



Evidence and gap map-studies of the effectiveness of transport sector intervention in low and middle- income countries

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Suggested citation: Malhotra, S, White, H, de la Cruz, N, Saran, A, Evers, J, John, D, Beveridge, E, Blondal, N 2021, *Evidence and gap map-studies of the effectiveness of transport sector intervention in low and middle – income countries CEDIL/Campbell Gap Map 2021* DOI: <https://doi.org/10.51744/CSWP3>

This project was funded by the Centre of Excellence for Development Impact and Learning (CEDIL), supported by UK Aid from the UK Government. The views expressed in this working paper do not necessarily reflect the UK Government's official policies.

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List of abbreviations

IIT-Delhi	Indian Institute of Technology
EGM	Evidence and gap map
SDG	Sustainable Development Goal (SDG)
LMICs	Low- and middle-income countries
ITPD	Institute of Transportation and Development Policy
RCT	Randomised controlled trial
DID	Difference-in-difference
IV	Instrument variable
PSM	Propensity score matching
RDD	Regression Discontinuity Design
ICORSI	Independent Council for Road Safety International
AMSTAR	Assessing the Methodological Quality of Systematic Reviews
PICOS	<i>Population, Intervention, Comparison, Outcomes and Study (PICOS) design</i>

Abstract

Background

There are great disparities in the quantity and quality of infrastructure. European countries such as Denmark, Germany, Switzerland, and the UK have close to 200 km of road per 100 km², and the Netherlands over 300 km per 100 km². By contrast, Kenya and Indonesia have less than 30, Laos and Morocco less than 20, Tanzania and Bolivia less than 10, and Mauritania only 1 km per 100 km².¹ As these figures show, there is a significant backlog of transport infrastructure investment in both rural and urban areas, especially in sub-Saharan Africa (Foster and Briceño, 2010). The situation is often exacerbated by weak governance and an inadequate regulatory framework with poor enforcement which lead to high costs and defective construction.

The wellbeing of many poor people is constrained by lack of transport, which is called 'transport poverty'. Lucas et al. (2016) suggest that up to 90 percent of the world's population are transport poor when defined as meeting at least one of the following criteria: (1) lack of available suitable transport, (2) lack of transport to necessary destinations, (3) cost of necessary transport puts household below the income poverty line, (4) excessive travel time, or (5) travel conditions unsafe or unhealthy.

Objectives

The aim of this evidence and gap map EGM is to identify, map and describe existing evidence on the effects of transport sector interventions related to all means of transport (roads, paths, cycle lanes, bridges, railways, ports, shipping, and inland waterways, and air transport).

Methods

The intervention framework of this EGM reframes Berg et al.'s (2015) three categories (infrastructure, prices, and regulations) broadly as infrastructure, incentives, and institutions as subcategories for each intervention category which are each mode of transport (Road, Rail and trams, ports, shipping, and waterways, and air transport). This Evidence and gap map identifies the area where intervention studies have been conducted as well as the current gaps in the evidence base.

An evidence and gap map (EGM) is a table or matrix which provides a visual presentation of the evidence in a particular sector or a sub-sector. The map is presented as a matrix in which rows are intervention categories (e.g., Infrastructure) and subcategories (e.g., Roads) and the column outcome domains (e.g., Environment) and subcategories as (e.g., Air Quality). Each cell contains studies of the corresponding intervention for the relevant outcome, with links to the available studies. Included studies were coded according to the intervention and outcomes assessed and additional filters as region, population, and study design. Critical appraisal of

included systematic review was done using A Measurement Tool to Assess Systematic Reviews (AMSTAR -2) rating scale.

Results

This EGM on the transport sector includes 442 studies from low- and middle-income countries, of which 28 are systematic reviews and 414 impact evaluation. The map identified that there are many studies of the effects of transport infrastructure, especially on roads. And there are no or fewer studies regarding ports, shipping, and waterways and also for civil aviation.

The evidence is most concentrated on transport infrastructure, services, and use, with the greatest concentration of evidence on transport time and cost (187 studies) and transport modality (156 studies). There is also a concentration of evidence on economic development and health and education outcome. There are 134 studies on economic development, 88 studies in household income and poverty, and 99 studies in health outcomes.

