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Travel Demand Modelling Practice and the Role of Health/Wellbeing

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Workshop sponsored by the
Scheme for Promotion of Academic and Research Collaboration (SPARC)
A Government of India Initiative

15 March 2021

Overview

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- Introduction to me and my team @USL
- Transport planning & Travel demand modelling practice
  - The trip-based 4-stage model
  - Activity-based models of travel demand
- Transport planning in emerging economies
- Evolving socio-technical systems
- Health impact assessment of transport policies

Urban Systems Lab - Themes

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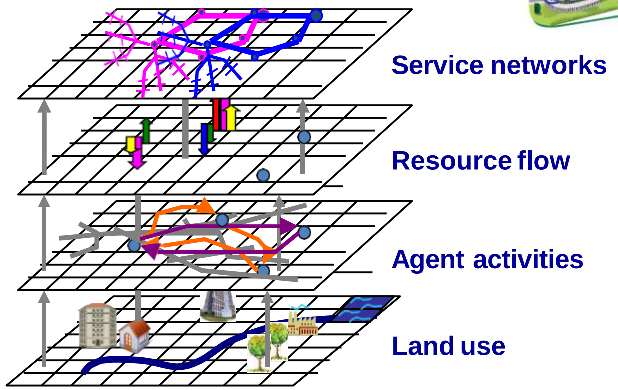
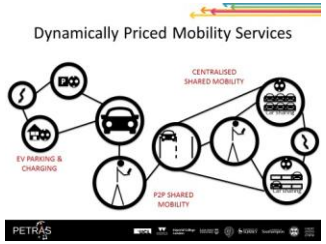
Research at the USL falls under several linked thematic areas

- Sensing, simulation and modelling
- Systemic analysis/ multi-criteria performance/ quality of service
- Economic performance
    - Compartmentalisation in an as-a-service economy
    - Scalability of impact
- Resilience and adaptability
- Low carbon operation and resource efficiency
- Business models and innovation
- Health, wellbeing and quality of life



Institute for Infocomm Research
A*STAR
HOUSING & DEVELOPMENT BOARD
NSF



Urban Systems Lab - Expertise

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- Descriptive and predictive models of human decision making and human activity patterns (e.g., consumption behaviour, time use, energy use, travel behaviour etc.) including virtualised behaviour
- Descriptive and predictive models of networked infrastructure systems and their operations
- Integrated urban systems modelling, linking demand and operation of different infrastructure systems
- Optimisation and decision support tools for infrastructure control, operation and management
- Pervasive sensing technologies applied to infrastructure, vehicles and people
- Sensor data fusion and data assimilation

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Transport Planning & Travel Demand Modelling Practice

What is the objective of transport planning?

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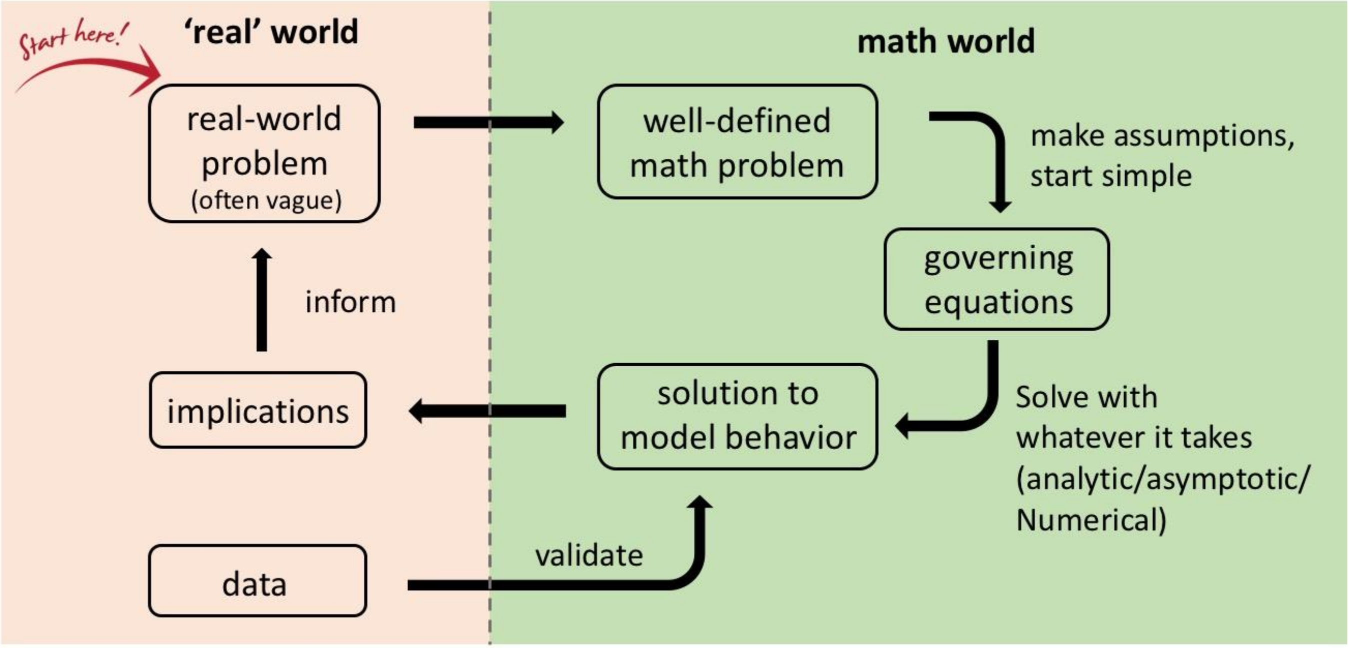
- How to preserve and enhance existing levels of mobility and access most **efficiently, economically, sustainably and equitably**?
- How to deal with the problems caused by high levels of mobility e.g. **Congestion, Energy use, Local pollution, Accidents**
- How to develop and compare different potential solutions?
- How to best regulate emerging products and services?

Typical mathematical modeling process



http://www.vcyang.com/model_flowchart/

Interventions and Policies

- In a sense one can think of the transport system, its subsystems and their interactions as a never-ending game
- There are many different types of agents (players) in the game (e.g., travellers, transport service providers, transport network managers, developers, businesses, governments etc.) each trying achieve their own objectives.
- Each agent has some capacity to exercise influence, by means of various actions that affect the system:

Transport system options include:	Activity system options include:
- network topology - network capacity - network pricing - vehicle and track technology - management policies - organizational policies	- user travel behaviour (e.g., mode, route, time of day etc.) - developer behaviour (e.g., type, location and availability of activity participation opportunities

Impacts of interventions in the transport system

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- The interventions made by different agents give rise to impacts that are felt by the agents themselves and/or by other agents
- Sometimes these impacts are desirable, sometimes not (and different agents sometimes disagree about what is desirable)
- While interventions are intended to have particular impacts, often they have unintended impacts as well
- Interventions by one agent can induce responses and interventions by another. Impacts will therefore cascade through the system.

