnerable road users. The EU has regulations (UN 127) that require the design of passenger cars to have pedestrian friendly car fronts and the Euro New Car Assessment Program (NCAP) performs pedestrian crash testing and assigns cars a pedestrian safety rating. There is evidence that such measures have been



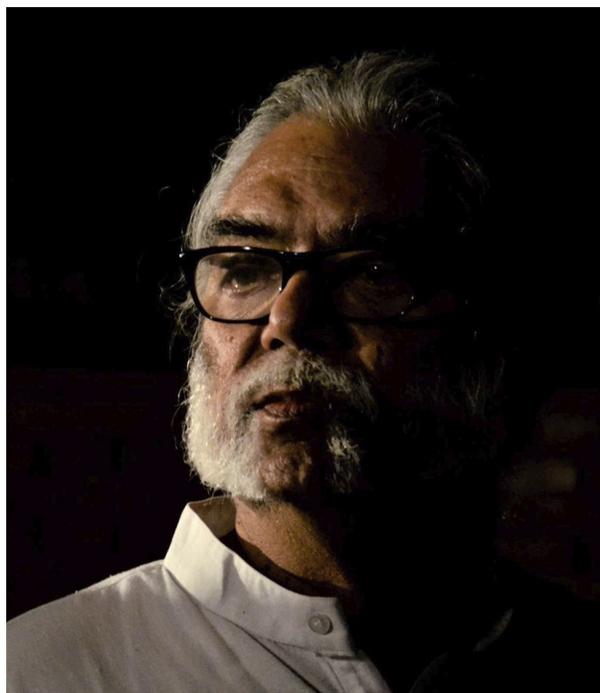
**Figure 3.** Simulation of an autorickshaw-bus impact at 60 ms and 150 ms, and effect of design modifications, including rearward facing passenger seat, driver restraints, and deformable bus-front (Mohan et al., 1997).

effective in reducing pedestrian injuries in real-world crashes in the EU (Pastor, 2013; Strandroth et al., 2014). However, these regulatory efforts focus solely on passenger cars, notably excluding heavy vehicles such as buses and trucks. In India and many LMICs, Dinesh argued that pedestrians are much more likely to be killed in crashes by buses and trucks than cars. He showed that nearly 90% of pedestrian deaths in the USA, but only 22% in India are with passenger cars (Mohan et al., 2017; Bhalla et al., 2017). In a series of papers, Dinesh and his colleagues at IIT Delhi developed the technical specifications of the shape and mechanical characteristics of the design of a bus-front that had been optimized to reduce injuries to pedestrians (Chawla et al., 1998, 2000; Kajzer et al., 1992).

Similarly, the safety design of locally manufactured para-transit vehicles has received very little attention from researchers or regulators, despite the ubiquity of such vehicles (Tuk-Tuks in Thailand, Jeepneys in the Philippines, autorickshaws and tempos in India, and a host of other vehicles) in many LMIC urban settings. Nevertheless, Dinesh highlighted that epidemiological evidence shows that occupants of these vehicles have lower injury rates per trip than cars despite these vehicles having no surrounding steel shell and a much lower weight (Mohan et al., 2016; Mohan & Bhalla, 2016). (This is surprising because there is extensive evidence from HICs that occupants are generally safer in heavier vehicles).

Dinesh and his colleagues undertook many investigations into the possible reasons for the lower crash risk and conducted engineering analyses of vehicle dynamics and structural crashworthiness to make the vehicles safer. The proposed design changes focused on the following areas: improvements in rollover characteristics of the vehicles; body designs that restrict passenger ejection from vehicles; use of rearward facing passenger seats; removal of all pointed and sharp objects (eg bolts and rivets) from the inside surfaces of the cabin, the provision of impact absorbing padding in areas where passengers are likely to hit the vehicle surfaces during a crash, and an 'outrigger design' that reduces risk of rollover (Chawla et al., 2001; Gawade et al., 2005; Mohan et al., 1997; Mukherjee et al., 2004, 2007) (Figure 3).

