

**Sustainable Transportation Systems**  
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**Lecture: 07**  
**Impacts of Transportation Systems - II**

Hi, friends. So, you may recall last time we discussed about impacts of transportation systems on different components of the environment. And before that we have discussed in detail climate change related issues. Today, we will see how transportation sector or transportation systems influence the human health or you can say the public health impacts of the transportation sector.

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So, first of all, we want to know in different ways like how transportation influences the public health or human health, its mental health, whether positive or negative, then is there any relationship between transportation planning and the mental health, after that we will see if there are accidents which are induced by traffic.

So, traffic generated accidents and their role in trauma and negative implications, then we will see the case studies of traffic induced air pollution and because, that eventually, we inhale, air pollution we inhale and our system gets negatively influenced.

After that, we will see the policy implications means, if there are some positive policies, which there are certain major technological or policy interventions, which can reduce the air pollution or other negative externalities which directly or indirectly influence the human health, so we will see those things, then health improvement strategies. So, health

improvement strategies we will see and after that one more case study briefly we will look into and then we will conclude this particular lecture.

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How Transportation impacts Human health ?

- Transportation has contributed in many ways to **improve human life and well-being.**
- Benefits includes **conveyance of goods and passengers, linking the centers of production, consumption and distribution.**

Transportation **negatively impacts human health** in three broad ways:

- **Traffic Accidents** ✓
- **Environmental pollution** ✓
- **Spread of Infectious diseases** ✓

Source: (Kenneth J. Button, 2010)

The slide features a graphic of two hands holding a heart with a person and a cross inside, and a small video inset of a man in a suit speaking.

So, see transportation, it is not that only negative sense, it has contributed initially or even now, in parallel you can say that there are a lot of positive impacts or positive aspects of transportation sector in our life in our society.

For example, we want to go from one place to another, so this is the transportation system, which helps us to reach the destination within minimum possible time, but if planning is bad, and in between there is lot of traffic congestion, then it will rather take a lot of time and it will increase the fuel consumption and then emissions. So, those will be the negative aspects.

But positive aspects that we can reach to our destination by using one or other kind of transportation vehicle, transportation sector you can say. Also, like, we transport our goods, and it also helps in connecting with different industrial areas means production centers to the consumption centers, and also the distribution center.

So, all these are networks which are connected by different mobility modes, but there are negative impacts like traffic accidents are there, if planning is not good, and speeds are not checked or rules are not followed, then there may be accidents and there are a lot of road accidents, you have seen data related to road accidents earlier.

Then environmental pollution is there, if we do not use fuel efficient engines, if our vehicles are very old, which are consuming a lot of fuel, their maintenance is not good, then lot of

pollution may be emitted by the vehicles. Also, spread of infectious diseases, the, I mean, the latest example of you can see of this Corona virus, this COVID because the whole world is integrated through transportation system, whether by air traffic or ships, etc.

So, it got all over the world a spread within few months. So, this is very negative aspect of the transportation earlier that mobility was not so fast, so efficient. So, usually, epidemics or pandemics, they were not spread in larger areas, but now it is very easy because of so much fast and efficient connectivity of the global scale.

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How Transportation impacts Human health ?

- In 1989, the International Agency for Research on Cancer concluded that diesel and gasoline engine exhausts are probably carcinogenic to humans.
- In 1998, the California Air Resources Board identified diesel PM as a toxic air contaminant (TAC).
- Children living near heavily travelled roads have about 50% higher risk of suffering from respiratory symptoms from ambient PM<sub>10</sub> concentrations.



Source: (Kenneth J. Button, 2010)

Then, we can see like how transportation impacts the human health and accordingly there were some regulations, for example, in 1989, the International Agency of Research on Cancer concluded that diesel and gasoline engine exhaust are probably carcinogenic to humans, very small particles, those exhaust particles were related to carcinogenic impacts or effects.

Then in 1998, this California Air Resources Board they identified pinpointed, you can say that diesel particulate matter as toxic air contaminant (TAC). So, they have been listed as toxic contaminants, in fact, for several years particulate matters were just like simple air pollutants, but later on when it was found that very small particles they can contribute into carcinogenic illness.

So, then they were categorized in toxic or hazardous kind of air pollutants, and because carcinogenic elements do not have threshold limits, so, then their limits were removed other earlier criteria pollutants, which have some threshold limits like, SO<sub>2</sub> should not increase with this national ambient air quality standard.

So, those kind of threshold limits are there for several pollutants, but carcinogenic elements or chemicals or pollutants, they do not have threshold limit even very small quantity can trigger the carcinogenic effect in the body. It was also found that children living nearer to the heavily travelled roads. So, more than 50 percent higher risk they were exposed to because of PM10 concentrations, which are higher, than the other regions which are not so much having so much traffic.

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**How Transportation impacts Human health ?**

- The **increased use of private motorcars** has contributed to the overall reduction of physical activities.
- Lack of physical activity is one of the major risk factors for **coronary heart disease**, the leading cause of mortality in Europe.

**Walking and Cycling** as daily activities can

- promote health
- decrease noise and air pollution

Source: (Kenneth J. Button, 2010)

The slide features three circular icons: a blue circle with a white walking figure, a green circle with a white bicycle, and a yellow circle with a white running figure. A small video inset shows a man in a suit speaking. Logos for Swajanti and other organizations are visible at the bottom.

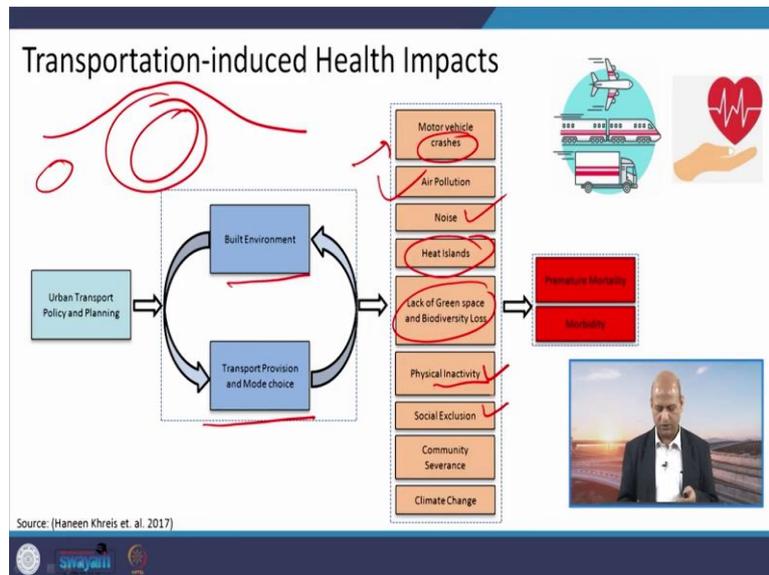
Next again, we can see like the increased use of private motorcars, they contributed overall reduction to the physical activities, means comfort level was increased like people try to have two wheelers than they migrate to four wheelers for as economy grows as our per capita income grows, we grow in this ladder of transportation comfort, but this also discourages us to walk to travel.