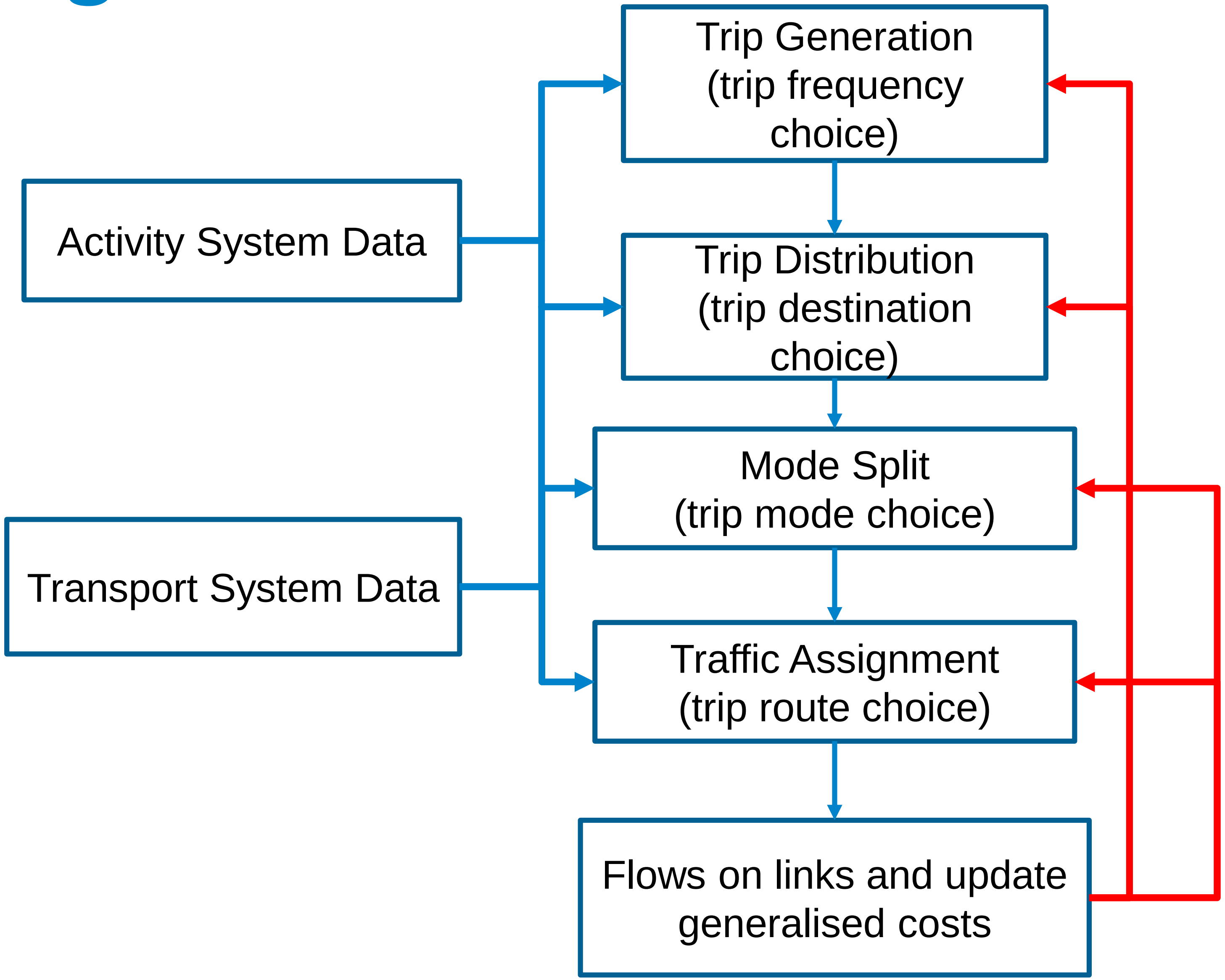
User impacts
- experienced travel time
- fares/petrol/parking fees
- accidents

Operator impacts
- revenues
- staff wages
- maintenance costs

Environmental impacts
- air quality
- energy use
- noise

Government impacts
- tax revenue
- compensation payments
- costs of medical care

The 4-stage model



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Activity-based models of travel demand

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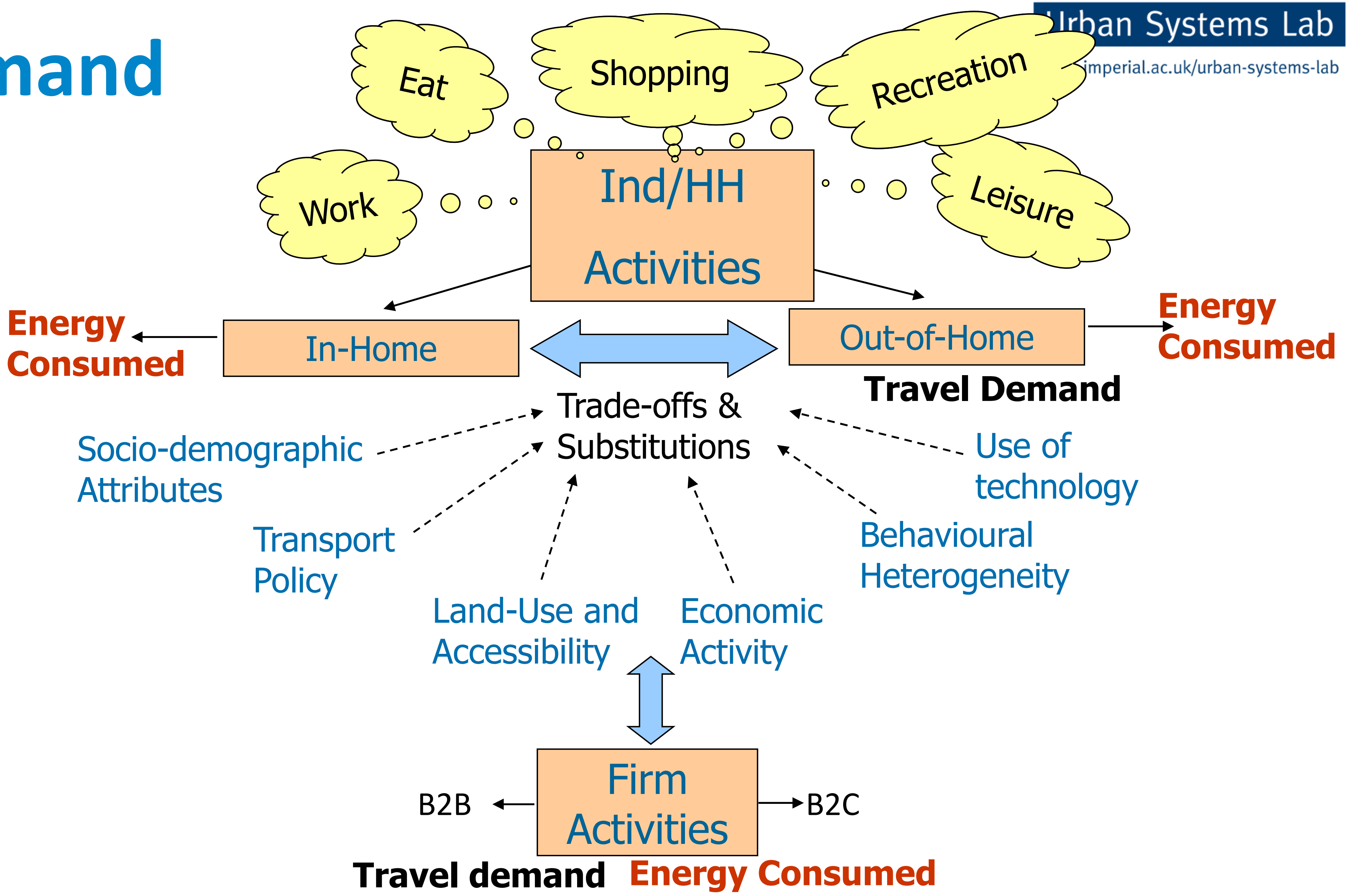
- Generate and schedule physical and virtual activities; different modalities of activity participation
- Link between consumption activities and production activities → urban freight implications



Policy examples (1)

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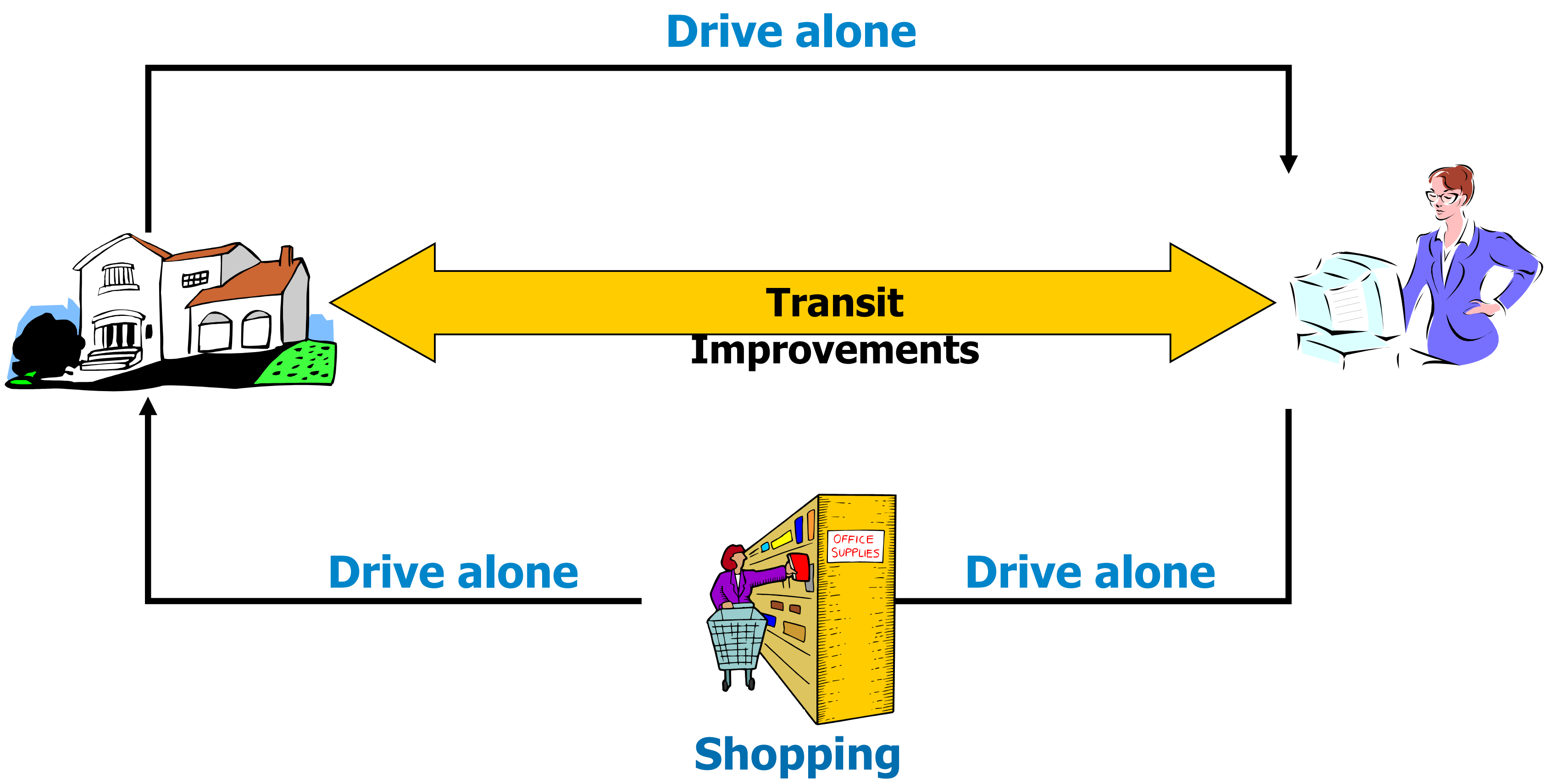