The major gaps in evidence from all sectors but roads. And there is a lack of evidence on cultural heritage and cultural diversity and very little evidence on displacement (3 studies), noise pollution (4 studies), and transport equity (1). There is a moderate amount of evidence on infrastructure quantity (31 studies), location, land use and prices (46 studies), market access (24 studies), access to education facilities (22 studies), air quality (48 studies), and cost analysis including CBA (21 studies). The evidence is mostly from East Asia and the Pacific Region. This EGM publishes the available evidence in the English language.

Conclusion

This map shows the available evidence and gaps on the effectiveness of transport sector intervention in low- and middle-income countries. The evidence is highly concentrated on transport infrastructure (especially roads), service, and use. It is also concentrated to the specific region and specific population. Sectors with great development potential, such as waterways, are under-examined reflecting also under-investment.

The available evidence can guide the policy makers, and government-related to transport sector intervention and its effects on many outcomes across sectors. There is a need to conduct experimental studies and quality systematic reviews in this area. Environment, gender equity, culture, and education in low- and middle-income countries are under-researched areas in the transport sector.

Plain Language Summary

The evidence base for transport is unevenly distributed and under-reviewed.

What is this map about?

Transport interventions can play a key role in the achievement of many of the sustainable development goals (SDGs). This evidence and gap map contains at the evidence base for all forms of transport: roads, bridges and paths; railways and trams; sea, ports, and inland waterways; and civil aviation. For each transport sector the interventions are divided into infrastructure, incentives and institutions.

What studies are included in this map?

Eligible studies had to be studies of the effects of a transport intervention, which is either the transport infrastructure or service itself, or transport-related incentives or institutions. Studies had to be impact evaluations designed to determine effects, including regression analysis. Before versus after, ex ante studies, and modelling studies without an empirical application are not included.

The map contains 442 studies, of which 28 are systematic reviews.

What are the findings from the map?

The studies are concentrated by sector and by outcome.

The majority of the studies are in the intervention category roads, bridges and paths, being mainly about roads. Of the three sub-categories – infrastructure, incentives and institutions – infrastructure is the most studied.

There is a moderate number of studies on railways, but the large majority of these are from East Asia, notably China. There are few studies on the other two intervention categories: sea, inland waterways and air.

The studies follow the infrastructure. The large number of Chinese rail studies reflects the rapid growth in the Chinese railway system. The lack of studies of inland waterways in Africa reflect the lack of investment in this means of transportation.

The most frequently reported outcomes relate to transport use, such as mode of transport and travel time. This followed by health and education and economic development outcomes. Other outcomes, such as environment, equity and culture. There are very few studies of known adverse effects like displacement.

Transport studies are under-reviewed. Typically, 20-30% of studies in an evidence map are systematic reviews. In the transport map there are only 28 studies out of 442: just seven percent? Moreover, most the included reviews have methodological weaknesses such as a failure to conduct meta-analysis and to assess the risk of bias.

What do the findings of this map mean?

The map points to a clear research agenda. A first step would be to review the included reviews. Based on this analysis, and that of the map, consultation with stakeholders can determine research priorities for reviews and primary studies. Since these studies contribute to the global public good of building the evidence base, it is best done in a coordinated manner.

1. Background

1.1 Introduction

The problem, condition, or issue

The wellbeing of many poor people is constrained by lack of transport, which is called ‘transport poverty’. Lucas et al. (2016) suggest that up to 90 percent of the world’s population are transport poor which is defined as meeting at least one of the following criteria: (1) lack of available suitable transport, (2) lack of transport to necessary destinations, (3) cost of necessary transport puts household below the income poverty line, (4) excessive travel time, or (5) travel conditions which are unsafe or unhealthy.

Better transport policies, infrastructure, and services are widely believed to be important to boost sustainable, inclusive growth in low- and middle-income countries in other regions (see, for example, Simon, 2002, Berg et al. 2015, and Quium, 2019). Transport allows people to reach jobs, education, markets, social services and engage in social and political life. Sustaining rapid economic and social development in low-and middle-income countries presents a range of challenges for the transport system, a central one being to provide the capacity to accommodate increased volumes of passenger and freight traffic (ibid).

Cheap, efficient, adequate, safe, and environmentally friendly transport services support agricultural and industrial production, inter-and intra-county trade, regional integration, tourism, and social and administrative services that are key to national and regional development. Better transport can affect production, consumption and prices, and access to services.