Dinesh used the example of the autorickshaw to develop a more contextually appropriate framework for thinking about crashworthiness standards for para-transit vehicles. Dinesh noted that almost all of our entire understanding of vehicle design derives from over a century of regulating cars in HICs, where the safety of car occupants was the central concern. Because of his training as a biomechanical engineer and his time spent at IIHS, Dinesh understood better than most people the importance of the improvements in crashworthiness engineering promulgated by design standards and NCAP testing. In the USA, almost half the gains in safety since the 1960s are attributed to safer vehicle designs (Kahane, 2015; Mohan & Bhalla, 2016; Mohan &



Caption: Dinesh Mohan, 2019.

O'Neil, 2020). However, in LMICs, where two wheelers and locally manufactured para-transit vehicles dominate the vehicle fleet, the benefits of importing the vehicle design regulatory framework of HICs would provide much smaller benefits. Although Dinesh strongly supported traditional car design regulations because *'hundreds of thousands of people are maimed and killed in cars all over the world and they must have access to the best safety systems as soon as possible'* (Mohan & O'Neil, 2020), he also pushed hard to re-conceptualize vehicle regulation in meaningful ways for local context. His core conclusion was that vehicles that have low engine capacity (<175 cc) and cannot exceed speeds of about 50 km/h were safer for occupants because of the lower speeds, and notably for LMIC settings, posed a much lower risk on pedestrians, bicyclists and other road users. This suggested the need for different regulatory standards and NCAP test conditions for low-speed vehicles, which should be used only in urban settings and prohibited from high-speed roads and highways.

In 2013, when Bajaj, the main Indian manufacturer of autorickshaws, tried to introduce a low-powered quadricycle for use as urban vehicles, Dinesh wrote in support of the vehicle. The RE60 quadricycle is a light (400 kg) 4-wheeled vehicle that is intended for use within city limits, primarily as a taxi. With a 216 cc single-cylinder engine and a power output of only 20 hp (about one-tenth of a typical American car), the quadricycle is highly fuel efficient (40 km/l; 90 mph) and has a top speed of only 70 km/h. Controversy arose because Bajaj applied for the vehicle to be exempt from the safety standards that apply to cars and other vehicle manufacturers vociferously objected. Dinesh pointed out that this sudden concern for safety was disingenuous, especially since most Indian auto-manufacturers had

opposed the NCAP safety ratings in India. In fact, Dinesh wrote, the vehicle that came closest to the quadricycle were autorickshaws, which were much safer than cars, as Dinesh had documented in extensive detail. And he argued that we need a separate set of standards for low-speed vehicles that were intended primarily for urban use (Mohan, 2013b). The standard car, he wrote, was *'an over designed, energy guzzling, highly polluting and wasteful piece of technology'*, but small, low-speed and low-weight vehicles like the quadricycle should be encouraged because they use less road space, cause less wear and tear of streets, and have lower impacts on the environment and long-term climate. The RE60 quadricycle is now available in India and is also becoming increasingly common in several African countries.

Another way in which Dinesh made important theoretical contributions to the field of global road safety was through broadening the range of urban and transportation system characteristics that could be viewed as risk factors. For instance, most road safety policy dialogue assumes vehicle mix (eg the proportion of motorcycles, or the amount of public transport) is fixed, and changes to vehicle mix are outside the realm of road safety discussions, even though there are huge differentials in the amount of risk associated with different types of vehicles. Dinesh would often highlight that much of the decline in road traffic injuries in HICs had been accomplished by substituting high-risk modes of travel (especially walking) with motorized transport (Mohan & O'Neil, 2020) and not just through safety policy as is usually claimed. Dinesh used mode-specific death rates to point out that Sweden and Japan would have much higher death rates if they had more pedestrians, bicyclists and motorcyclists – *'These estimates indicate that significant gains in traffic safety in HICs are partly due to reducing exposure of vulnerable road users and not only due to effect of safety policies'*. In his public lectures, he would remind the audience that Hollywood movies from the 1960s and earlier usually showed children walking to school but today they are typically dropped off to school in personal cars. Similarly, outdoor play for children has reduced dramatically resulting in large losses to the independence, autonomy and emotional well-being of children.