Impact of Transit Improvements (Mode Choice)

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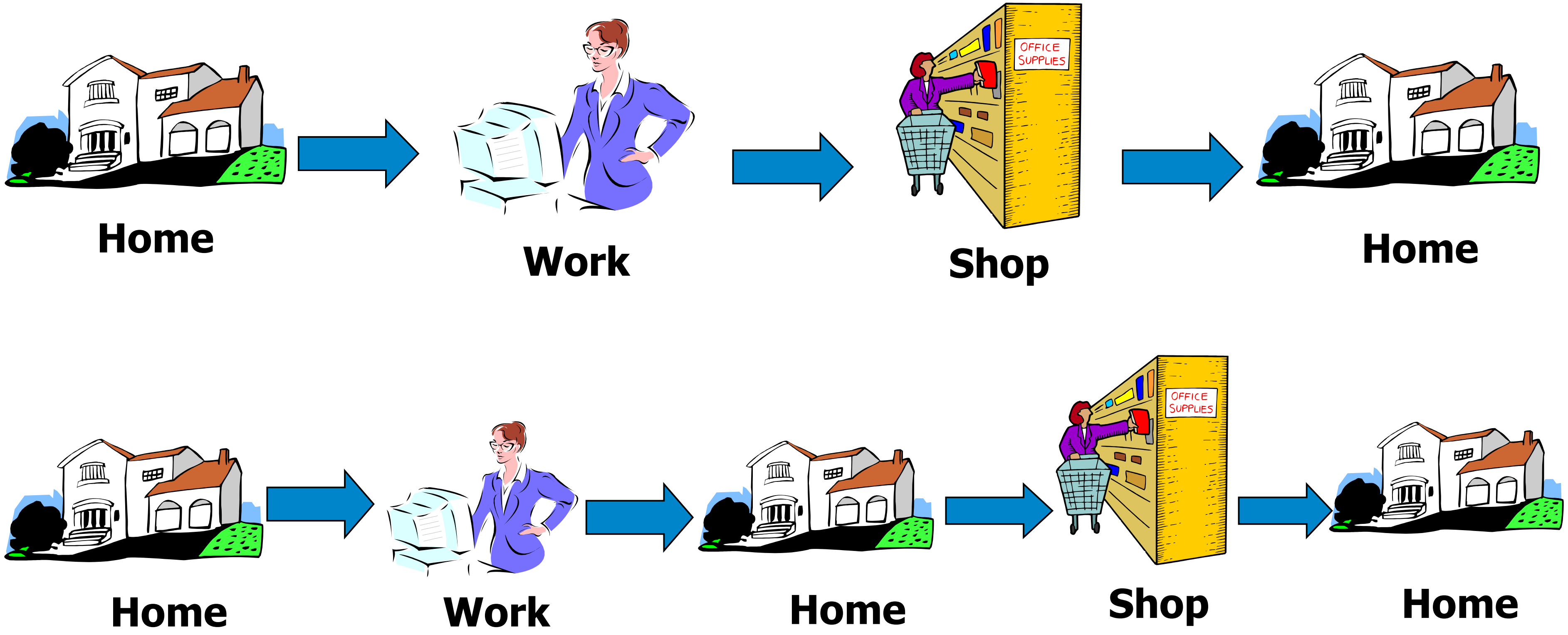
Policy examples (2)



Impact of Congestion Pricing (Temporal Substitutions)

Policy examples (3)

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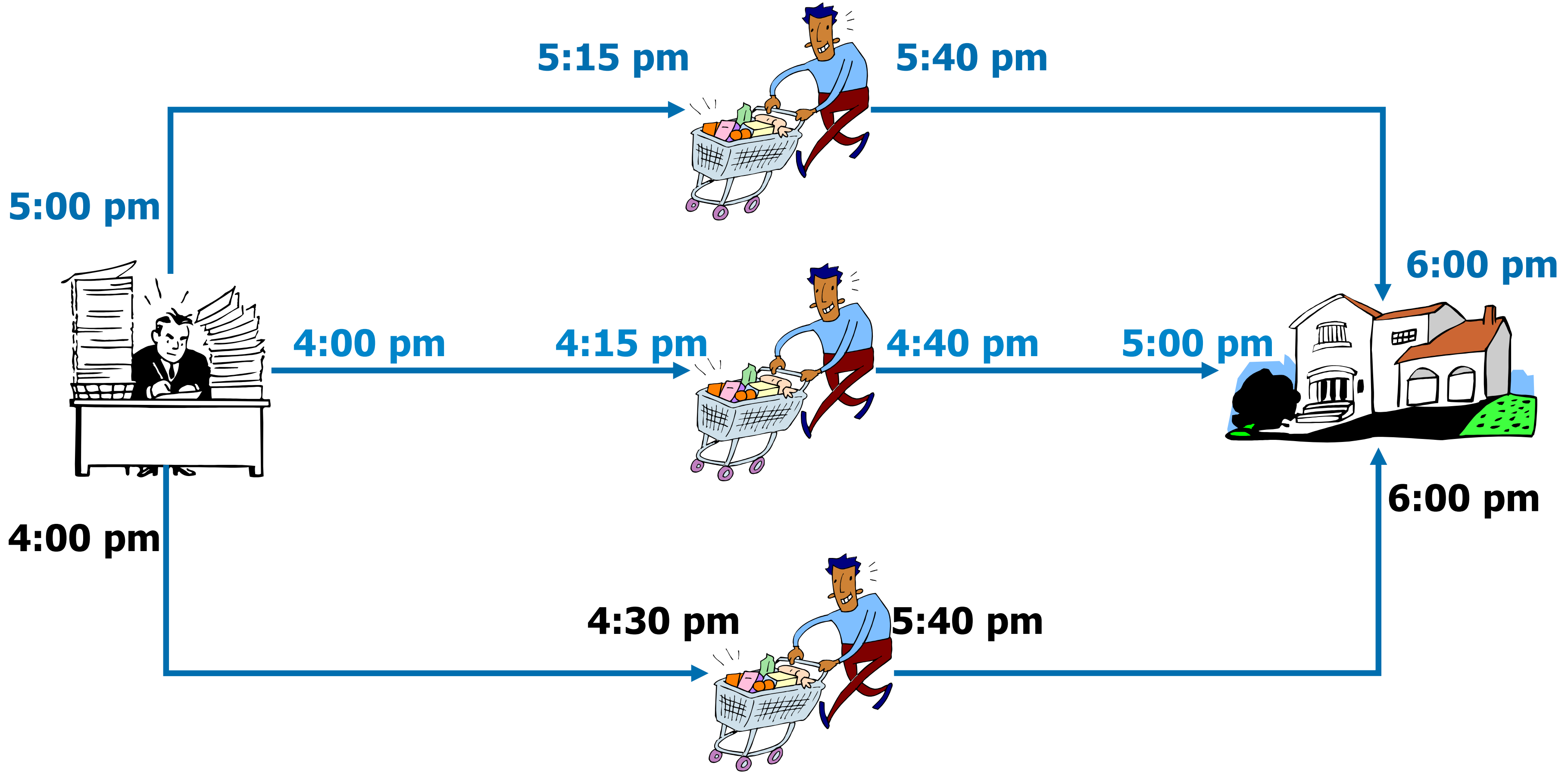

