SUSTAINABLE TRANSPORT SOLUTIONS IN THE HEALTH SECTOR

Shailendra P. Singh and Sundeep Singh Chauhan

Introduction

Greenhouse gas emissions from transportation primarily originate from burning fossil fuels to run cars, trucks, ships, trains and planes. Globally, the transportation sector generates 23% of all greenhouse gas emissions (Kahn *et al.*, 2007), making it a major contributor towards climate change. In the United States, the sector accounted for 28.2% of all GHG emissions in 2018 (USEPA, 2018). In India, the transport sector is the third-largest contributor amongst GHG emitting sectors, where the majority comes from road transport (90.1%), with rail (3.1%), civil aviation (5.6%) and domestic water-borne navigation (1.2%) making up the remainder in 2014.

Diesel transport is one of the world's major sources of black carbon, a short-lived climate pollutant (SLCP) that is the second-highest contributor to global warming after CO₂. Black carbon has a significant warming effect, but it is also a major component of particulate matter, the air pollutant most closely associated with increased air-pollution related mortality and morbidity. This chapter will provide:

1. An overview of the health risks associated with transport-related pollutants.
2. Adaptation and mitigation measures to deal with transportation-related GHG emissions in the health sector.

Health risks from transport-related pollutants

The transport sector releases gases such as NO₂, causes ozone-layer depletion and increases the amount of UVB exposure responsible for non-melanoma skin cancer, as well as playing a major role in malignant melanoma development. Carbon dioxide persists in the atmosphere for over a century, with long-term warming effects (IPCC, 2014). Black carbon particulate matter is responsible for premature deaths due to heart or lung disease,

Table 17.1 Health risks associated with transport related pollutants

<i>Health Risk</i>	<i>Associated Transport Related Pollutants</i>
Mortality	Black smoke, ozone, PM _{2.5}
Respiratory disease (non-allergic)	Black smoke, smoke, ozone, nitrogen dioxide, VOCs, CAPs, diesel exhaust
Respiratory disease (allergic)	Ozone, nitrogen dioxide, PM, VOCs, CAPs, diesel exhaust
Cardiovascular diseases	Black smoke, CAPs
Cancer	NO ₂ , diesel exhaust
Adverse reproductive outcomes	Diesel exhaust, also equivocal evidence for NO ₂ , CO, SO ₂ , TSP

non-fatal heart attacks, irregular heartbeat or arrhythmia, aggravated asthma attacks, decreased or restricted lung function, increased respiratory symptoms, such as coughing, irritation of the airways, and other breathing problems (USEPA, 2018).

Transport-related health risks are considered a major cause of the deaths of millions of people annually. For example, the World Health Organization estimates that around 1.3 million people are killed annually due to urban air pollution, much of it transport-generated (WHO, 2011). Traffic injuries are the cause of death for another 1.3 million people each year, primarily in low- and middle-income countries (WHO, 2011). Some 3.2 million deaths are annually attributed to physical inactivity in the transport sector (WHO, 2011). The health risks associated with transport-related air pollutants are summarised in Table 17.1.

Outdoor air pollution kills more than three million people across the world every year and causes health problems ranging from asthma to heart disease. This costs around USD 3.5 trillion considering just OECD countries, India and China. It is estimated that road transport contributes to approximately half the cost in the OECD region.

Low- and middle-income cities may have the most to gain in health terms from low-carbon transport. These cities are experiencing the most rapid urban population growth as well as traffic congestion, air pollution and risks of traffic injury. The same cities face growing risks of noncommunicable disease from more sedentary lifestyles. Healthier transport strategies and the judicious use of effective measures for road transport in the value chain of the health sector, such as the transportation of medical goods and equipment and the travel footprints of patient and medical staff, will go a long way in addressing these risks (WHO, 2011).

The two-pronged strategy to combat the climate change caused by transportation involves (a) mitigation measures and (b) adaptation measures. The key measures under each are described in the following sections.