So, even for shorter distances people have tendency to take motorcycle or car for getting something which earlier used to walk or used to use the bicycle, those are very healthy means for keeping us physically fit. So, the physical activities were reduced because of these privately owned vehicles.

So, negative impact because if you are not physically active then there are problems and problems are like coronary heart diseases, means it has been found that those people who are doing desk job, etc. they are more susceptible to cardiovascular problems, if they do not exercise if they do not indulge in physical activities.

So, walking and cycling daily activities, which promotes health or decrease noise and air pollution, so that is why in policy planning in transportation planning, now in several cities, dedicated tracks are built for constructed for cycling for walking, etc. because of those positive health effects.

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Now, again, we see this built environment and transportation modes choices like motorcycle and related crashes or accidents, then air pollution emissions noise also. So, all these listed heat island effect, heat island effect is like in cities the temperature, average temperature of urban areas is more than the countryside.

If you go towards cities, you will find that for example, this is the countryside and this is city, if you go from countryside to cities, the temperature will increase and as you go out of city the temperature will decrease. So, this effect is known as heat island effect, because of several industrial activities burning of fossil fuel in transportation sector or industries, or absorption of solar heat by concretes, etc.

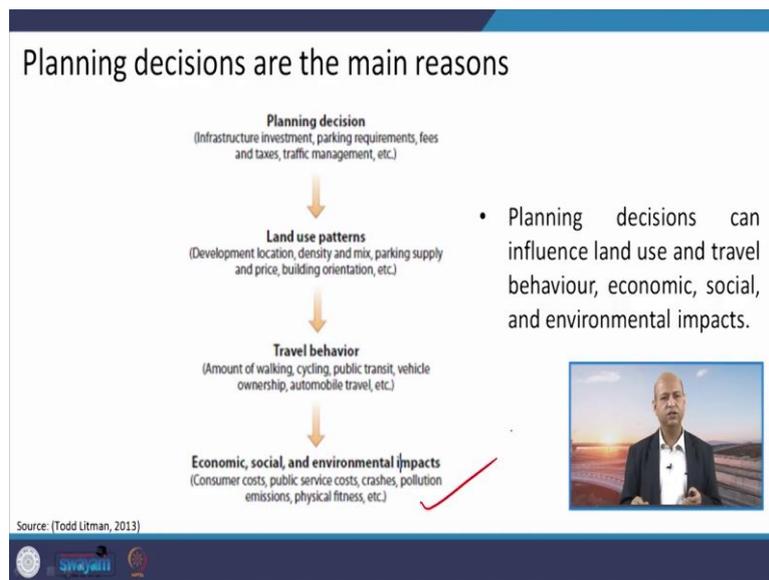
The average temperature of cities increases and the effect is known as heat island effect. Again, this has negative impact, because when temperature is more than, tendency will be there for using more air conditioning and air conditioning again emit heat. So, this is a vicious cycle more heat because of using these devices or these instruments and then using more and more these kind of cooling devices and adding to the heat.

Lack of green space, because we need to consume the land space for roads etc., so, green spaces are reduced, physical inactivity is enhanced, we do not do much activities, social

exclusion, because people used to walk, people used to do some activities together, but when you are having private vehicle, you just go from one place to another.

So, the interaction becomes less and rather than inclusion, exclusion happens, but of course, indirectly you can say, because it can help us to go to fairs or some community related activities, so these are both the pros and cons. Well, community related activities may be influenced and then climate change, which we have already discussed in detail.

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So, the planning decisions really influence because land use patterns or travel behavior or economic, social and environmental impacts all these are related to the planning aspects of urban area or regional area.

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### Planning decisions Impacts on Mental Health

- **Transport planning decisions** can affect mental health
- **Improving walking and cycling conditions and public transit** tends to improve mental health by
  - increasing physical activity
  - supporting community cohesion (i.e. positive interactions among neighbours)
- **Increased neighbourhood walkability**
  - reduces symptoms of depression in older men ✓
  - reduces frequency of dementia in women and men ✓
- **High-quality public transport facilities can reduce commute stress** compared with driving. ✓



Source: (Kenneth J. Button, 2010)

So, the planning decisions will influence our mental health also indirectly, because it will influence the transportation and transportation will affect our mental health in positive or negative manner. Positive because you can go to the gym the mobility helps you can get your motorcycle and you can go to the gym or, but as there is an anecdote that our modern life increases our weight or makes us physically inactive and then to reduce that weight we go to the gyms, etc. So, those kinds of things are there.

But of course, positive interactions are there by traveling from one place to another, if we have better planning, so it can increase neighbourhood walkability. And there are many benefits health benefits of walkability or physical activity like it can reduce the depression, it can reduce the dementia effect, dementia means forgetfulness, brain size, start to shrink in the older age and we start forgetting things, those kinds of things.

So, if you are active physically, mentally, then it helps us to remain fit. And then high-quality public transportation facilities can reduce commute stress, because when you are driving you are stressful. And there are several cases of road rage you can hear you can read in newspaper, sometimes people are so tense, they do not have tolerance power they are so intolerant that because of very trivial issues, they fight and even sometimes they indulge in physical harms to each other. So, those kinds of because of stress. So, if we are using good public transportation system, it can reduce the, these kinds of stresses.

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### Effects on Mental health

- Children who have the opportunity of playing unhindered by street traffic and without the presence of adults have been found to socially active twice than those who are restricted at homes, unaccompanied by adults because of heavy traffic.
- Lack of this opportunity of children hinders the development of children's independence and reduce their opportunities for social contact and cycling, and is associated with mental ill health, including depression.



Source: (Kenneth J. Button, 2010)



Well, but then there are negative effects of means mental health, because if we are having indoor activities and if we are not working, if we are not allowing our kids, etc. to play outside, then it is a negative impact.

And you can see that children who have the opportunity of playing unhindered by street traffic means if there are very less traffic and means people can allow their kids to go out and play because they know it is safe territory, then they have very good development, their social interaction abilities, their soft skills, interpersonal skills, they enhance, if you keep them closed in house or indoors, those kinds of traits are reduced drastically.