However, the presence and extent of these benefits depends on context: there is a great difference between those living in remote rural areas with little contact with the outside world and residents of a slum next to a highway in a rapidly growing city. How they interact with and can benefit from transport policies, of course, varies greatly. The impact of transport also depends on factors, such as employment opportunities, access to markets and distribution of health and education facilities, and other factors that may affect the use of all of these. The map must capture this full range of relevant interventions and possible policies, as well as the possible harms which may arise from transport.

Transport can bring disadvantages to some: displacement to make way for construction, poor road safety, higher land prices, spreading disease air pollution, reduced accessibility on foot, moving access to jobs and goods further away, and adverse cultural effects.

Whilst transport infrastructure and services generally improve access to social services, they may have adverse effects on both health and education through the role of transport in spreading disease (the Black Death, HIV/AIDS in Africa in the 1980s and 90s, and Covid-19 in 2020 – see, for example, Apostolopoulos and Sönmez, 2007), accidents,

and a busy road through a village stopping parents sending young children to school (Jeyaranjan et al., 2010). Over 80 percent of road traffic deaths are in developing countries (WHO, 2018).

Some of these factors are not captured in most analyses, so there is a risk that, if adverse effects are not measured, then the cost-effectiveness of transport investments is overstated and they may not produce the full range of expected benefits, hence the importance of the regulatory framework. Understanding how transport policies can produce growth-inducing effects and have social benefits, whilst considering possible adverse effects can guide setting priorities in the strategic use of scarce resources, and setting the regulatory framework for, transport investments.

1.1.1 The Intervention

The intervention is the transport system itself and any intervention aiming to construct, improve, maintain or affect the use of that transport. The main categories in the map are modes of transport: roads, paths, cycle lanes, bridges, railways, ports, shipping and inland waterways, and air transport. For each mode of transport, the sub-categories are infrastructure, information and incentives, and institutions.

The sub-categories are the three policies which contribute to improving transport networks: (i) infrastructure investments, (ii) price instruments (which we label more broadly as incentives), and (iii) regulations (Berg et al., 2017). The infrastructure investments entail building new transport infrastructure (e.g. roads, railways, ports, or airports), upgrading existing links and technology, or improving transport services. The incentives include subsidies or taxes to influence mode choice and transport behaviour (e.g., student fare reductions, tolls, parking fares, fuel taxes, and clean transport subsidies). The regulations include rules to directly reduce emissions (such as fuel emission standards or driving restrictions) or to organize the transport sector (for example, freight, taxis, or buses) or standards for the construction of infrastructure. Some policy interventions may affect supply, such as infrastructure investments, whereas others target demand, such as subsidies for transport.

1.1.2 Why it is important to develop this EGM

Although there is no separate Sustainable Development Goal (SDG) for transport, of the 17 Sustainable Development Goals (SDGs), seven (Goals 2, 3, 7, 9, 11, 12 and 13) include one or more targets that address transport, both rural and urban; and 4 (Goals 2, 3, 9, and 11) make specific reference to transport and infrastructure (United Nations, 2015). According to the Institute of Transportation and Development Policy (ITPD), ‘this elevation of transport in SDGs recognizes it as a key tool in reducing emissions, improving equity, and reducing poverty’. Analysis of these goals identifies the following key aspects of transport in the SDGs: access (urban, rural, affordable for all), road safety, fuel type/efficiency; quality, reliability, resilient, and sustainable infrastructure; regional and trans-border transport; sustainable urban transport for all; reduce vehicle emissions/air pollution in cities; reform fossil-fuel subsidies; rural/urban logistics, supply chain efficiency; and mitigation and adaptation of climate change.

The challenge is to harness the available evidence so as to prioritize investments and optimize policy decisions. There is currently no map, repository or database of studies of the effectiveness of development interventions. An earlier review by ADB (2018) used narrower inclusion criteria than this map, so had far fewer included studies. This map the first is to document all relevant studies.

2. Objectives

2.1 Objectives

The EGM aims to identify, map and describe existing evidence on the effects of transport sector interventions related to all means of transport (roads, paths, cycle lanes, bridges, railways, ports, shipping and inland waterways, and air transport) in low- and middle-income countries. For each sector, these interventions are classified as infrastructure and maintenance, information and incentives, and the institutional framework (including regulations). The primary outcomes of this EGM include transport infrastructure, economic impact, health and education, environmental, economic, and equity outcomes.