Furthermore, Dinesh argued, when conceptualizing how vehicle mix affects road safety, one needed to assess all fatalities associated with a vehicle, not just the risk to occupants, but also the threat posed to other road users. For example, when assessing the risk that a car poses to society, we should include both the number of car occupants killed and the number of pedestrians, bicyclists, motorcyclists and other road users killed by cars. In his papers, he operationalized this concept by presenting all deaths associated with the vehicle and contrasting this with analysis that showed only victims' vehicle type (which is typically how crash statistics are presented). This lens provided important new insights. For instance, compared with cars, vehicles such as autorickshaws and motorized two wheelers pose much less risk to pedestrians, bicyclists and other motorcycles, who are the most common road users in LMICs. As Dinesh explained, a policy maker needs to think differently about risk than a private citizen. If you are thinking about



Caption: Dinesh Mohan lecturing at the Road Safety Course held at the Shiraz University of Medical Sciences, Shiraz, Iran, February 21-23, 2015.

individuals (eg a parent thinking about the safety of a child), a motorcycle is a high-risk mode. However, a policy maker needs to think about the risk imposed by the availability of a transport mode on all of society (Mohan et al., 2016; Mohan & O'Neil, 2020).

Another surprising finding from the analysis of how vehicle-mix affects crashes was that simulations predicted that a mode shift in Delhi that aimed to increase bus use

would result in an increase in pedestrian crashes (Bhalla et al., 2005). The reason for this unexpected finding was that the use of public transport requires pedestrian trips, who are at particularly high risk, especially from bus crashes. Therefore, Dinesh and his colleagues argued that encouraging public transport for environmental benefits must be accompanied by large investments in infrastructure dedicated to safe transport for vulnerable road users.



Caption: Participants at the 2016 International Course on Transportation Planning and Safety, which has been hosted at IIT Delhi, India, annually since 1990.

The debate around the Bus Rapid Transport (BRT) system, whose design and development Dinesh championed, provides an illustration of why vehicle mix and the broader transportation environment are essential to safety considerations. In the mid-1990s, Delhi was abuzz with new plans for a mass rapid transit system, which, it was claimed, would reduce congestion and air pollution dramatically. The Central Pollution Control Board of India was interested in the latter and asked Dinesh's team at TRIPP to study the issue and provide them with a comprehensive plan for sustainable transport policies for Delhi. The report, *Delhi on the Move 2005 – Future Traffic Management Scenarios* (Mohan et al., 1997), highlighted three core ideas: (a) the non-viability of metro systems in many locations and evidence that such systems do not reduce vehicular traffic on the surface, and hence do not result in pollution reduction either; (b) the success of high-capacity bus systems initiated in Curitiba (Brazil) and the reasons why such systems would be ideal for Delhi; and (c) the need to establish dedicated bicycle lanes on all arterial roads in Delhi as a pre-condition for efficient traffic flow. The study was widely reported in the press and led to the newly appointed Minister for Transport for Delhi to commission the preparation of a Bicycle Master Plan for Delhi (Tiwari, 1998), which included detailed designs for dedicated bus and bicycle lanes for two corridors. This was the early opening of a window, or the beginning of a process that could have far reaching consequences on urban road designs and planning. In part, this was possible because of Dinesh's insistence on working with the politicians and government institutions to influence policies.

In 2001, a new Minister of Transport and the Chairman of the Delhi Transport Corporation showed renewed interest in the bus system design in 2001, and an international conference was organized and attended by many of the leading professionals associated with BRT systems around the world, including Enrique Peñalosa, former Mayor of Bogotá, Colombia. At the conference, the Delhi government announced plans for establishing BRT corridors in Delhi, and work on the first corridor started in 2006. After adapting international guidance for BRT systems to Indian conditions, the detailed designs included exclusive bicycles lanes and pedestrian friendly raised crossings and tactile markings on the road for the first time in Delhi. Delhi's decision to build a BRT system spurred seven other cities in India to follow suit. However, as implementation progressed, it seemed that the primary focus was often on accommodating the demands of the major stakeholders of the transport industry – the Delhi Metro Rail Corporation, the public works department, and the light rail and monorail industry. The government actively pursued the extensions of metro lines, often sacrificing goals of providing efficient and safe transport to the masses. Although surveys of bus commuters and bicycle users routinely showed that an overwhelming majority (~80%) were satisfied with the new corridor design, the system was not extended. In 2012, the Delhi High court dismissed a public interest petition to scrap the Delhi BRT noting 'Within the parameters of a scope of judicial review, the scattered material placed before us would not justify a conclusion that BRT as a concept is bad and is a misfit in Delhi and thus should be scrapped' (Staff Reporter,