And in some developed countries, you may find it a little bit funny, but there are courses that they train people to interact with each other means, they are so, isolated nowadays, because of this, so called developed, development model, they are not interacting with each other. So, this growing GDP and having developed economy have several negative impacts also, we should not be discarding them or ignoring them. So, these are the things which are related to planning and transportation or mobility related issues.

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## Effects on Mental Health

Effects on mental health, includes

- Risk-taking and aggressive behaviours
- Depression
- Post-traumatic psychological effects of accidents.

• High levels of traffic can cause social isolation and limit interpersonal networks of support, the factors associated with higher mortality and morbidity in the elderly.



Source: (Kenneth J. Button, 2010)

Next, like effects of mental health, because if risk taking and aggressive behaviours, related issues also increases, because of mental health, depression, post traumatic psychological effects, because of accidents. When accidents happen, it is a traumatic experience. And people take several weeks to come out to the normal stage and these are related to traffic accident sometimes.

So, again, negative part of the transportation sector, but, if we have again and again, I emphasize that if we have better planning we can have better transportation or mobility and we can be stress free. High levels of traffic can cause social isolation and limit interpersonal networks, as we already discussed.

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## Traffic Accidents

- Globally, every year more than 1.17 million people die in road crashes and over 10 million are crippled or injured.
- Almost 70% of the accidents involves young people.
- India is accounted for about 6% of the global road traffic incidents.
- Accidents resulted in approx. 45,000 deaths in the United States in 2006.

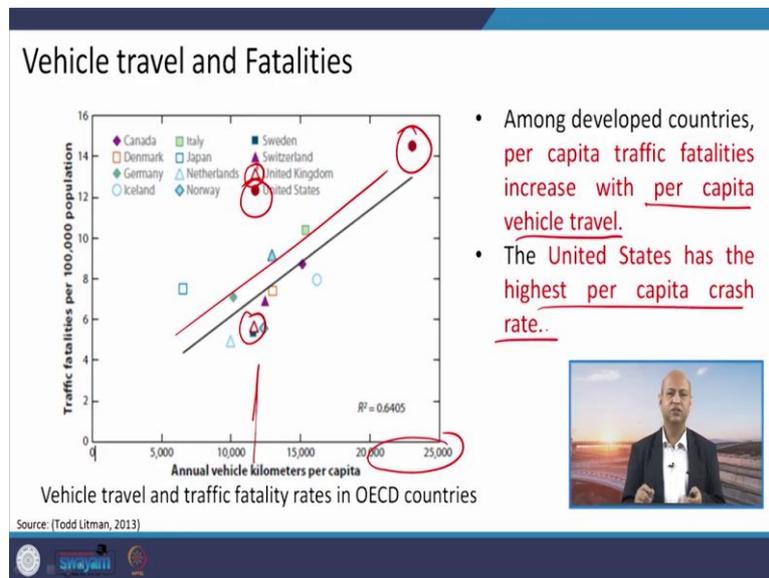


Source: (Kenneth J. Button, 2010)

If we talk about traffic accidents earlier also we talked about this, then, we find that every year, around 1.17 million people die in road accidents, look at this figure, when every day we see the data of COVID related deaths because it is pandemic and media is there to report every day, but these kind of deaths sometimes go silently, people do not pay attention to it, that is very sad part and over 10 million are crippled or injured. So, this is a kind of havoc because of traffic. Almost 70 percent of the accidents involves young people.

So, if young people are involved, you can see the lifetime tragedies in those families. India is accounted about 6 percent of the global road traffic incidents, 6 percent, it is very high number because of our population if you convert it into numbers, it is very high. And 45,000 deaths in the United States in 2006 alone occurred because of these traffic related accidents.

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Well, if we compare vehicle travel and fatalities, among developed countries only, per capita traffic fatalities, increase with per capita vehicle travel. So, very, means it is intuitive also you can say means like annual vehicle kilometer per capita as it increases, fatalities also increases and for different countries it is given like United States and this is here, this kind of per capita annual vehicle kilometer and around lower, but, sorry United Kingdom that is United Kingdom and this is United States, very high number.

So, United Kingdom is having better planning that means, and they are restricting, because of private owned vehicles, more in United States people travel more longer distances, there is road network is very high and highest per capita crash rate is there in the United States. So, that is very alarming thing.

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### Role of Traffic-generated Air Pollution

- Motor vehicle traffic is the **main source of ground level urban concentrations** of air pollutants with recognized hazardous properties.
- **CO and benzene levels inside cars can be around 2-5 times higher** than at the roadside.
- **Car users are more exposed to pollutants** than pedestrians, cyclists or public transport users.



Source: [WHO, 2000]



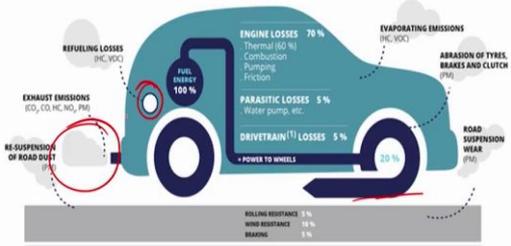
Role of traffic generated air pollution; we have seen already environmental impacts of air pollution. So, this also influences our health as we have talked about it several times.

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### Role of Traffic-generated Air Pollution

**Vehicle emissions and efficiency**

Fossil fuel powered road transport represents the most significant source of transport related air pollution. Each vehicle releases pollutants from a number of sources.



Source	Percentage
Fuel Energy	100%
Exhaust Emissions (CO, CO <sub>2</sub> , HC, NO <sub>x</sub> , PM)	10%
Engine Losses (Thermal (60%), Combustion, Pumping, Friction)	70%
Parasitic Losses (Water pump, etc.)	5%
Drivetrain Losses	5%
Power to Wheels	20%
Revolving Losses (HC, VOC)	1%
Evaporating Emissions (HC, VOC)	7%
Abrasion of Tyre, Brakes and Clutch (PM)	1%
Road Suspension Wear (PM)	1%
Billing Resistance	1%
Wind Resistance	1%
Braking	1%

10 The drivetrain of a motor vehicle is the group of components that deliver power to the driving wheels. This includes the transmission, the axles and the wheels.  
HC - Hydrocarbons; VOC - Volatile Organic Compound; PM - Particulate Matter; CO - Carbon monoxide; CO<sub>2</sub> - Carbon dioxide; NO<sub>x</sub> - Nitrogen oxides.