Impact of Early Release from Work

Policy examples (4)

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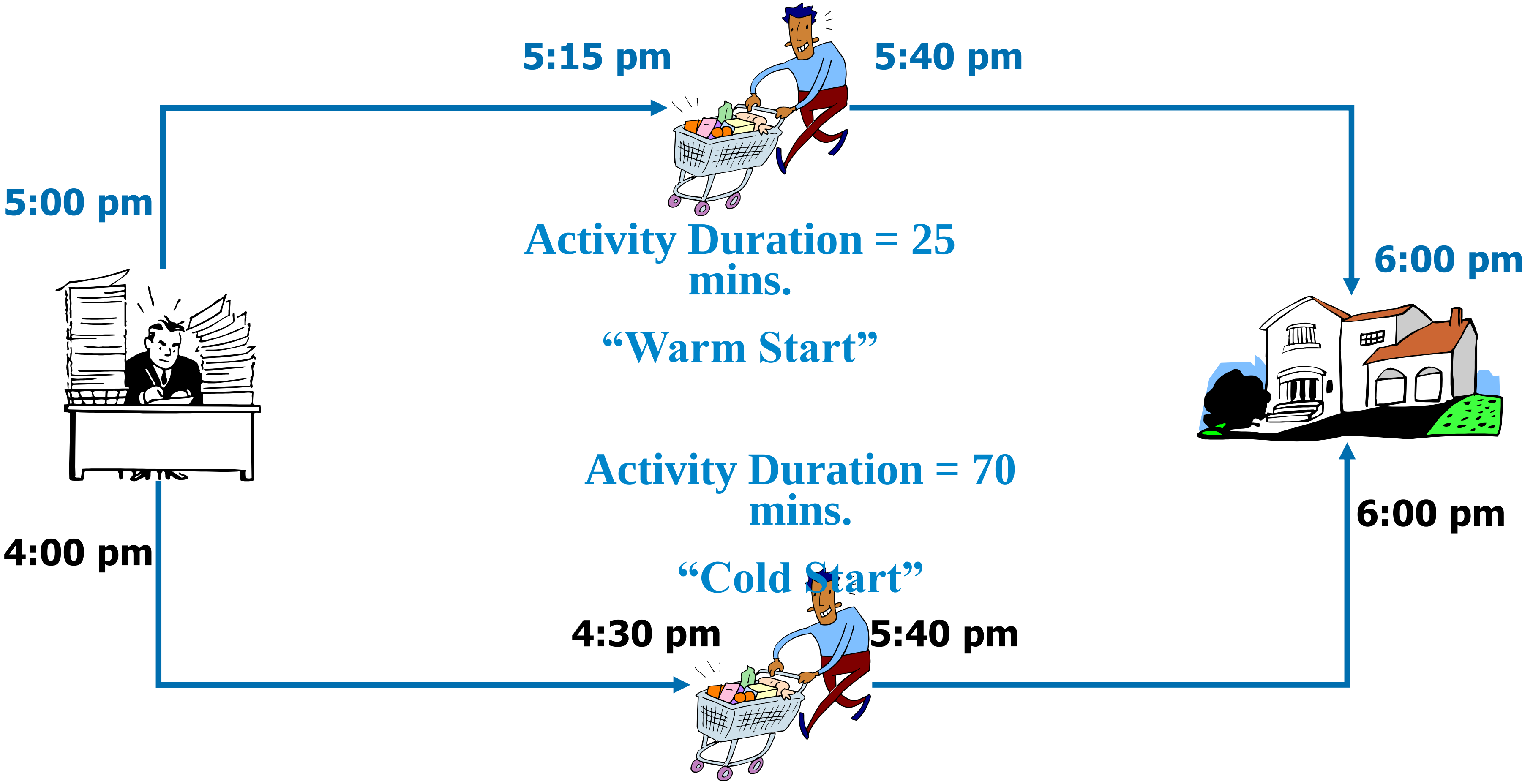

Air-Quality Modeling Requirements

Transport Planning in Emerging Economies

Systematic literature review

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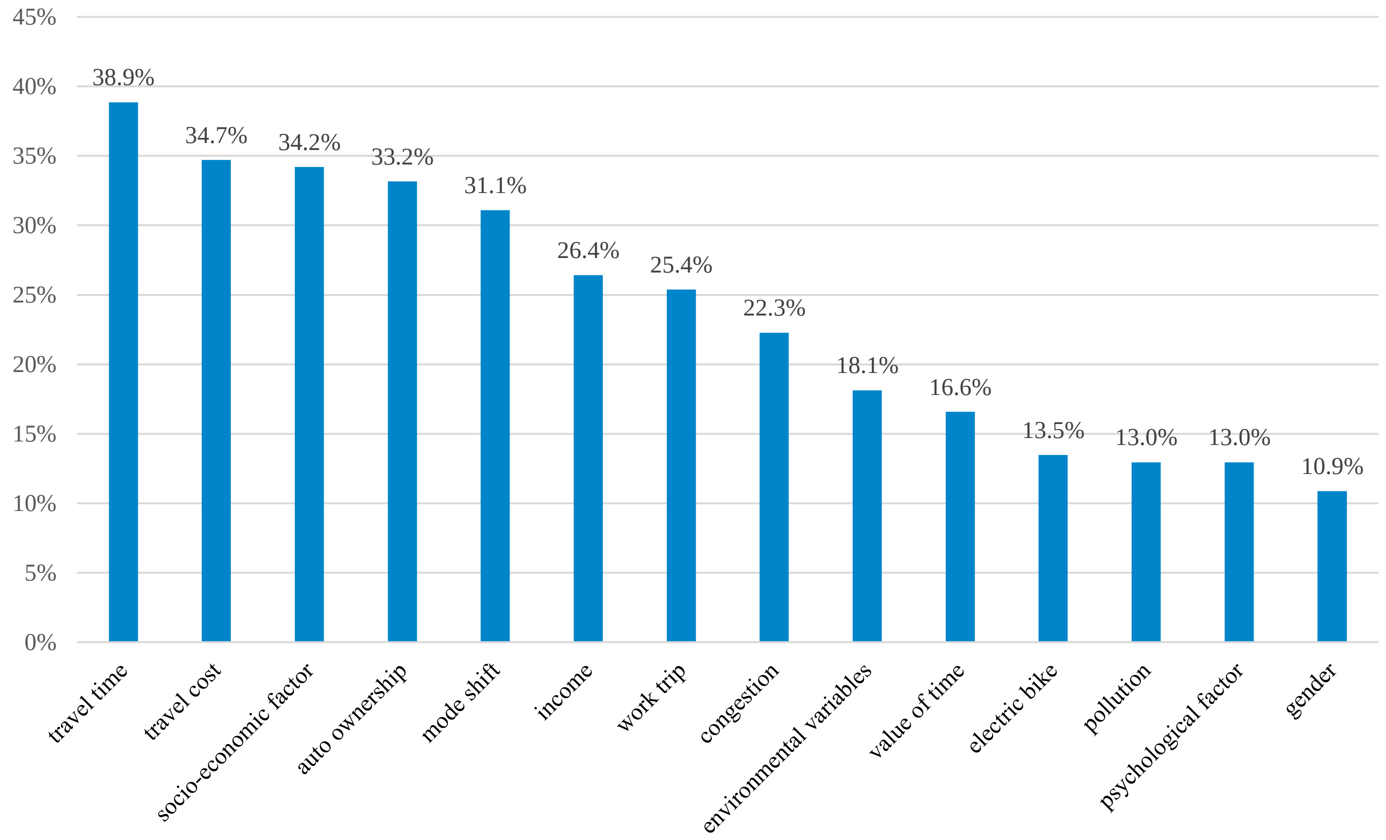
Common topics of focus in mode choice research in developing countries

(based on textual analysis of 192 papers)

Transport appraisal focused on

- Travel time saving
- Travel time reliability
- Effects of crowding



VOT and WTP

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	Mean	Standard Error	Observations
Research Purpose			
Behavioral Analysis	2.817	0.381	54
Policy Evaluation	1.423	0.409	14
Model Type			
Binary Logit	1.596	0.323	14
Multinomial Logit	1.631	0.324	28
Nested Logit	2.832	0.918	10
Mixed Logit	5.406	1.136	9
Others	4.577	1.481	7
Data Type			
SP Data	2.399	0.407	45
RP Data	2.598	0.526	23
Travel Time			
Total Travel Time	2.883	0.391	41
In-vehicle Travel Time	1.617	0.487	18
Walking and Waiting Time	0.383	0.305	9
Trip Type			
All Types	2.299	0.483	26
Business	2.799	0.233	10
Leisure	0.906	0.536	4
Commute	3.156	0.605	20
To CBD	4.694	1.206	8
Mode Choice			
All Modes	2.008	0.460	19
Car	3.772	0.651	27
Transit	1.457	0.238	22
Income	continuous variable		
Total	2.530	0.321	68