Mitigation measures applicable to transportation in the health sector

- **Modified vehicles and fuel**

The strategies under this are mandatory fuel economy/CO₂ standards for road transport; shifting to lower-carbon fossil fuels, biofuels, CNG and hybrid/electric vehicles; other vehicle design modifications. The IPCC estimates that these strategies could reduce global emissions from light-duty vehicles (LDVs) in 2030 by about 800 MtCO₂ (about 21%) compared with business-as-usual scenarios. IPCC estimates that 718–766 MtCO₂ could be achieved at a cost less than US\$ 100/tCO₂ and up to 697 MtCO₂ at costs less than US\$ 0/tCO₂ (i.e. using cost-saving measures). IPCC also cites estimates of the mitigation potential of shifts to biofuels in the transport sector, reflecting a possible mitigation potential of between 600 and 1500 MtCO₂ in 2030 at a relatively low cost of less than US\$ 25/tCO₂.

Electric vehicles also can potentially offer substantial local air pollution reductions and fewer health impacts when compared with conventionally fuelled vehicles, particularly in heavily trafficked urban areas (Kahn *et al.*, 2007). The IPCC also notes that vehicles powered by CNG can provide relatively low greenhouse gas emissions for fossil-fuel-powered vehicles. As noted, CNG vehicles are already widely used in many low- and middle-income countries partly due to lower fuel costs (Sharma *et al.*, 2014 and WHO COP24 Report). But CNG for buses or taxis has also been promoted and, in some cases, required explicitly as a means of reducing urban pollution emissions (e.g. all public buses in New Delhi, India; auto-rickshaws in Dhaka, Bangladesh). Battery electric vehicles (BEVs) emit no tailpipe emissions and have potentially very low fuel-production emissions (when using low-carbon electricity generation) (Kromer and Heywood, 2007). BEVs operate at a drive-train efficiency of around 80% compared with about 20–35% for conventional ICE LDVs. The Government of India has targeted 30% electric vehicle adoption by 2030. In the Indian electric vehicle ecosystem market, the EV market is anticipated to grow at a robust CAGR of 43.13% during the forecast period from 2019 to 2030.

- **Modified price of vehicles, fuel and infrastructure**

Under this, the strategies are higher taxes on vehicle purchase, registration, use of higher taxes on motor fuels; road and parking fee; congestion/area pricing, etc. As described by the IPCC: “transport pricing refers to the collection of measures used to alter market prices by influencing the purchase or use of a vehicle. Typically, the measures applied to road transport are fuel pricing and taxation, vehicle license/registration fees, annual circulation taxes, tolls and road charges and parking charges.” The operating cost of an electric vehicle may be low, but the capital cost may be high. A tax reduction for the electric vehicle in least developed countries could be options. The Government of India’s policy think tank is considering

tapping into the green cess in place of taxing electric vehicles, and additional road taxes imposed on certain types of vehicles to incentivise the sale of electric vehicles (EVs).

Similarly, the cost of solar and renewable fuel is decreasing, but is yet to be made at par with other cheaper fuels. Therefore, economic incentives for renewable energy and low GHG emission fuels are better options in India and developing countries. As traffic congestion grows and freeway infrastructure reaches the physical, political and economic limits, the modal share of public transit has also increased. In addition to improved access in developing countries, a substantial number of people are employed in the formal and informal public transport sector. A shift to public transport modes is likely to generate additional employment opportunities in this sector (Santos *et al.*, 2010). One of the oldest examples of congestion pricing is the area licensing scheme introduced in Singapore in 1975, involving a fee to enter a restricted zone during the morning commuting period. It reduced car traffic by 75% (Seik, 1997).