Source: EEA Report — Explaining road transport emissions — a non-technical guide (2016)



And, if you want to see the role of traffic generated air pollution in terms of one particular vehicle like car, so there are several points, we generally care only about these tailpipe emissions, but there are several other sources of emissions from a car these indoor hydrocarbons because of indoor those different materials.

And then there may be some leakages because of tyre abrasion, pavement related these secondary pollutants and then when we are having gasoline, then again some fugitive

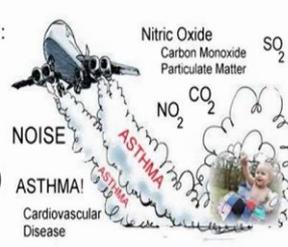
emissions may be there during refuelling the fuel and exhaust emissions are added by non-exhaust emissions. So, these are called as known exhaust emissions.

When we apply brake again because of friction, there are some emissions particles heavy metals because of tyres etc. So, there are various sources of emissions, we should take care of those emissions also, because they are also part of ambient air quality, which we are inhaling.

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### Traffic-generated Air pollution

- The **main air pollutants from Transport sector** includes:
  - Particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>) ✓
  - Carbon Monoxide (CO)
  - Nitrogen oxides (NO<sub>x</sub>);
  - Non-methane Volatile Organic Carbons (NMVOCs)
  - Ozone (O<sub>3</sub>) ✓
  - Benzene ✓
- **Trace emissions** includes
  - Methane (CH<sub>4</sub>),
  - Carbon dioxide (CO<sub>2</sub>),
  - Oxides of sulphur (SO<sub>x</sub>)
  - Total suspended particles (TSPs)



Source: (WHO, 2006; Ajay Singh Nagpure and Gurjar, B. R, 2012; Bhola Ram Gurjar, 2021)

You can see PM10 PM2.5, CO all these NOx etc. criteria air pollutants and then secondary air pollutants like ozone, benzene, which is carcinogenic, then there are trace emissions like methane, carbon dioxide, et cetera. They are greenhouse gases, but sulphur oxides, this is not greenhouse gas, but it can contribute to the acid rain.

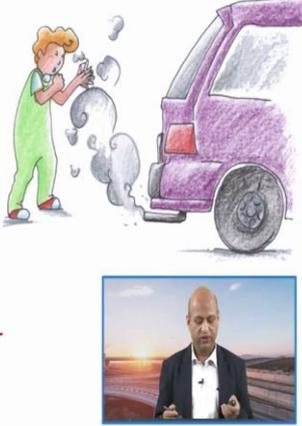
So, NOx and SOx emissions are there all these have direct or indirect impact on the environment and human health.

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### Traffic-generated Air pollution

#### Particulate matter (PM<sub>10</sub>)

- Short-term effects of PM<sub>10</sub> (µm)
  - leads to increased mortality
  - respiratory and cardiovascular diseases
  - increased frequency of respiratory symptoms and use of medication by people with asthma
  - reduced lung function
- Recurrent cumulative exposure increases morbidity and reduces life expectancy.



Source: [WHO, 2000]



Well, particulate matter related studies have been now quite a lot and we have found there is a lot of scientific literature that it can lead to mortality, because it can influence our respiratory system, our not only lungs, but cardiovascular diseases can also be induced by these particles. PM10 that is particles which are of the size 10 micrometer or less PM2.5 means particles which are of the size of 2.5 micrometer or less.

So, PM10 includes PM2.5 also, that should be clear. It can increase frequency of respiratory some symptoms, some people are allergic to pollens, etc. Those are also air pollutants, you can say it reduces lung function. So, because of that, we have asthmatics problems also and then we do not do our job, so efficiently.

And then cumulative exposure increases the morbidity and reduces life expectancy also. So, morbidity, both morbidity and mortality means, morbidity means you do not function properly you do not attend your work you take leave and there are in health and you are not feeling well and the mortality because of ill health longer ill health or you may die also.

So, it can reduce your work life expectancy, if you are living in clean environment, clean air, you may live let us say 80 years old, but if that is poor air quality, you do not know in 10 years are gone silently because of air pollution. So, those kinds of impacts are there.

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### The Case of Los Angeles city (LA), California

**Exposure to PM<sub>2.5</sub> pollution**



- Millions of California residents live near highways and are exposed to high levels of vehicular air pollution
- People in Los Angeles county are exposed to 60% more vehicular pollution than the state average



Source: (UCUSA, 2019)

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Then, effects of PM<sub>2.5</sub> pollution also on visibility, and this is one case study of Los Angeles that is also known, like summer smog, in summer a lot of smog was created and people initially did not know what is happening, but later on one professor, took samples of air and analyzed in the lab and found there are several pollutants which are emitted by traffic and those are present in the air, which are resulting in this summer smog. So, vehicular air pollution was the real culprit.

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### The Case of Los Angeles city (LA), California



**Thick Smog in Los Angeles**

The thick smog was noticeable over LA from the 1940s and lasted over 3 decades



Source: (<https://laist.com/news/happy-smogiversary-la>)

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You can see this thick smog in the Los Angeles in 40s. And it lasted around three decades. You can imagine the health effects of these kinds of smogs on the people living there.

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The Case of Los Angeles city (LA), California



A Smoggy day in Los Angeles, 1964.

LA known as the City of Stars was also called the "City of Smog"



Source: (<https://laist.com/news/happy-smogiversary-la>)

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And in 64 one smoggy day is shown in this particular picture and it is also like called as city of the smog later on, sometimes cities are known because of environmental impacts like this, in one book, I read that although Bangalore is such a beautiful city and very good climate, but there are many pollens and many people have respiratory problems there because of these allergic pollens, etc. and some people call it as city of asthma.

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The Case of Los Angeles city (LA), California



A Smoggy day in Los Angeles, 1966.