- VOT estimates (£/hr, 2017-prices)

Challenges with transport planning in emerging economies

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- Burden on infrastructure and environment increasing rapidly, as capacity cannot keep up with the rate of growth… near term solutions are necessary to meet primary needs
- Transport information or data are not always easily available to policy makers
- Engaging mode shift from private cars to public transport is a more complex undertaking
- Public transport dealing with issues of hygiene, safety, crowding, unreliability
- Conditions at rail and bus stations make wait/transfer less attractive
- Affective and symbolic motives for car use outweigh the instrumental motives

Sustainable Development Goals

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- Analysis of SDGs identifies the following key aspects of transport:
    - Access (urban, rural, affordable for all), Regional and trans-border transport;
    - Road safety, fuel type/efficiency, reform fossil-fuel subsidies;
    - Quality, reliable, resilient, and sustainable infrastructure;
    - Sustainable urban transport for all; Reduce vehicle emissions/air pollution in cities;;
    - Rural/urban logistics, supply chain efficiency, and mitigation and adaption of climate change
- In rural areas: access to markets, places of employment and health centres and schools are critically important
- In urban areas: long journeys to work, congestion, road accidents and air pollution are key issues
- For both rural and urban areas: Vehicle emissions are a major source of illness and premature death; the mobility of vulnerable people, women, children and people with disabilities also remain a key priority

Evolving Socio-technical systems

Trends (1)

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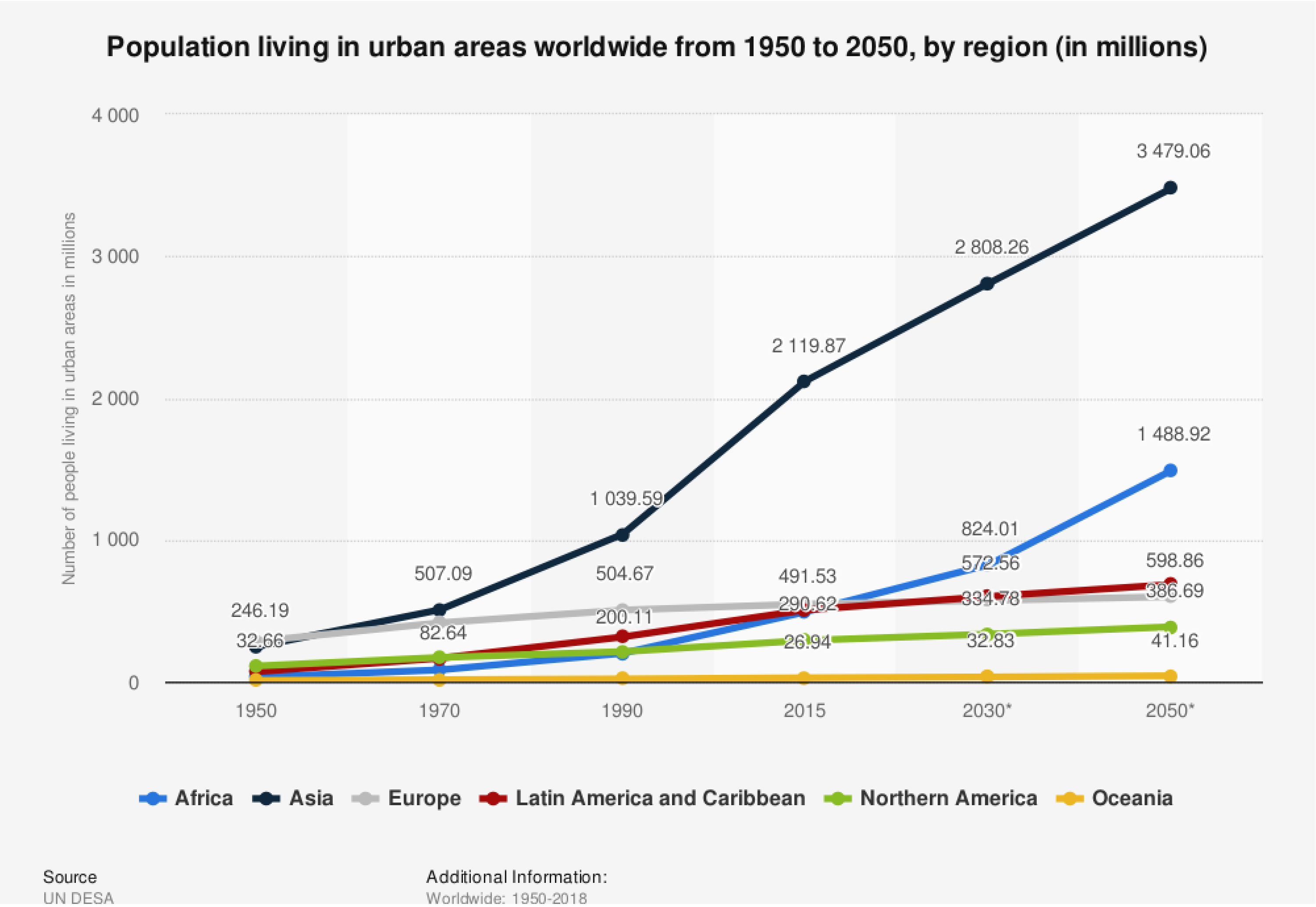
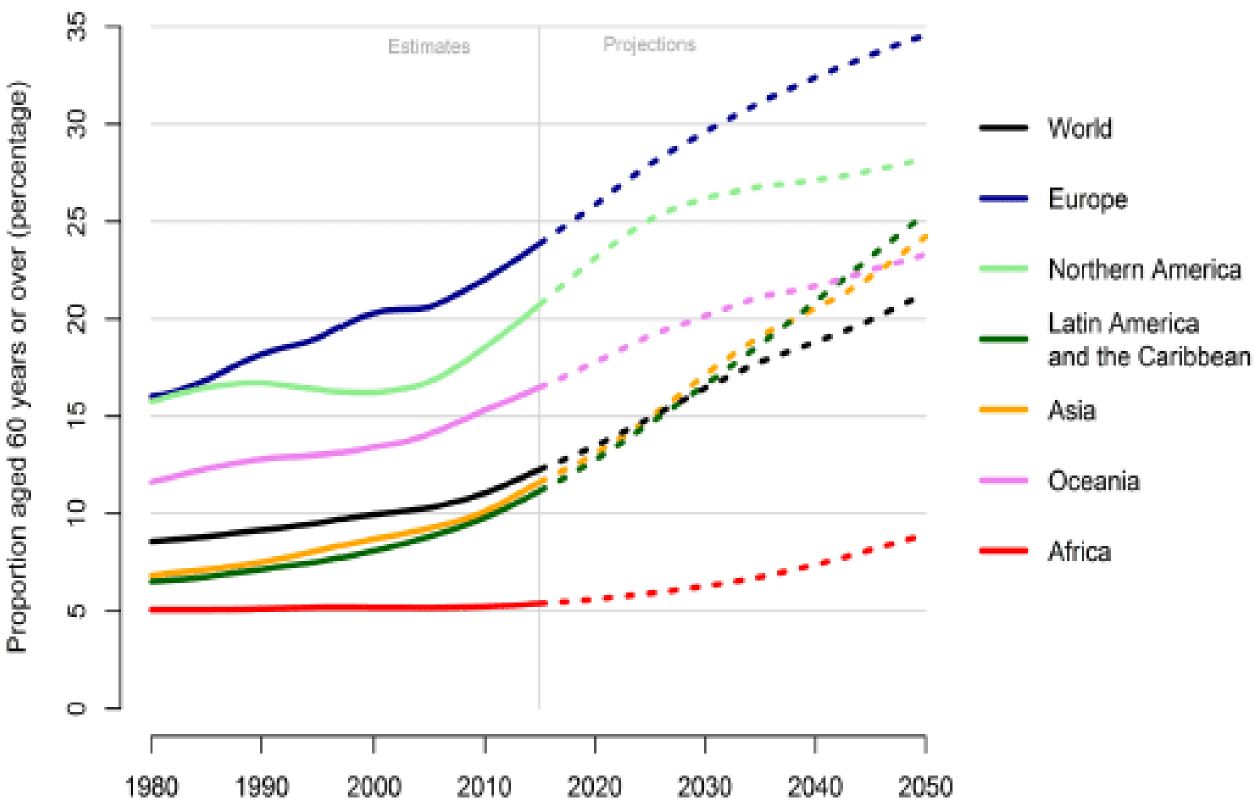
- Cities worldwide have been growing steadily in population; with the urban growth in developing countries in Asia being significantly steeper
- There is greater pressure on ageing urban infrastructures (transport, electricity, water, housing etc) in the developed world
- In the developing world, the growth in infrastructure is unable to keep up to the pace; and is danger of following unsustainable pathways
- Without appropriate planning, this is a recipe for disaster