- **Land-use strategy/land-use changes and mode shifts from private to public transit and non-motorised modes**

Influencing mobility needs through land-use design/regulations and infrastructure planning; prioritisation of, and investment in public transportation systems such as city buses, metro and non-motorised transport infrastructure and amenities such as cycling lanes. Barías *et al.*, (2005) found that a hypothetical “optimal land use” reallocation in the existing urban form of Santiago in Chile could achieve a 67% reduction in transport emissions in the city over a 20-year period, although costs were prohibitively high. However, more moderate measures to relocate residential and commercial facilities closer together reduced emissions by 21% and were cost-effective in carbon mitigation terms (US\$ 91/tCO₂ reduction over 20 years). Very low-cost measures to relocate schools and hospitals closer to residences could potentially achieve a 12% reduction in transport emissions in the same period for only US\$ 2 per tonne of CO₂ reduction (Barías *et al.*, 2005). The IPCC cites a study by Wright and Fulton (2005) estimating that increases in the mode share of walking in Bogotá, Colombia from 20% to 25% of travel could reduce transport emissions by 6.9% at a cost of US\$ 17/tCO₂ (Table 17.2 to 17.4).

Thus, shifting from diesel to gasoline vehicles could reduce emissions of health-damaging small particulates (PM₁₀ & PM_{2.5}), while a shift to the use of active transport, such as walking and cycling besides rapid transit/public transport, combined with improved land use can lead to much greater and instantaneous health co-benefits. The adoption and promotion of economic incentives have also proven to be effective, as seen in Table 17.5. Some of these measures were adopted in developed and developing countries, and their impacts on health were measured. The outcomes of selected climate change mitigation activities of transport sector presented at COP24 are summarised in Table 17.5 (Box 17.1).

Table 17.2 Summary of case studies of climate change related measures on health

<i>Area (study)</i>	<i>Description of case study</i>	<i>Scale and/or parameters</i>	<i>Outcomes</i>
Europe emissions impacts (Watkiss <i>et al.</i> , 2005)	Ozone and PM health impact analysis at national and continental level	Continental (EU25) and national. Whole population, approx. 450 million	Found that ozone generates large numbers of morbidity effects, with tens of millions of minor restricted activity days and respiratory medication use days each year. PM exposure annual impacts across the EU 25 total an estimated 3.7 million years of life lost each year. The morbidity effects of PM estimated 100,000 cases of respiratory or cardiac hospital admissions in 2008.
Delhi emission reduction	Emission Reduction from MRTS Projects – A Case Study of Delhi Metro Rail	CO, HC, NOX, PM emission estimate at Delhi level	Delhi Metro Rail Corporation carried out a similar study and reported emissions savings of 1453 t per day for 2011 of CO ₂ emissions using fuel-based emissions factor (Sharma <i>et al.</i> , 2014).

Table 17.3 Benefits of core measures – land use strategy

<i>Land use strategy</i>	<i>Reduction in transport emission</i>	<i>Cost (US\$/tCo₂) over 20 years</i>
Relocating educational and hospital facilities in proportion to residential locations	12%	2
Relocating non-residential land uses in proportion to residential locations	21%	91
Concentrating a high proportion of residential and non-residential land uses into subcentres on urban edges	40%	538
Hypothetical optimum land use re-allocation	67%	2014

Table 17.4 Impact of transport-related mitigation activities on climate and health

Mitigation activity	Certainty of major effect on shortlived climate pollutants	Aggregate level of potential health benefit	Main health benefits; direct benefits; indirect benefits; ancillary benefits for health	Potential level of reduction in CO ₂
Support for active (and rapid mass transport)	High	High	Improved air quality Less crop damage and extreme weather Increased physical activity Reduced noise Fewer road traffic injuries	High
Support for active (and rapid mass) transport	High	High	Improved air quality Less crop damage and extreme weather Increased physical activity Reduced noise Fewer road traffic injuries	None
Ultra-low-sulphur diesel with diesel particle filters	Medium–High	Medium	Improved air quality Less crop damage and extreme weather	None
Higher standards for vehicle emissions and efficiency	High	Medium–High	Improved air quality Less crop damage and extreme weather	High

Table 17.5 Impact of economic incentive measures on GHG savings in different countries