People used Gas masks to protect from irritating air



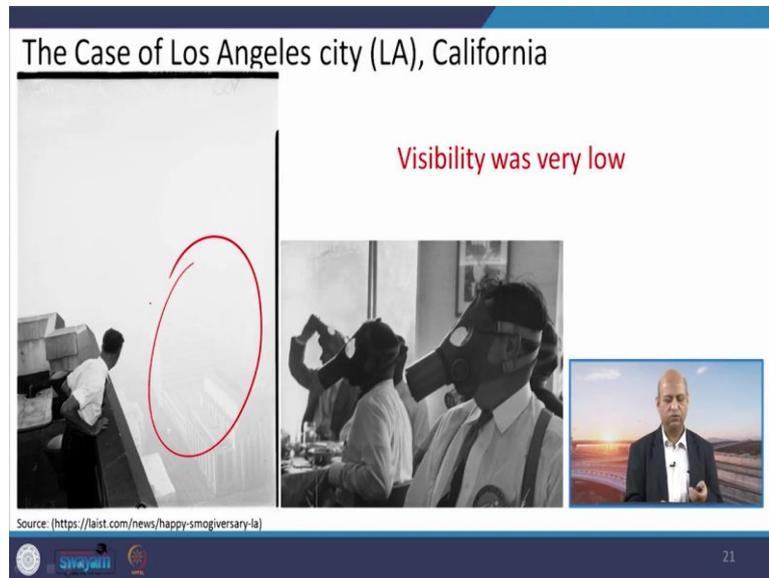
Source: (<https://laist.com/news/happy-smogiversary-la>)

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So, those kinds of things happen sometimes anyway, but these are only temporary phenomena then our urban in a population they take care and they clean the environment and they address those issues and then city becomes good in quality of living. So, these pictures show what kind of estate was there in Los Angeles when it was it smoggy. But later on these

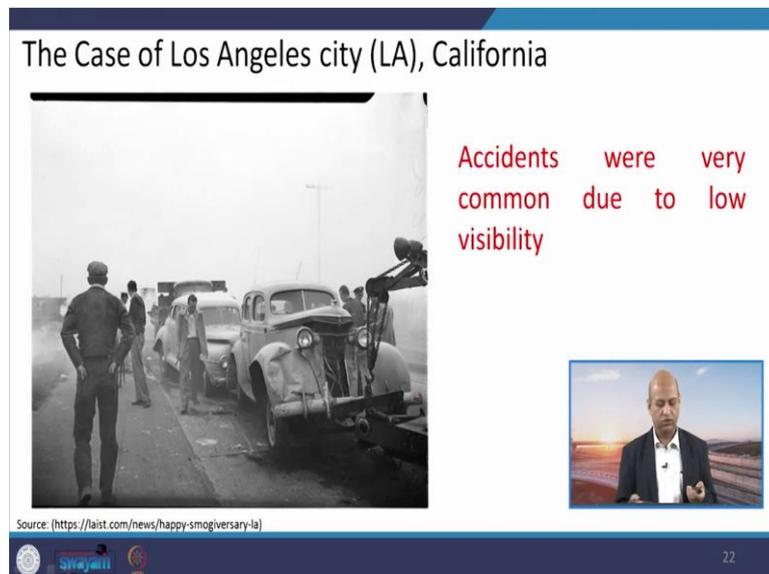
traffic related emissions were reduced drastically and it was properly cleaned. So, you will see the pictures how it was earlier how it is now.

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And, see the visibility this is like fog in winter in North India. So, that was in the summer itself visibility was very very low. And people used to feel suffocated they used to be or some sort of mask and to have extra air or clean air or oxygen mask related they used to use.

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Accidents were there because of poor visibility, car accidents happened. So, again the negative part of the traffic or transport.

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### The Case of Los Angeles city (LA), California



The Clean Air Act was passed in 1970

Harsher pollution control measures were implemented in LA and California



Source: (<https://laist.com/news/happy-smogiversary-la>)

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Pure air you can see the people used to have these kind of things in 70s and then earlier this Clean Air Act was passed in 1970 because of this very grave problem. And harsher pollution control measures were implemented in Los Angeles and entire California.

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### The Case of Los Angeles city (LA), California



Smog in Los Angeles, 1972



Source: (<https://laist.com/news/happy-smogiversary-la>)

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## A Smoggy day in Los Angeles



Los Angeles used to be the **most polluted air basin** in the United States.



Source: (California Air Resources Board)



## A Clear day in Los Angeles



Source: (California Air Resources Board)



And that, then it started to work even in 72 you could see this kind of smog. But later on, you can see also the clean. So, see in 1972 or so, these kind of pictures, and this is one smoggy day in the Los Angeles and but in, when it was clear day, no smog and proper measures are implemented. So that kind of clear picture was also achieved.

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### Determinants of Traffic-generated Air pollutants

- The levels and composition of pollutants in the air depends on
  - **Number** of vehicles ✓
  - **Age** of vehicles ✓
  - **Engine** type and condition ✓
  - Type of **fuels** used ✓
  - **Meteorology** ✓
  - Shape of the **urban environment** ✓
  - **Traffic organization** ✓



Source: USDOT Transportation and Climate Change Clearinghouse Modal Wheel. Developed by ICF International



Source: [WHO, 2000]

Well, this determinants means which are the factors which induce the air pollutants. So, there are variables like age of the vehicle if it is more old and it can emit lot of emissions, number of vehicles even if efficient vehicles you have but if total number is more in a city again the total emission may be higher. Then engine type and condition. So, if a good engine and they follow good norms like Bharat stage 1, Bharat stage 2, Bharat stage 3.

Now, we are talking about BS VI, those euro one, euro two, euro three that kind of norms you might have already heard. Type of fuels used as I gave earlier also this example that in Delhi when it was found that diesel buses were polluting a lot. So, they were converted into CNG. So, the type of fuel also vary the pollution load.

Meteorology, even if there are two cities in different geographical locations even if they have exactly same emission, their air quality vary because meteorology may be different somewhere it could be good air flow and it can flush out the pollution very early, but in a city where this wind is not moving fast, it is calm winds kind of the air condition, then lot of pollution load may increase. Then, traffic organization related issues also influence the emissions total emissions and air quality.

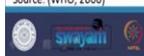
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### Determinants of Traffic-generated Air pollutants

- **Heavy vehicles** are major polluters.
  - Ex. When compared to a car with a catalytic converter, a diesel truck produces 50-100 times more fine and ultra-fine particles per km travelled.
- **Modern diesel engines emits less PM<sub>2.5</sub> but a larger number of ultra-fine particles than older engines.**
- It is **now suspected that the ultra-fine particles** (or the number of particles, rather than particle mass) **are the main cause of health effects in humans.**
- If this is true, then the new diesels cause more harm than the old ones.



Source: [WHO, 2000]



So, these are the traffic related determinants or variables and heavy vehicles, heavy vehicles are major polluters, because, these diesel truck in compared to the car 50 to 100 times more fine and ultra-fine particles per kilometer are emitted by heavy trucks, because they consume lot of fuel, they are taking load.

So, in comparison to car if heavy trucks are moving more in diversity there are chances that you will have lot of ultra-fine or fine particles. Then modern diesel engines emits less PM 2.5 but a larger number of ultra-fine particles than older engines. That is very tricky. We only talk about mass concentration micrograms per cubic meter.