The objectives of this EGM map are to:

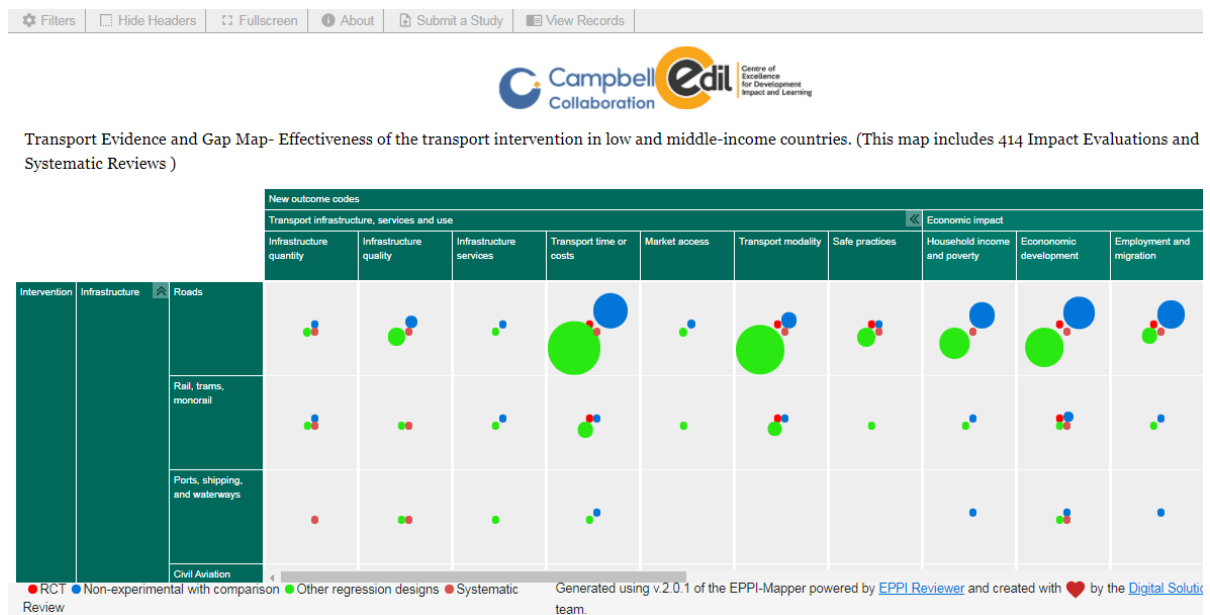
- a) Develop a clear framework of interventions and outcomes related to the effects of transport in low- and middle-income countries
- b) Map available systematic reviews and primary studies of the social and economic effects of interventions aimed at improving transportation in low- and middle-income countries in this framework, with an overview provided in a summary report.
- c) Provide database entries of included studies, which summarize the intervention, context, study design, and main findings.

The map has been produced in accordance with the Campbell Collaboration Guidance for the productions of evidence and gap maps (White et al., 2020).

2.1.1 Snapshot of Transport EGM

The intervention and the outcomes are the primary dimensions of this map. The online map also shows the secondary dimension (filters) such as region, population, study methods, etc. (see Figure 1). The bubbles indicate the study design, green colour denotes other regression designs, blue denotes non-experimental with a comparison group and red denotes RCTs. Systematic reviews are shown by brown bubbles. The size of the bubbles indicates the volume of the evidence in that cell.

Figure 1: Snapshot of the transport map



3. Methods

3.1 Evidence and Gap Map: Definition and Purpose

The objective of evidence and gap maps (EGMs) is to provide a picture of the completeness of existing research literature on a given topic. EGMs display their results in an interactive matrix. Identified studies are plotted in the matrix so that the user can find evidence. EGM are global public goods that attempt to democratize high-quality research evidence for policymakers, practitioners, and public and research funders. The EGM presented here includes evidence from impact evaluations and systematic reviews.

3.1.1 Types of evidence

This evidence and gap map will include ongoing and completed impact evaluations and systematic reviews of the effectiveness of transport sector interventions. This is a map of effectiveness studies. The impact evaluations will include:

- Experimental designs: RCTs and natural experiments
- Non- experimental designs: (i) quasi-experimental designs using statistical methods to create a comparison group such as propensity score matching and regression discontinuity, (ii) regression-based designs such as instrumental variables and Heckmann sample selection models; and (iii) other studies with a comparison group. Before versus after studies with no comparison group will not be included.
- Regression designs which control for confounding variables.