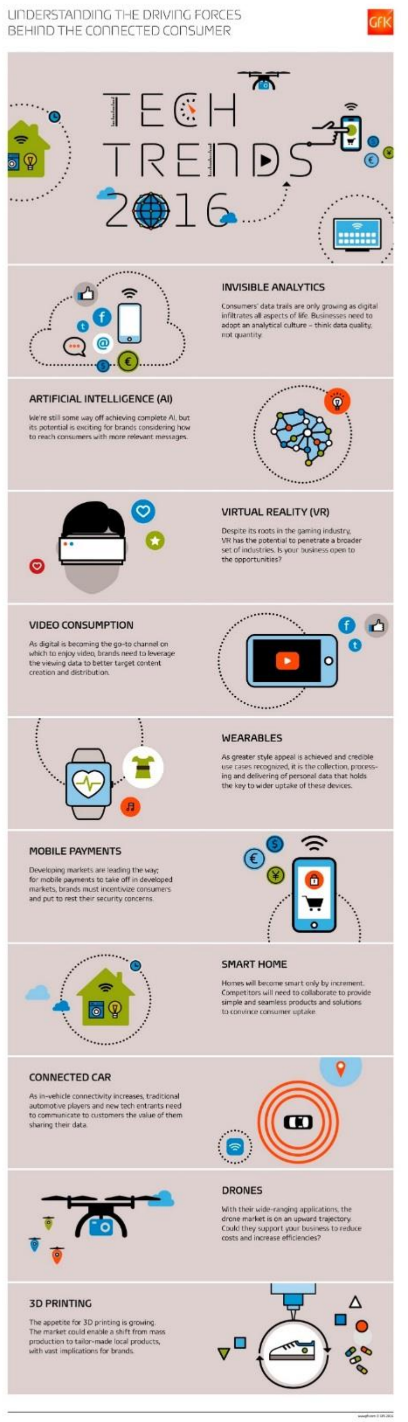


Trends (2)



At the same time, there are significant changes in the socio-technical systems

- Populations are ageing
- People are more ‘connected’
- Infrastructure is more ‘connected’
- Infrastructures are becoming more closely interdependent



Trends (3)

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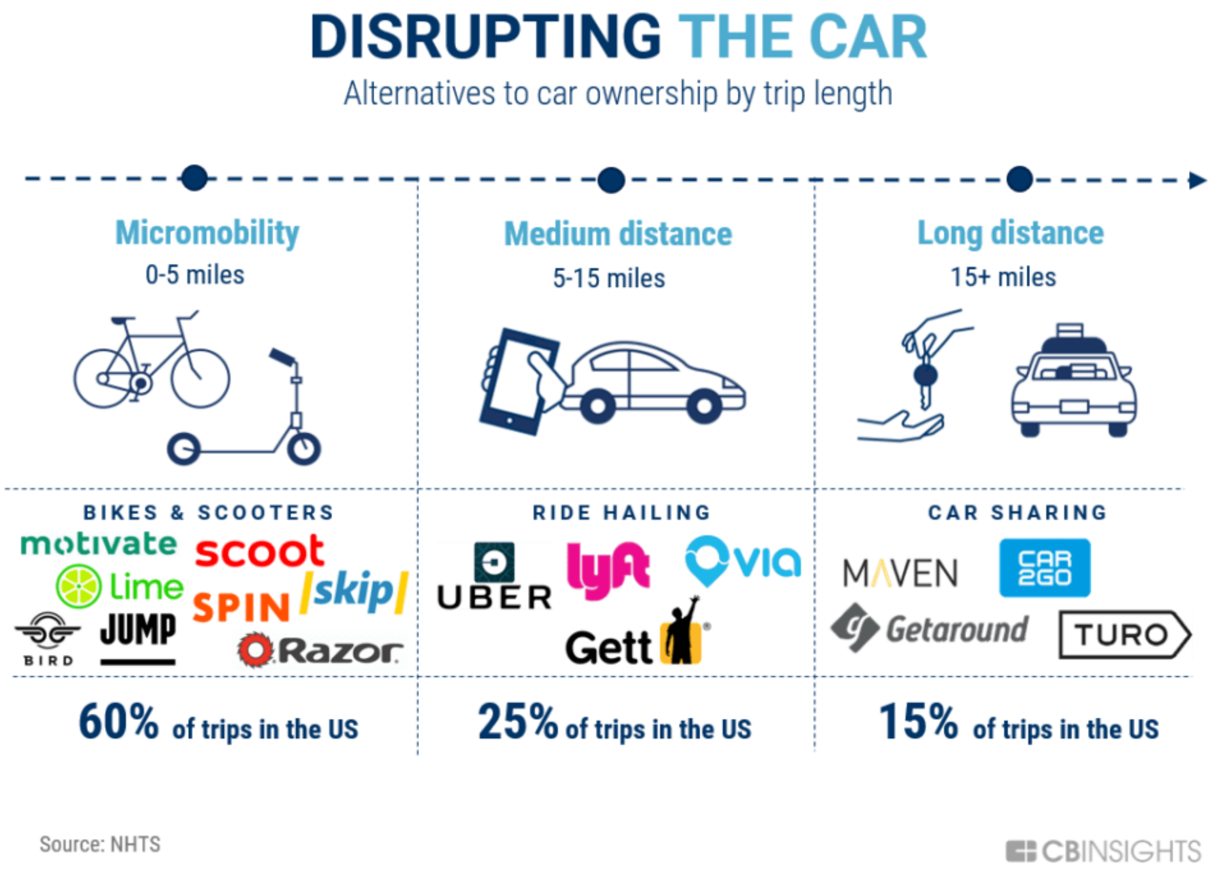
The transport system is on the cusp of major changes

- Electric vehicles: personal and fleets
- Connected and autonomous vehicles
- Location based services
- Shared mobility
- Mobility as a service
- Micromobilities
- On-demand transit
- Collaborative logistics
- Drones, UAVs



Emerging data landscape

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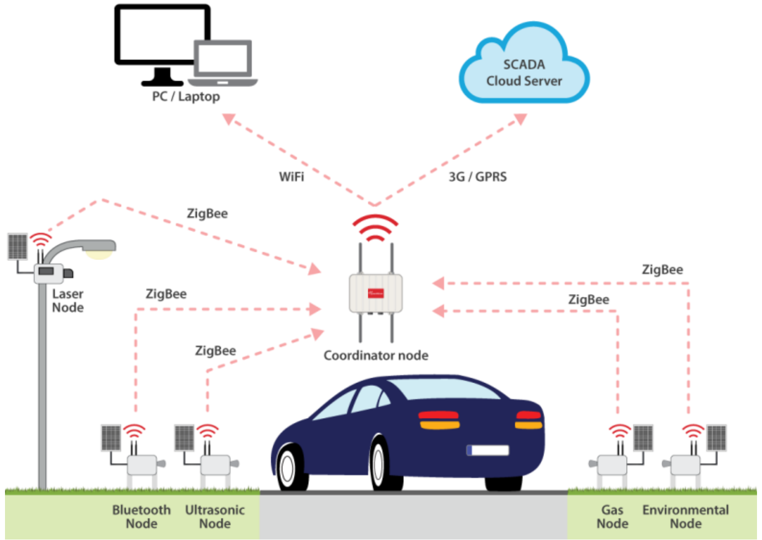
- Information and mobile communication technologies
  - Location/mobility: Mobile phone traces, GPS traces, accelerometer data
  - Digital footprints: Twitter feeds, credit card use data, mobile phone use data, public transport use data (e.g. Oyster data in London), mobile phone app data (e.g. Strava)
- Pervasive sensing
  - Next generation traffic counters (Bluetooth, Zigbee)
  - Cameras + LiDAR
- Enhanced surveys (life course, VR-stated response…)
- Transport operations data
  - PT operators, Uber, Bike sharing data, EV charging infrastructure etc

Source: IntelligentTransport.com



Source: Libelium World

Opportunities with emerging data

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- Real time OD matrix estimation (transport operations):

  with wider geographical coverage, higher sample size, taking into account the day-to-day variability of trips and providing potential time and cost savings.