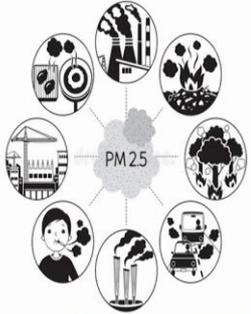
So, maybe very fine particles are less in mass concentration, but their numbers maybe more and because when we are inhaling more number of fine particles more chances they can go up to the lung. So, again, this is another unit which we should take care about that number of particles are also very important you need to look into. So, they can cause health effects of negative nature.

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### Health Effects of Air Pollution

Health end-points for PM and other exposure can cause

- Mortality (aged  $\geq 30$  years, excluding accidental causes) – long term
- Cardiovascular diseases
- Respiratory diseases
- Acute bronchitis (aged  $< 15$  years)
- Asthma exacerbation (aged  $< 15$  years)
- Asthma exacerbation (aged  $\geq 15$  years)
- Restricted physical activity (aged 15–64 years)
- Lung cancer

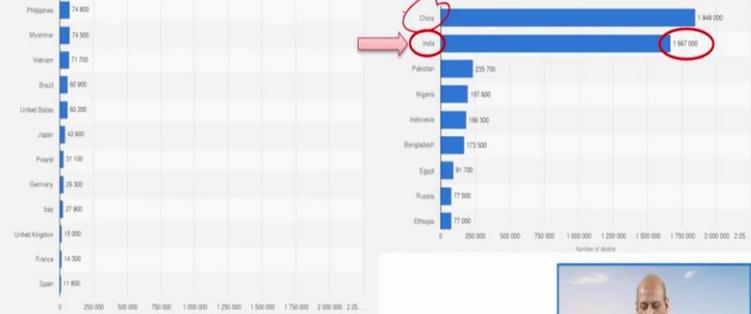


Source: [WHO, 2006]

Well then, like health end-points for particulate matter and exposure can cause mortality, we have already discussed and these excluding accidents or long-term effects more than 30 years. Cardiovascular diseases respiratory diseases, acute bronchitis even in kids or young population, asthma less than even 15 years, then lung cancer all those things maybe because of these pollutions.

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### Fatalities due to Air Pollution



Country	Number of Deaths
China	1,468,000
India	1,687,000
Pakistan	225,700
Nigeria	187,600
Indonesia	168,300
Bangladesh	173,500
Egypt	81,700
Russia	77,500
Ethiopia	77,000

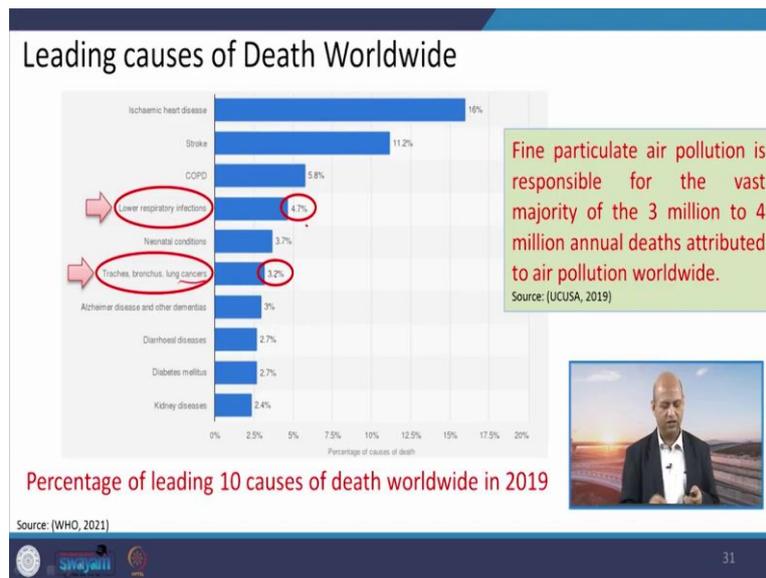
Number of Deaths by Country due to Air Pollution Worldwide, 2019



Source: [IHME, Health Effects Institute, 2020]

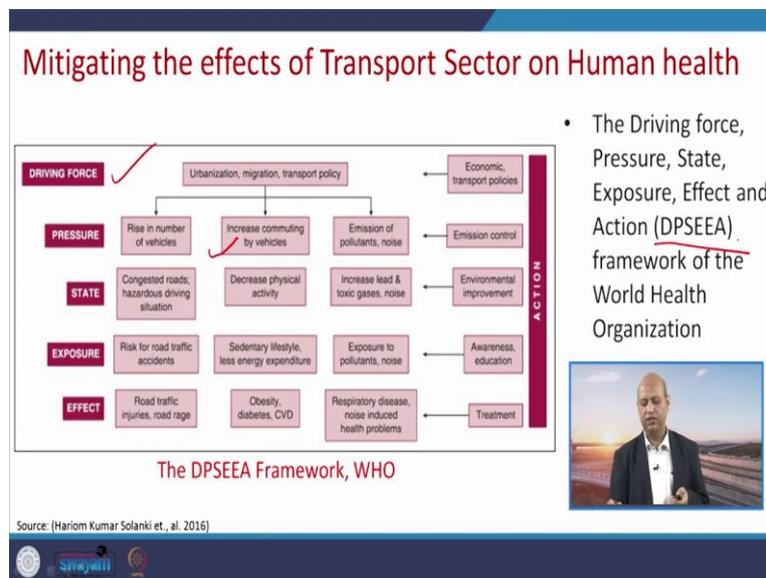
Well fatality, we have already seen this this bigger India related fatality such a higher number of 16 lakh or more that is country wise and the China is more but population of China, India the largest ones, and accordingly deaths are also more.

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Leading cause of death worldwide because, lower respiratory infection 4.7 percent or these lung related cancer 3.2 percent. So, these are directly related with the, these air pollution. Fine particulate related negative impacts.

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If you want to mitigate the effect of transportation to the human health, then we can see that there are these flowchart like driving forces are urbanization migration, so, they need mobility and because of that transportation sector increases, pressure because of rise in number increase in commuting vehicles, then state also exposure effect all those things, these are known as DPSEEA framework and WHO recommended this to look into this problem in a proper manner, systematic manner.

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## Health Improvement Strategies

### Policy Implications

- **Technological improvements**, such as the introduction of **unleaded petrol and catalytic converters**, have already had a positive impact
- **A holistic approach should be adopted.**
- Tackling individual pollutants in isolation could even be **counterproductive** if it leads to increases in another pollutant component.
  - Ex. Attempting to lower CO<sub>2</sub> emissions through the promotion of new diesel vehicles, would lead to an increased number of ultra-fine particles, which seem themselves to be a cause of concern



Source: (WHO, 2000)

swajati

If we have better policy implications, and holistic approach means from infrastructure to transportation, vehicle technology, travel behaviour, all these things if we can address then perhaps, we can do better in terms of improving air quality.