We do not include before versus after studies, ex ante impact estimates including cost-benefit analysis, or modelling studies without an empirical application. Qualitative studies are not included.

Type of population (as applicable)

The target population for this EGM is populations living in low- and middle-income countries. Rural/Urban and global region (by World Bank classification) are included as population sub-groups. These sub-groups were added to the map as filters.

Types of interventions/problem

The EGM includes intervention categories are each mode of transport such as roads, paths, cycle lanes, bridges, railways, ports, shipping and inland waterways, and air transport, and the sub-categories are infrastructure, information and incentives, and institutions. Table 1 shows the resulting set of intervention categories.

Table 1: Intervention categories and sub-categories

Category	Sub-categories	Examples
Road, paths, and footbridges	Infrastructure	Construction and upgrading of roads, and highways Infrastructure maintenance
	Incentives	Road pricing and tolls Subsidies and taxes
	Institutions (including regulations)	Road legislation and agencies Vehicle and driving regulations Public-private partnership (PPP)
Rail and trams	Infrastructure	Construction and upgrading Maintenance
	Incentives	Pricing structure Subsidies to rail operators
	Institutions (including regulations)	Regulatory framework Public-private partnership (PPP) Nationalisation/privatisation
Ports, shipping, and waterways	Infrastructure	Port and inland waterway construction and rehabilitation including modernization Maintenance
	Incentives	Tolls and other charges Taxes and subsidies
	Institutions (including regulations)	Port authorities
Civil Aviation	Infrastructure	Airports

	Incentives	Taxes and subsidies
	Institutions (including regulations)	Airport authorities

Since the sub-category labels are the same across all categories it is possible in the EGM to swap the categories and sub-categories. We will present the map in both layouts.

Types of outcome measures

The outcomes are listed in outcome domains (Table 2). Each domain has a number of sub-domains. The map covers positive and adverse outcomes, with outcomes being broadly defined so as to capture unintended outcomes.

Table 2: EGM Outcomes

Domain	Sub-domain
Transport infrastructure, services, and use	Infrastructure quantity Infrastructure quality (inc. safety assessment) Infrastructure services Transport time or costs (inc. congestion and VOC) Market access Transport modality (inc. car ownership) Safe practices
Economic Impact	Household income and poverty Economic Development Employment and migration Trade and tourism Location (land use) and prices Displacement
Health and education	Access to health facilities Health outcomes

	Access to education facilities Education outcomes
Culture	Values, language, and social cohesion Cultural heritage Cultural diversity
Environment	Air quality Noise pollution Habitat destruction
Economic and equity analysis	Cost-effectiveness or CBA Gender equity Transport equity ²

Types of settings (as applicable)

All included impact evaluations must have been conducted in low- and middle-income countries (LMICs) as defined by the World Bank. Systematic reviews containing evidence only from high-income countries will be excluded.