- Efficient traffic control systems (transport operations):

  CAVs, real time OD flow prediction

- Integrated and efficient mobility services (transport supply & planning):

  MaaS, shared mobility services, co-operative intelligent transport systems

- User-centric mobility services (transport demand):

  Demand responsive, personalised, maximising consumer welfare and well-being

- Integrated and efficient use of urban infrastructures (planning & operations)

Challenges with emerging data

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- Privacy and security concerns
  - Regulatory environment
- Pre-processed data (e.g. mobile phone data)
  - Transparent and collaborative analyses
- Wide range of data standards and formats
  - GIS-T, GTFS, Open data initiatives… development of data exchange standards
- Data gaps
  - not all private services make data available
  - missing data and poor quality of data
- Degree of semantic content: ‘thick’ and ‘thin’ data; Lack of qualitative insight
- Data driven vs theory driven analysis – reliability, validation

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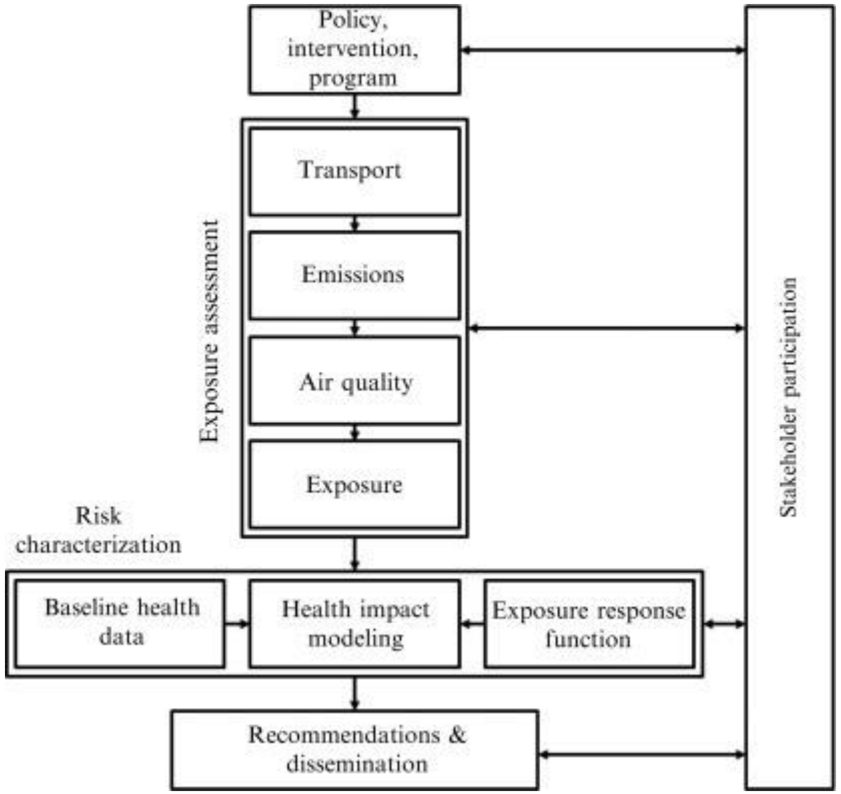
Health impact assessment of transport policies



https://www.sciencedirect.com/science/article/pii/B9780128181225000132 (Mueller et Al, 2020)

State of the practice (1)

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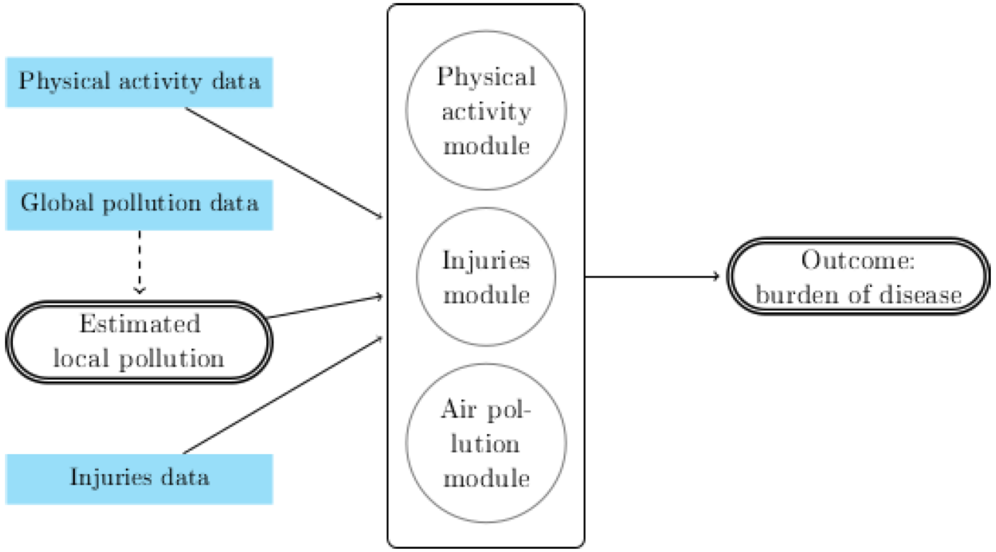
ITHIM (Integrated Transportation Health Impacts Model)

- Applied in the UK, US, India, Brazil, Malaysia
- County/region scale
- Physical activity, air pollution (in some countries), collision risks
- Comparative risk assessment, from epidemiology: simulate a change in health outcomes (eg deaths due to heart disease, disease adjusted life years) in response to changes in a key exposure (e.g. air pollution, noise)



TIGTHAT application to LMICs…

State of the practice (2)

C-PHAM (California Public Health Assessment Model)

- Applied in the US
- 150m gridcell
- Traffic injury, air pollution, urban form variables (linked indirectly through physical activity)
- Direct estimation, with regression models that link built environment and demographic characteristics to health outcomes (BMI, physical activity, prevalence of health outcomes).
- Less common approach due to statistical challenges and need for details such as intersection density and distance to parks. Easier to link directly to LUT models

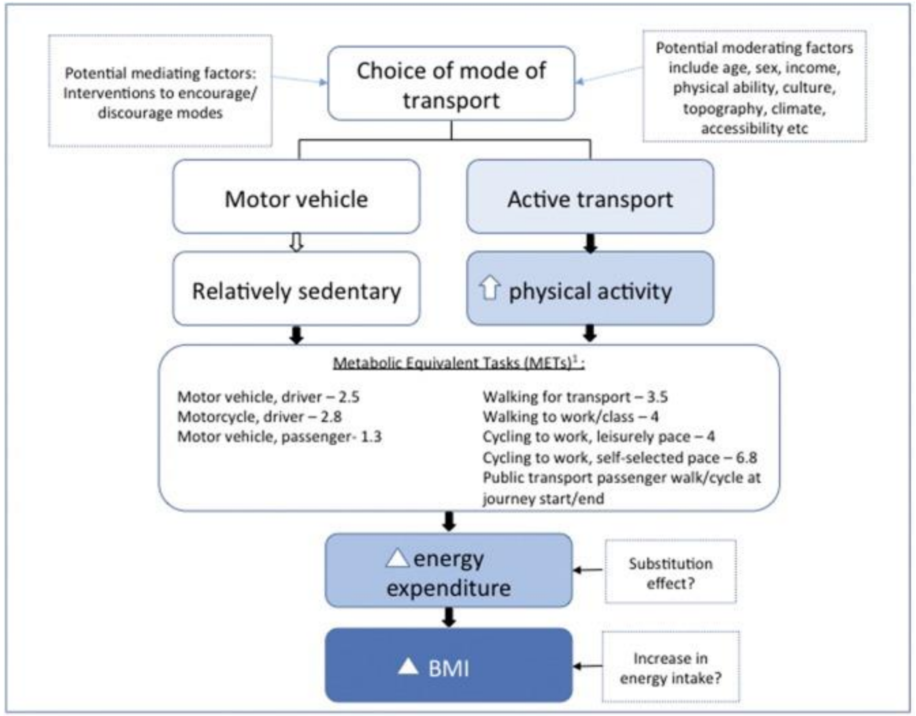
Both types of tools are fundamentally limited by the representations of travel behaviour that underlie them. The impacts of individual projects aimed at increasing physical activity (e.g. improvements in footpath quality or the implementation of a single bike lane) are not likely to be well-represented by current travel demand models, so assessing their public health impacts using either approach is not likely to yield meaningful results.