2012). In 2016, a new Delhi government scrapped the BRT, while reiterating its commitment to public transport and non-motorized road users. Dinesh's obituary in the Times of India, the largest selling English-language newspaper in the world, called him the 'Brain behind the BRT' but made no mention of the role played by the English media in representing middle-class interests and nixing the project. As Dinesh wrote, '*The politics of sustainable transport will revolve around the power that poorer sections of the population can exert on decision-making. Wherever the lower income groups are able to get themselves heard we are more likely to have more sustainable cities as they will need facilities for walking, bicycling and public transport closer to place of work and shopping and leisure activities around their homes. This will influence what sustainable cities will look like in the future. The upper classes are unlikely to do it willingly.*' (Mohan, 2007)

Similar issues around public transport came up again when the Delhi government undertook fairly severe measures to reduce car trips and encourage use of buses as a pollution control measure. Since 2016, the Delhi government has repeatedly implemented brief periods of odd-even vehicle-use restrictions. When the restrictions are in effect, privately owned cars with even numbered licence plates are allowed on the streets on even dates, and odd numbered plates on odd dates. Dinesh evaluated the effects of this policy on transport patterns and vehicle use. His team carried out observational surveys and vehicle speed measurements that showed that during the experimental periods, car flow rates on roads were reduced by less than 20%, but rates increased for motorized two wheelers, buses and autorickshaws. There was an insignificant rise in car occupancy rates, showing that most car owners did not opt for car sharing. Importantly, no improvements in levels of particulate matter (PM 2.5) were detected, showing that the policy had failed at reducing air pollution (Mohan et al., 2017). Pointing to the experience from many other attempts at similar vehicle-use restrictions in cities worldwide, Dinesh argued that Delhi's short experiments (<1 month each time) cannot be used to study behaviour change because it takes many months for a new equilibrium in travel patterns to be established. The Latin American experience, he noted, shows that such driving restrictions may sometimes be effective in reducing congestion and pollution in the short run but can have negative consequences in the long run as people learn to cope with the regulations by buying older second cars, shifting to motorized two wheelers and changing their travel patterns. Instead, he reasoned, there is extensive research that shows that people shift to public transport when travel by personal vehicles is slower than by buses (which is possible when buses operate on reserved lanes) and metros, and when parking is not readily available at the destination. Furthermore, use of public transport involves walking trips, and '*... if women get teased on the way, if the footpaths are narrow, dirty, uneven and inaccessible for the disabled, and if there is fear of accidents, then you lose a large number of potential users.*' In other words, in addition to the quality of the experience on the bus or metro, the quality of the access trips to public transport facilities was of paramount importance.

#### 4. Influence on global road safety policy

As we have discussed, Dinesh's writings on traffic safety in LMICs reflect the best principles of injury prevention. His work was always sharply focused on the structural determinants of safety, shaped by local epidemiological evidence, and emphasized the safety of the most vulnerable road users. Therefore, it is unfortunate that in the last two decades the international institutions that have shaped the global dialogue on road safety often preferred to keep him off the stage. In fact, Dinesh's influence on the global stage evolved and shifted considerably over time, broadly reflecting the large shifts in political economy that have occurred in global development policy during the last three decades. Through the 1990s, Dinesh was closely involved in a push from the World Health Organization (WHO) and the World Bank to bring attention to the pressing need to address road safety in LMICs and to promote the use of the evidence-based and systematic approach to safety programmes developed by William Haddon. In 1991, Dinesh's research group was selected as a WHO Collaborating Center for Research and Training in Safety Technology. WHO uses the designation for institutions of high scientific and technical standing that have attained international recognition. Collaborating centres shape and implement WHO's strategic objectives at the global and national levels (WHO Regional Office for South-East Asia, 2016). A decade later, Dinesh hosted the 5<sup>th</sup> World Conference on Injury Prevention and Control in Delhi, a biannual conference organized by WHO as a gathering of leading technical experts and policymakers to exchange knowledge on interventions. Perhaps, most importantly, Dinesh was a named author of the founding document of the modern global road safety advocacy – the 2004 World Report on Road Traffic Injury Prevention, jointly released by WHO and the World Bank (Peden et al., 2004).