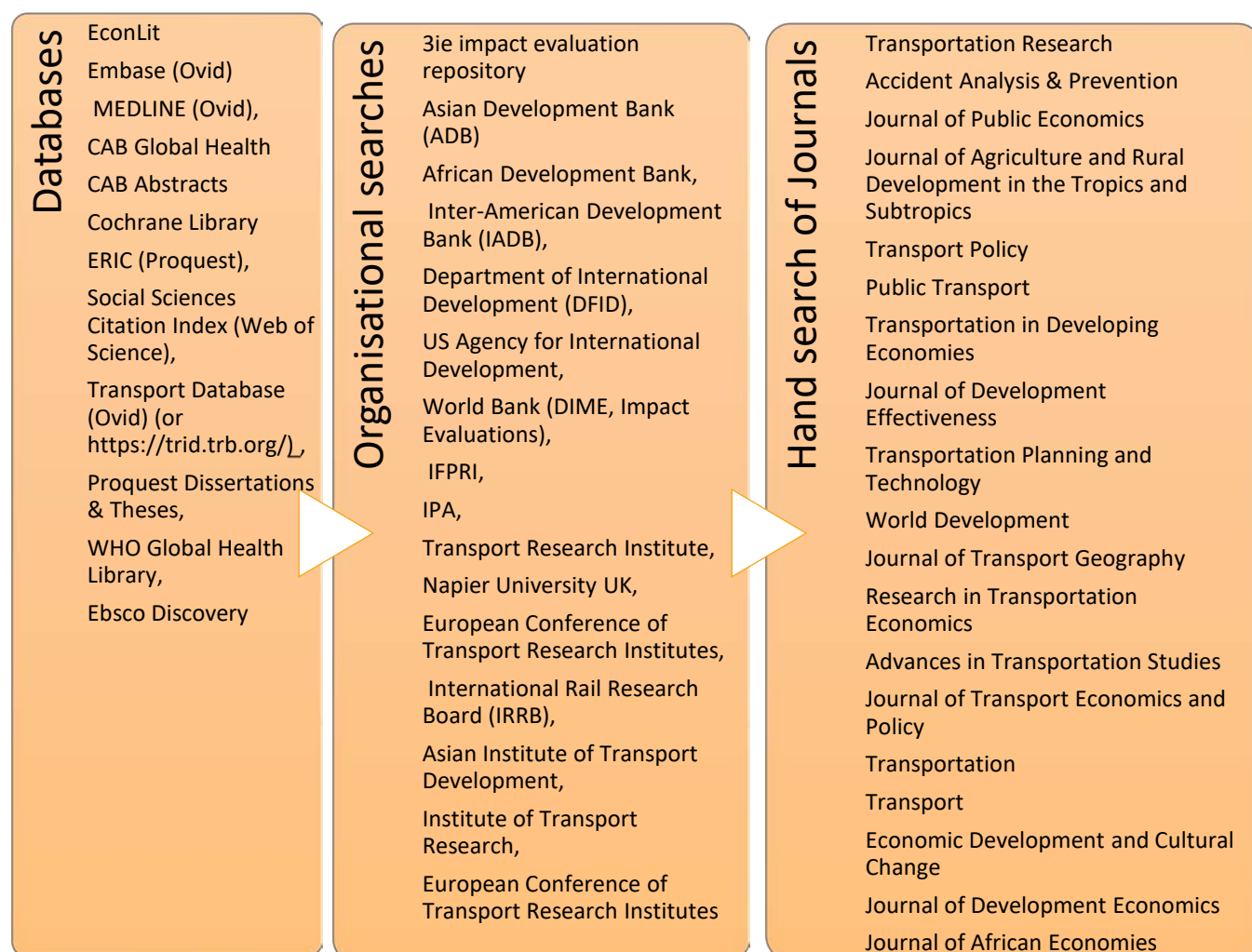
Search methods and sources

The search strategy included 12 databases, and more than 20 relevant websites and hand search of more than 20 journals (see Figure 1). We also for grey literature on google (as well as the listed) websites. We conducted bibliographic back-referencing of reference lists of all included systematic reviews to identify additional primary studies and systematic reviews.

In addition, we identified the developing country studies from the on-going map of road safety interventions (Mohan et al., 2020). All screening was done independently by two people (SM, NdIC) with a third-party arbitrator in case of disagreement (HW).

² Transportation equity or justice usually refers to the fairness with which the impacts of transportation such as benefits and costs are distributed. Horizontal equity, also called fairness and egalitarianism, is concerned with the distribution of impacts between individuals and groups considered equal in ability and need; vertical equity is concerned with the distribution of impacts between individuals and groups that differ in abilities and needs, for example by income or social class (also called social justice, environmental justice and social inclusion) or in transportation ability and need otherwise known as universal design (Litman, 2018)

Figure 2: Search sources



EGM Protocol

The EGM protocol was published on 21, January 2021 (Malhotra et al., 2021).

3.2 Stakeholder Engagement

The choice of transport as a map was based on the map of maps (Philips et al., 2018) which identified a gap in this area, and was seen as a priority by the funder, that is the UK Foreign, Commonwealth and Development Office (FCDO).

We have engaged stakeholders in developing the evidence matrix at the various organization that work on transport sector interventions. These include:

- TERI University (Department of Civil Engineering)
- IIT-Delhi,
- and Independent Council for Road Safety International (ICORSI).

Earlier versions of the map have been presented at ADB in Manila (September 2019), at the What Works Global Summit 2020 (October 2020), and in the Campbell Collaboration webinar series (December 2020). We will reach out to the World Bank, ADB, African Development Bank and FCDO with our map findings. And we will reach out to key leading global university transport research centres including the University of Sydney, University of Leeds, and LET, and University of Lyon.

3.3 Dimensions

3.3.1 Scope

The scope of this map covers (1) types of transport; (2) the policies and other actions to promote transport-related development; (3) the outcomes of interest; (4) the population of interest; and (5) eligible study designs.