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## Health Improvement Strategies

### Co-Benefits Policy Implications

- **The effect on the pollution mix as a whole must always be considered in designing interventions.**
  - Ex. In selecting actions to reduce emissions of greenhouse gases, those that also reduce other air pollutants, such as particulate matter, should have priority.



Source: (WHO, 2000)

swajati

Then there are some co-benefits issues also like if you are reducing greenhouse gases, we may end up reducing air pollutants also, or which is like, if you are reducing air pollutants, we can reduce greenhouse gases also. So, those kinds of benefits may be there depending upon what kind of policy you are having.

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## Health Improvement Strategies

### Traffic Calming and Speed Control

- Improves safety by
  - Reducing crash frequency and severity
  - Reduce total vehicle travelled
- Impacts on pollution emissions vary on conditions
  - Ex. Per-km emission rates tend to decline with reductions from high to moderate traffic speeds, but rates increase at very low speeds (under 20 km per hour) and with more stop and-go driving (for example, due to speed bumps).
- Speed reductions tend to improve walking and cycling conditions, which can reduce per capita emissions, increase physical activity, and improve basic access.



Source: (Todd Litman, 2013)

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Then, if we have traffic calming and speed control related policies, so, this will improve the safety and it will also reduce the pollution levels, in those areas.

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## Health Improvement Strategies

### Active Transport Improvements (Walking and Cycling)

- Walking and cycling infrastructure improvements, such as better sidewalks, crosswalks, and paths, can reduce crash risks.

Increasing active transport can

- Reduce total crash rates ✓
- Large reductions in air pollution emissions ✓
- Reduce congestion ✓

Promote active travel



Incorporate physical activity into everyday life, such as walking, cycling or combining with public transport instead of travelling by car

- A 1% shift from motorized to Non-motorized Transport (NMT) modes can typically reduce emissions by 2–4%.
- Also increases physical activity



Source: (Todd Litman, 2013)

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And, it will increase the walkability also, because if traffic is less then we will feel more safe and we can walk in those particular areas and the total crash rates also reduce and the reduction of congestion also happens. So, those kind of improving infrastructure for walking and cycling, they are very good to reduce the traffic related accidents as well as traffic related and environmental impacts and human health impacts.

You can see like 1 percent shift from motorized non to non-motorized transport means, motorized means from let us say two-wheeler to cycle or to walking it can reduce emissions by 2 to 4 percent. So, quite higher effect, maybe there, multiplier impact may be there.

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**Health Improvement Strategies**

**Public Transit Service Improvements**

- Public transport service improvements can reduce Total crash rates and pollution emissions.
- Public transport service can be improved by
  - Providing more routes
  - Longer operating hours
  - Frequent transit services ✓
  - Quality vehicles and terminal stations
  - Grade separations
  - Real-time user information systems

Public transit travel has lower traffic fatality rate than other automobile travel

Source: [Todd Litman, 2013]

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If we invest a lot of in public transportation system, then it is also good, because, if we use less private transportation then and using public transportation system, then we are reducing emissions per passenger kilometer, very, very simple, which we have seen earlier also. So, providing more routes and longer operating hours and those kind of issues are there and then real time information system can also help us to have like this information system or intelligent transportation system, ITS, they can also help us to have better transportation planning.

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### Health Improvement Strategies

#### Transport Pricing Reforms

- A one-cent state gasoline tax increase in the U.S reduces per capita traffic fatalities 0.25% and traffic fatalities per vehicle-mile by 0.26% (Grabowski & Morrisey, 2006).
- A sustained 20% gasoline price increase in the U.S would prevent ≈2,000 traffic crash deaths (≈5% of the total), plus ≈600 air pollution deaths (Leigh & Geraghty, 2008).
- A 1% vehicle travel reduction reduces crashes by more than 1% (Chi et al., 2010).

Pricing reforms increases use of active modes and therefore physical fitness.



Source: [Todd Litman, 2013]

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Pricing reforms also help us because, like, you might have heard that in London, this tax was imposed those who wanted to have their own vehicle to city center. So, then people feel discouraged and they parked it outside and they came with public transportation system and air quality improved in the city center.

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### Health Improvement Strategies

#### Mobility Management Marketing

- Mobility management marketing refers to various programs and information resources that encourage people to shift travel from automobiles to alternative modes.
- Methods include:
  - Commute trip reduction programs (employers encourage their employees to use alternative modes)
  - Transportation management associations (through which businesses support alternative modes)
  - Ride matching and Vanpool support programs
  - Direct marketing programs



Source: [Todd Litman, 2013]

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So, those kind of pricing, etc. They can also plus pricing of not only taxes, but these tickets also like if you have some policy of multimodal transport, so one ticket can be there for even railways, for bus, etc. So, people feel incentive to use those kinds of tickets. So, and this is, these are economical also. When we talk about mobility management, marketing, so all these things come like pricing and the trip reducing or these ticketing, etc.

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## Health Improvement Strategies

### Smart Growth Land Use Development Policies

- Smart growth policies **encourage**
  - More **compact and mixed development**
  - More **connected path and road networks**
  - **Better integration** between transport and land use planning
  - **Improved walkability**
  - More **efficient parking management**
  - **Other features that improve accessibility and transport diversity**



The diagram shows a central green circle labeled 'Smart Growth' surrounded by six smaller circles: 'Enhance Quality of Life' (top), 'Promote Economic Development' (top-right), 'Create Livable Communities' (right), 'Promote Alternative Transportation' (bottom), 'Create a Range of Housing Opportunities' (bottom-left), and 'Preserve Open Space, Natural Resources & Environment' (left).



Source: [Todd Litman, 2013]

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All those things are part of the smart growth and land use planning, so more compact and more population can walk or can have their own, I mean facilities in nearby areas, then they do not need to use transportation and then naturally, there is no negative impact of the transportation.

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## Health Improvement Strategies

### Smart Growth Land Use Development Policies

- People who live and work in **Smart growth communities** tend to **own fewer motor vehicles, drive less, and rely more on walking, cycling, and public transport.**
- Smart growth residents **typically drive 20–40% less** than automobile-dependant communities.
- Smart growth residents have **substantially lower per capita traffic casualty rates** than automobile-dependant communities.