The publication of the 2004 World Report became a watershed moment for coordinated global action (Bowman et al., 2013) (Box 3). It was followed by a series of nine UN resolutions between 2004 and 2020 calling for increased action and proclaiming two global Decades of Action for Road Safety (2011–2020 and 2021–2030), and substantially increased funding for research and large-scale projects. Paradoxically, however, as the global movement for evidence-based road safety policies in LMICs grew, Dinesh was increasingly missing from the stage at most major

events where he would have arguably been the most qualified speaker. What happened is best described as the capture of the major global institutions involved (primarily WHO and the World Bank) by private interests, including automobile manufacturers, road builders, private philanthropies and public–private partnerships. These groups were the primary funders of the new global road safety movement, and they rapidly reshaped priorities in the field to align with their corporate outlook and their economic interests.

Most importantly, while the 2004 World Report emphasized the importance of reducing exposure to risk because of the obvious connection between roads, cars and road traffic injuries, the formulation of the road safety policy agenda in later WHO and World Bank publications largely eliminated interventions aimed at reducing motor vehicle use. To the extent that the issue still gets a passing mention in major agency reports, it is primarily in reaction to the many commentaries by Dinesh and his colleagues highlighting the distortions of the public interest introduced by private interests (Mohan & Roberts, 2001; O'Neill et al., 2002; Roberts, 2007; Roberts et al., 2002). For instance, the new global road safety discourse takes for granted that LMICs will build high-speed road infrastructure, allowing conversation only about what safety infrastructure should be put on these highways. Similarly, it is assumed that there will continue to be large increases in private motor vehicle sales in LMICs, and the only issue for debate is how to get existing safety technologies deployed in most cars.

While most other safety researchers reframed their work to fall in-step with the reframed agenda, Dinesh's work continued to question such basic assumptions and continued to develop ideas that were increasingly inconvenient to the major global actors. This work included, many of the themes we have discussed above, such as studies that questioned the role of motorization, urban design and trip modal shares (Mohan et al., 2017; Mohan & Bhalla, 2016; Mohan & O'Neil, 2020). Even his work discussed earlier on the safety of autorickshaws and the quadricycle are closely related to this issue, because they fundamentally questioned whether motorization must mean traditional cars rather than low-powered locally manufactured vehicles that he showed could be made to be much safer and better for the environment. His vision of a low-carbon, low-energy, transportation system with increased levels of walking and cycling and much less car travel is vital to avoiding catastrophic climate change. Reclaiming the streets for walking and cycling is the future of sustainable transport but is not in the interests of the car lobby who control the safety agenda.

Dinesh and his colleagues also identified other problems with letting the funders control the conversation. Corporations tend to view road safety initiatives as public relations exercises, caring more about how these activities influence their corporate image and much less about the effectiveness of the initiatives at reducing crash losses. This results in a strong bias towards discredited approaches of behaviour change, such as driver training and educating children to cross roads. In his lectures and his writings, Dinesh repeatedly and forcefully argued against such approaches, pointing to the extensive high-quality evidence

##### Box 3. On automatic protection.

The emphasis of Dr. Haddon's 'Ten Strategies' is on technological modification to reduce injuries. Trying to persuade people to act in self-protective ways is sometimes futile ... it is far more effective to provide automatic protection than to hope that people will behave in a 'safe' way. ... The principle of automatic protection is valuable in all walks of life ... People, when walking down a flight of stairs, usually pay attention to the first one or two steps to judge their configuration, then continue without watching their feet at every succeeding step. If steps vary in length or height, falls are likely to occur, especially among the elderly and disabled. Uniformly constructed stairs automatically protect everyone using them.

Dinesh Mohan (Tiwari et al., 2005)

from decades of research that such educational approaches, by themselves, do not change behaviours in meaningful ways. At worst, they can lead to an increase in injuries by creating a false sense of security in driving skills and the abilities of young kids to cross roads without supervision.