State of the practice (3)

HEAT (Health Economic Assessment Tool) developed by the WHO

- Applied in several European countries, and the UK
- For cycling and walking, designed to evaluate the health and economic impacts (using the value of a statistical life) of individual projects… mortality, economic benefits
- But it requires valid information about the travel behaviour changes likely to result from project implementation. Additionally, HEAT is based upon the same methodological principles as ITHIM, so in principle, an ITHIM implementation could generate similar estimates of the health impacts of a transportation project.

Example of a health impacts model of active travel



https://www.sciencedirect.com/science/article/pii/S0091743516304248
(Brown et al, 2017)

State of the practice (4)

- **BenMAP-CE (Environmental Benefits Mapping and Analysis Program-Community Edition)**
  - Developed by US EPA, Applied in US, China, S Korea, Spain, Japan
  - Specialist tool for air pollution (PM and ozone) impacts
  - CRA
- **UTOPHIA (Urban and Transport Planning Health Impact Assessment)**
  - Applied in Spain, census tract level analysis, CRA
  - Physical activity, air pollution, noise, heat, access to green space

State of the practice (5)

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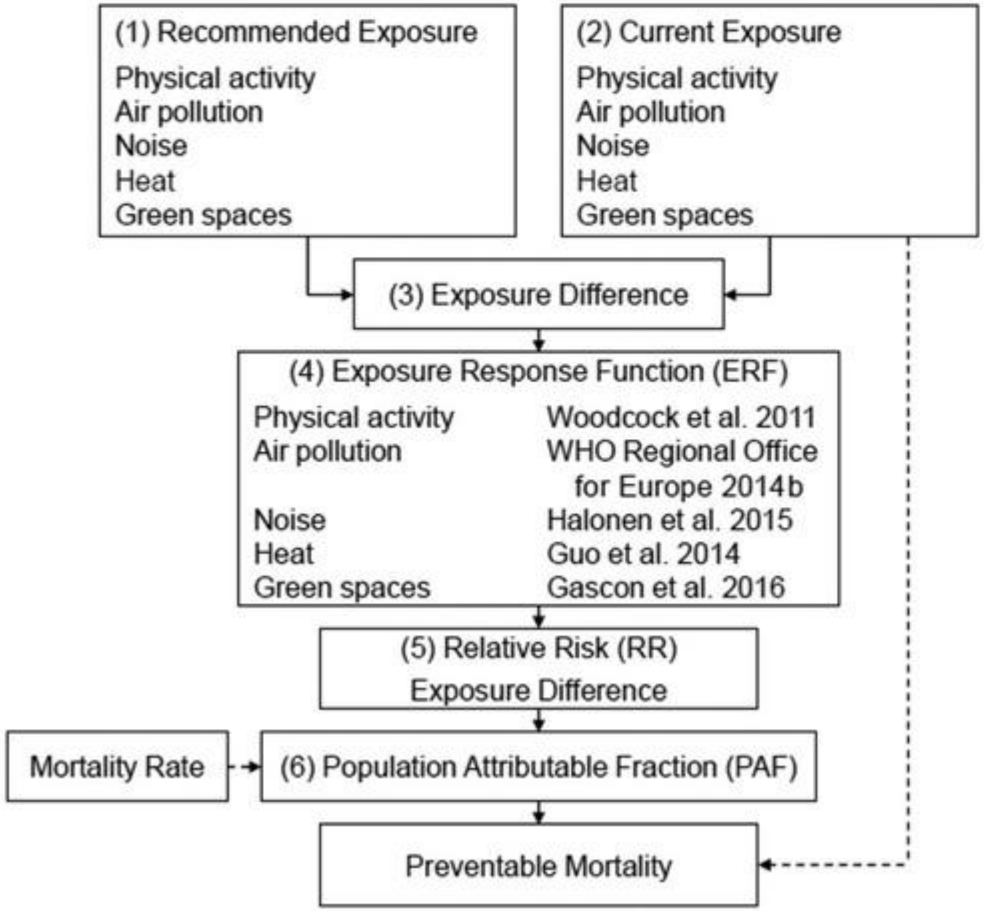

Conceptual framework of the Urban and TranspOrt Planning Health Impact Assessment (**UTOPHIA**) tool. https://ehp.niehs.nih.gov/doi/10.1289/ehp220

State of the practice (6)

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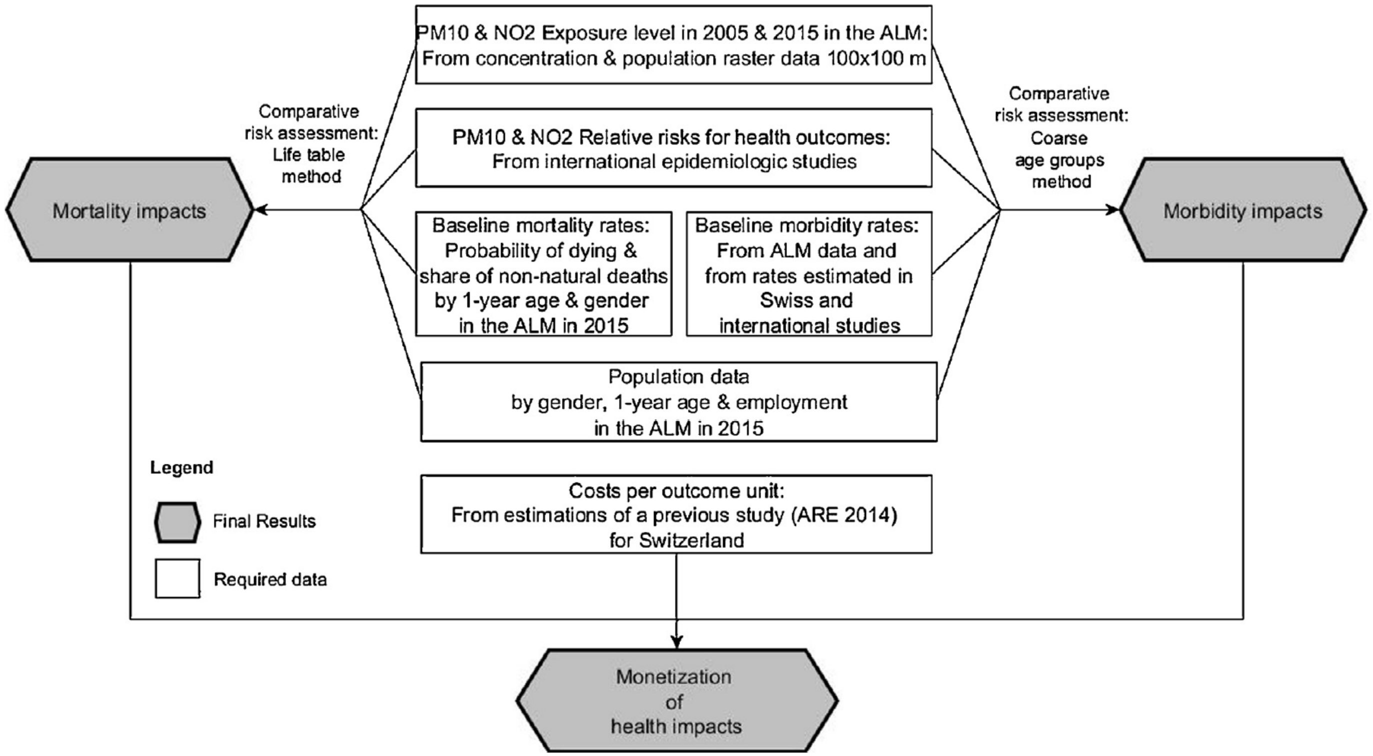
<u>Example application:</u>
Simplified workflow of health impact calculation

Estimates health impacts attributable to decrease in PM10 and NO2 exposure

In Lausanne-Morges, Switzerland between 2005-2015

Due to a basket of measures targeting transport, energy and industry

A. Castro et al. / International Journal of Hygiene and Environmental Health 220 (2017) 829–839



To conclude…

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- State of the practice health impact assessment models
  - Effective at ascribing a value to health impacts of transport and land use system changes
  - With 4-stage trip/tour based travel demand models, it is non-trivial but feasible to undertake 'exogenous', soft-linked health impact assessment
  - The missing link is really the ability to predict the pathways of these health impacts
- State of the art *Activity-based Travel Demand Models* and *Land Use Transport Models* contain the relevant information that can be used to measure the impacts of built environment and transport policies on health and well-being through a variety of pathways
  - Exposure to emissions, accident risk, noise pollution, changes in physically active travel, quality of life through accessibility to opportunities, stress due to travel conditions…
- There are still several statistical challenges in direct estimation of the impacts of transport/land-use changes on health outcomes; difficult to ascribe causality
- HIA models focus on the physical health aspects of wellbeing

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Questions?

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