The diagram shows a central blue circle labeled 'SMART GROWTH' surrounded by six smaller circles: 'RESILIENT' (top), 'WALKABLE/BIKABLE' (top-right), 'QUALITY OF LIFE' (right), 'CONNECTED COMMUNITY' (bottom), 'BUSINESS FRIENDLY' (bottom-left), and 'SUSTAINABLE' (left).



Source: [Todd Litman, 2013]

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## Health Improvement Strategies

### Smart Growth Land Use Development Policies

- Smart growth communities **reduce pollution emissions**, although more compact development may increase some pollution exposure
  - Ex. If more people walk, bike, live, and work close to busy roadways create a canyon effect on urban roads.
- These risks can be mitigated through targeted strategies** such as using cleaner transit vehicles on major urban roads and locating sidewalks and paths away from traffic.




Source: (Todd Litman, 2013)

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## Health Improvement Strategies

### Smart Growth Land Use Development Policies

- Smart growth community **increases active transport significantly** because more destinations are within walking and cycling distances

Smart Growth communities include improvements to walking, cycling, and public transport such as better sidewalks and crosswalks, traffic calming, bike and bus lanes, and bike racks.




Source: (Todd Litman, 2013)

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So, smart growth land use and land planning are nowadays part of the urban planning regional planning and people are using those kind of smart growth land use development policies, which are reducing, congestion and reducing pollution levels.

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**Case Study: Potential Health Risks due to in-car aerosol exposure across 10 Global cities**

### PM<sub>2.5</sub> Data Collection

- PM<sub>2.5</sub> data were collected every 1 minute, using a portable laser particle counter, from the backseat of a passenger car.
- 3 car settings were used:
  - Windows-open ✓
  - Windows-closed with fan on ✓
  - Windows-closed with recirculation ✓
- Morning peak, Evening peak and Off-peak data was collected.

Source: [Prashant Kumar et. al, 2021]



Portable particle counter



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Well, one case study here we can see very recent vacation from University of Surrey, they tried to measure the health risk due to in-car aerosol exposure across 10 Global Cities, and they saw in different cases like windows open, windows closed, with fan windows closed, with the recirculation of the air.

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**Case Study: Potential Health Risks due to in-car aerosol exposure across 10 Global cities**

### Hotspot Identification

- Hotspots in 10 cities were identified by counting data points exceeding 90<sup>th</sup> percentiles (P90) of the one-minute average PM<sub>2.5</sub> concentrations during window-open setting.
- PM<sub>2.5</sub> concentrations were used to compare the inhaled doses at hotspots to those concentrations at the free-flow segments of roads.
- PM<sub>2.5</sub> concentrations were also compared to socio-economic parameters such as GDP, value of statistical life and road density, to derive the health burden and economic losses.

Source: [Prashant Kumar et. al, 2021]



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And accordingly, they found that, indoor, air pollution is also there within those cars. And it is not that you are very safe in the car, because of hotspots or this interaction of outside air as well as indoor emissions, you can get exposed to some very fine particles, but there is relationship of GDP also.

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### Case Study: Inference

- A relatively short time spent at hotspots contributed to a significant concentration of total inhaled air pollution doses, during a car travel.
  - Ex. Hotspots at cities Guangzhou (CAN) and Addis Ababa (ADD) accounted for only about 26-28% of the total time spent on each route, but corresponded to around 54-56% of the total inhaled doses during a trip.
- An increase in percentage length of hotspots were observed with the increase in road density.
- The percentage length of hotspots shows negative correlation with increasing GDP and Value of Statistical life (VSL), except for the city Guangzhou (CAN).



Source: [Prashant Kumar et. al, 2021]

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Like more GDP, then more clear areas less hotspots, those kinds of relationships they have found. It is very interesting study, you can see in your reference, and you can go through at leisure.

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### Conclusion

- The Negative impacts of Transportation on human health can vary from Respiratory and Cardiovascular diseases to Lung Cancer to Death.
- Health Improvement Strategies should be given primary concern from the planning stage of Transportation systems.
  - Focus on strategies such as
    - Strict and effective Policy implications
    - Promoting Active transport
    - Improvements in existing public transit facilities
    - Pricing reforms ✓
    - Mobility management awareness measures.
    - Smart growth land use development measures.



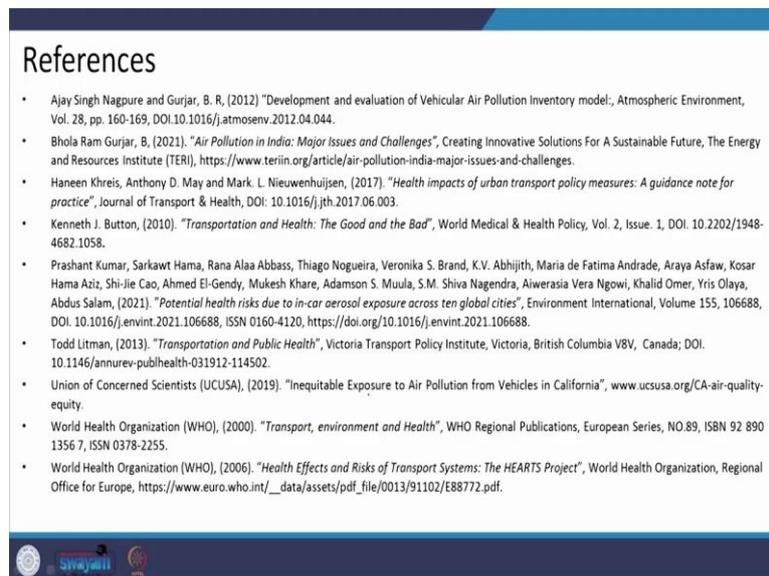
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So, in conclusion, we can say that negative impacts of transportation on human health are there. Though, transportation sector has lot of positive impacts, as I said, because it helps us to reach in time to our destination, including schools, colleges, workplace hospitals whenever we need, but it also has negative impacts in terms of negative externalities like traffic accidents or air pollution etc.

So, we need good transportation planning and the pricing reformation and the mobility management awareness all those things will help us to have better mobility within the city and within the region. And maybe we can improve upon, those kinds of regional planning and urban planning where a lot of things can be done by simple walking and bicycling.

And like in Copenhagen, we saw in last lecture that they promote lot of walking and cycling. So, those kind of, policy measures may be adopted in different cities and better planning, maybe they are so that we can have very less negative impact on the human health.

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These are the references which you can go through to get more information about those case studies, etc. which we have discussed during the presentation. So, thank you for your kind attention and see you in the next lecture. Thanks again.