Finally, and crucially, the new rhetoric insists that we already know what works in road safety and that we now only need to find ways to implement known interventions in LMICs (Box 4). This claim runs counter to the primary thrust of Dinesh's work in injury prevention. As we have described, understanding how LMICs were different from HICs, where most injury prevention solutions have been developed, and developing solutions that made sense in the sociocultural, political and physical environment of particular LMIC settings, was central to his work. As he repeatedly would say, LMICs suffer from a 'poverty of theory'.

It is, of course, well understood that neoliberal globalization and transnational capital have weakened major international development institutions and recreated colonialist ways of how international agencies and scholars engage with LMICs (Abimbola, 2019; Büyüm et al., 2020). However, Dinesh's last project sought to challenge this situation in road safety. In 2016, Dinesh established and led the Independent Council for Road Safety International (ICoRSI, [www.icorsi.org](http://www.icorsi.org)), a non-profit organization focused on rigorously evaluating 'all mobility related policies' and strengthening the capacity of safety professionals to understand existing evidence and undertake new research. ICoRSI was founded with the vision of maintaining 'independence by not accepting funding that could in any way compromise the integrity of the organization or the individual members'. ICoRSI bylaws limits Council membership to individuals, who are committed to road safety on a personal basis, and excludes representatives of organizations and governments, to ensure that the group would not be easily influenced by outside interests. ICoRSI is headquartered in India and, in addition to leading scholars from the western hemisphere, includes prominent safety experts from Africa, East Asia, South Asia, Latin America and Middle East.

Since ICoRSI's establishment, the fledgling organization has hosted three International Symposiums (Paris, France: 2018; Changsha, China: 2019; and Stockholm, Sweden: 2020), hosted an online Webinar Series, and published a series of position papers summarizing the state of

knowledge in the field and its implication on global road safety, highlighting the need for fresh thinking. ICoRSI's first major research study – Dinesh's last research project – was the development of an evidence gap map (EGM) that catalogs all impact evaluation studies on the effectiveness of road safety interventions ever conducted (Mohan et al., 2020).

Most importantly, perhaps, ICoRSI has hosted or co-sponsored a series of inter-disciplinary training courses in LMICs on transportation planning and safety. Through these courses, and the international safety courses organized annually at IIT Delhi since 1990, many were exposed to Dinesh Mohan's teachings and were profoundly influenced. Thus, Dinesh's legacy is not only his extensive, insightful, professional, scholarly and scientific work. Dinesh was a passionate educator. Based on solid scientific theory and complemented with strong epidemiological observational and experimental data, he developed insights and ideas for protecting the right to safety of the vulnerable in society by design, as well as our precious planet. The passion with which he communicated the scientific evidence is now with the thousands of researchers, politicians and government officials, road transport and auto-industry engineers, and other who had the pleasure of hearing him. It is through these people that the fight for the safety, security and well-being of all of the vulnerable people in the world must go on. They are the ones that now go 'Onwards'!

## Notes

1. Congress (I) was the ruling party at that time. The 'I' here stands for "Indira Gandhi"
2. New York was the first state to enact a seat belt law, which went into effect starting December 1984. At the time, some groups and individuals opposed these laws stating that all the government should do was ensure that vehicles had seat belts installed and that use (or non-use) should be an individual choice.
3. In this study, the airbag equipped cars had been installed in 'approximately 10,000 on-the-road vehicles which have travelled over 250 million miles'.
4. At the time of this study seat belt use in the USA was 'approximately 30 percent'.

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### Box 4. A colleague on Dinesh Mohan's influence on the global stage.

WHO wanted good scientists like Dinesh at the table because they're an international agency focused on LMICs and it makes them look very good to have good scientists from LMICs at the table. It used to be in the 1990s that the main actors at WHO (and the collaborating centers) were from the US and Europe. So, the IIT collaborating center made WHO look much more international. .... [but after 2005] although WHO wanted Dinesh at the table, they didn't want independent thought. But, with Dinesh, whether you liked it or not, you got independent thought.

Colleague and longtime collaborator of Dinesh Mohan

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