The map included the interventions related to all kinds of transport: rail/tram, road and on foot or bike by land, both inland waterways and international maritime transport, and air.

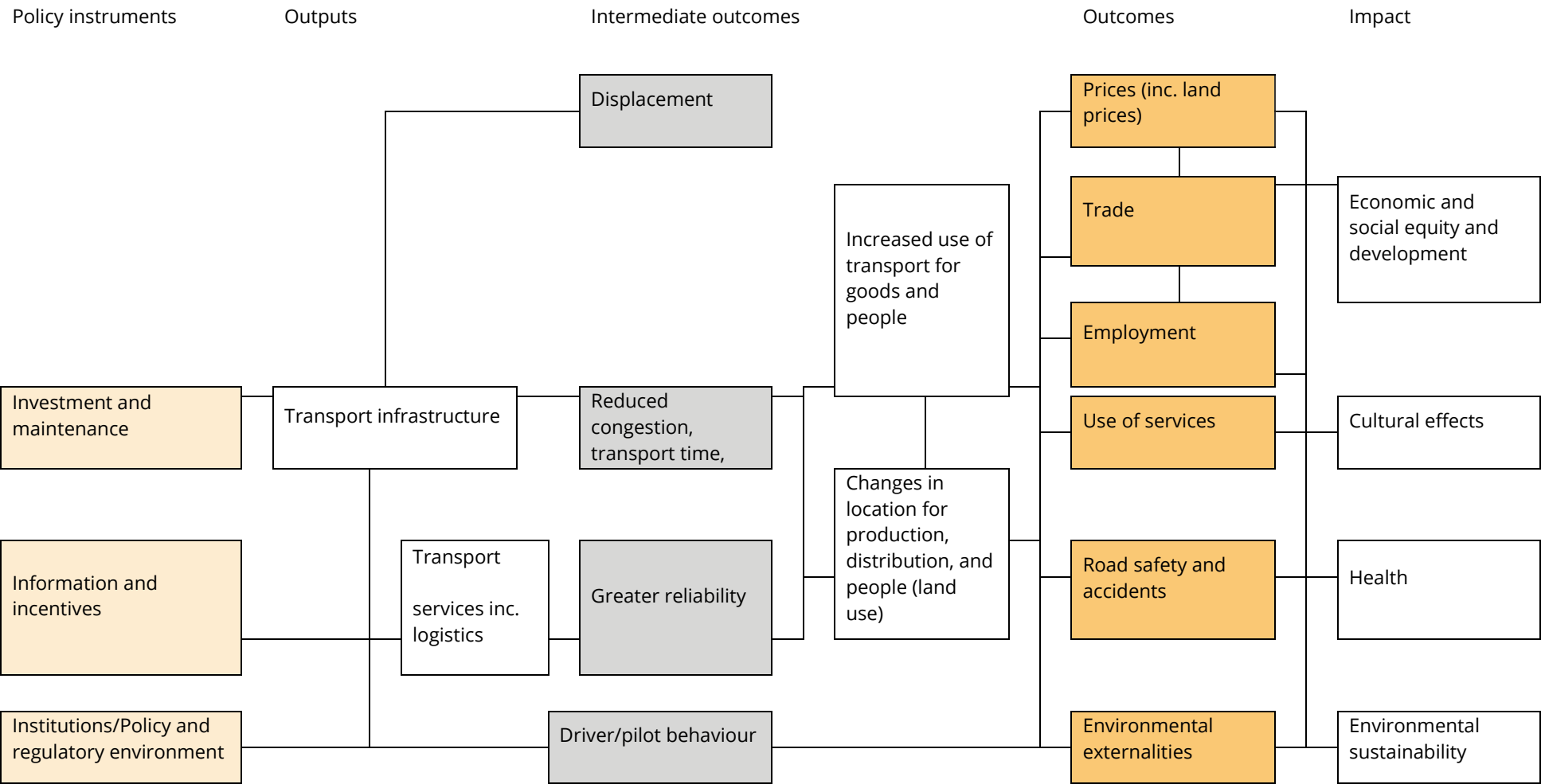
3.3.2 Conceptual Framework

Several sources present theories of change figured for transport interventions, for example, Berg et al. (2017), Raitzer et al. (2018), and Quiun (2019). Our theory of change, shown in Figure 2, draws on each of these to give a high-level representation that applies to all our included modes of transport. The framework identifies common causal pathways for the different modes of transport, meaning that there are likely to be common lessons across sectors that may get overlooked by researchers and policymakers specialized in just one sector.