<i>Economic incentive measures</i>	<i>Impact on GHG savings</i>
Optimal road pricing based on congestion charging (London, UK)	20% reduction in CO ₂ emissions because of 18% reduction in traffic
Congestion pricing of the Namsan Tunnels (Seoul, South Korea)	34% reduction of peak passenger traffic volume. Traffic flow from 20 to 30 km/hr.
Fuel pricing and taxation	15–20% for vehicle operators
Area Licensing Scheme (Singapore)	1.043 GJ/day energy savings. Vehicular traffic reduced by 50% Private traffic reduced by 75%. Travel speed increased 20 to 33 km/hr
Urban gasoline tax (Canada)	4 million ton by 2010 and 2.6 million ton by 2020
Congestion charge trial in Stockholm (2005–2006)	13% reduction of CO ₂

Source: IPCC Fourth Assessment Report: Climate Change 2007. Working Group III. Mitigation of Climate Change. https://archive.ipcc.ch/publications_and_data/ar4/wg3/en/ch5s5-5-1-2.html

Box 17.1 Case Studies

Mitigation measures in hospitals around the world

The “Go Well” Travel Plan in Hawke’s Bay District Health Board, New Zealand, aimed to change the way staff travelled to the hospital once a fortnight. The annual travel survey results showed the following travel behaviour from 2015 to 2018: driving alone (–18%), arriving by car (–16%), travelling by bus (+7%), travelling by bicycle (+6%), walking/running (+3%) and in patients; driving alone (–8%), arriving by bus (+11%), walking (+2%). Parking complaints reduced from a high of 88 in 2015 to zero in 2018.

Sunnybrook Health Sciences Centre in Toronto, Canada, has a shuttle bus running to and from the site; this has been fitted with a low-emission and eco-friendly dual-fuel system.

Martha’s Vineyard Hospital in Massachusetts, USA, provides special parking amenities for low-emission vehicles, car-poolers, and cyclists to promote more environmentally-friendly forms of transportation.

Narayana Health City in Bengaluru, India, uses electric vehicles for their daily operations; Table 17.6 lists out their energy consumption and cost savings.

Table 17.6 Energy consumption and cost savings of Narayana Health City, Bengaluru, India

<i>Vehicle No.</i>	<i>Capacity KW</i>	<i>Operating Trip in Total KM</i>	<i>Year of Commissioning</i>	<i>Electricity Consumption per Month in KWH</i>	<i>Electricity Consumption per Month INR</i>	<i>Total Electricity Consumption to Date INR</i>	<i>Diesel Vehicle Consumption for the Same Operation/ Month INR</i>	<i>Total Diesel Consumption INR</i>	<i>Total Savings from Commissioning INR</i>
Buggy # 1	2.6	80	11-08-2008	312	2028	292032	6000	864000	571968
Buggy # 2	2.6	80	14-05-2009	312	2028	281892	6000	834000	552108
Buggy # 3	2.6	80	11-07-2009	312	2028	277836	6000	822000	544164
Buggy # 4	2.6	80	11-07-2009	312	2028	277836	6000	822000	544164

Adaptation measures to reduce climate change vulnerability in the transport sector

Mapping out the impact of climate change on the transport sector reveals that sea-level rise, storm surge, and flooding; strong wind and storms; increasing precipitation intensity; change in (average) precipitation; extreme heat; change in (average) temperature; freezing cold; increased freeze-thaw cycles; and permafrost degradation can damage the physical infrastructure and create inconvenience in the associated transportation services and create foundational change.

The impact can be minimised with the appropriate adaptation measures in the transport sector through innovative programme formulation and implementation at all levels: design, construction and O&M. Some successful practices could be used in road infrastructure for generating and using solar energy; provision of rainwater harvesting and groundwater recharge component in transport projects; and the adaptation of green design, construction best practices and associated training.

Key takeaways

- Transportation is a major contributor to GHG emissions.
- There are numerous health risks associated with transport-related pollutants.
- The mitigation measures discussed modified vehicles and fuel, modified pricing of vehicles, fuel and infrastructure, changes in land-use strategies, shifts to active transport and economic incentives.
- The adaptation measures outlined how to minimise the impact of climate change on the transport sector through green design and sustainable strategies.

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