The theory of change shows the causal chains through which inputs are turned into outputs, intermediate and outcomes, and higher-order welfare effects (impact). On the left of the figure are the intervention areas of investment and maintenance, information and incentives, and the institutional framework (policies and regulations). These effects are mediated by the political economy context and governance framework.

The availability of transport infrastructure and services affects the mediating variables through reduced travel time and greater reliability which drive location decisions for production and people, and so transport and commuting. These in turn, and together, affect a whole range of outcomes, some of which further interact prices, internal and external trade, employment, use of services, road safety and accidents, and a range of positive and negative environmental externalities.

Figure 3: General theory of change for transport interventions



These effects on outcomes lead onto the changes link to changes in final welfare outcomes under the broad headings of:

- Economic and social equity and development: Effects on both economic development through trade, productivity and growth, and social development in various forms through better access. Adverse effects on displaced populations who lose their land or livelihood will also be captured here. Transport planning may mean that transport makes life harder for the poor not easier if the way in which they travel is marginalized, such as roads without pedestrian access.
- Cultural effects: The positive and negative consequences of increased mobility within and between nations. The increased mobility of the population may have effects on the culture beliefs, values, customs and norms. An example is cultural heterogeneity resulting from migration to urban areas which can result in the loss of traditional values.
- Health: Health is separated out as there are many channels through which transport can affect health, both positive (access to health services, higher income, availability of more diversified diet etc.) and negative (road traffic injuries, air pollution, and spreading disease).
- Sustainability: Transport can have adverse effects on the environment, through impact on land use and local flora and fauna. Congestion is a growing problem, contributing to air pollution from increased traffic volumes.

This framework is used to define the categories of interventions and the outcomes along the causal chain to be shown in the map.

3.4 Description of Intervention

Table 1 lists the intervention categories and sub- categories.

3.5 Description of Population/Geographic location/Outcome categories

Included studies were those that include population from low- and middle-income countries and reported the transport sector intervention and reported on the main six outcomes.

The six main outcomes, which follow from the theory of change, are:

- Transport infrastructure, services, and use
- Economic Impact
- Health and education

- Culture
- Environment
- Economic and equity analysis

The outcomes categories and subcategories are given in Table 2.

3.6 Analysis and Presentation

3.6.1 Presentation

This EGM has two primary dimension intervention as rows and outcomes as columns. The map will display the interventions (road, rail and trams, ports, shipping and waterways, and civil aviation), sub-category (infrastructure, incentives, institutions (including regulations) against outcomes for each mode of transport. In the online map we used secondary dimensions:

1. Study design
2. Population (Rural, Urban, and Both)
3. Region: East Asia & Pacific, Latin America & Caribbean, Middle East & North Africa, South Asia, Sub-Saharan Africa Europe & Central Asia

For this map, we will present two forms of visualization of the evidence

1. Interventions as rows and outcomes as columns with additional filter study design
2. Interventions as rows and additional filter quality of the reviews.

4. Data Collection and Analysis

4.1 Screening and study selection

The studies screening for inclusion/ exclusion was undertaken in two stages using EPPI reviewer 4. The first stage involved title and abstract screening and the second involved the screening of the full text. Both stages of screening were done by two independent researchers (SM and NdIC) against the predefined inclusion criteria for the map, with a third-party arbitrator in case of disagreement (HW).

4.2 Data extraction and management

For impact evaluation and systematic reviews, we used a standardized data extraction form (Annexure 1) to extract descriptive data from all the studies that met our inclusion criteria. Data extraction from each study included context/geographical information, population, study design and method, intervention types and outcomes type, and subcategory. Two researchers (AM and NdIC) conducted the data extraction for each study. Both coders were trained on the tool before starting. Disagreements were resolved through discussion with a third reviewer consulted as needed (HW).

4.3 Tools for assessing the risk of bias/study quality of included reviews

All systematic reviews were appraised for quality using the AMSTAR2 tool. Critical appraisal was completed by two reviewers (AM and NdIC).

The 16 items in AMSTAR2 cover:

1. PICOS in inclusion criteria,
2. Ex-ante protocol,
3. Rationale for included study designs,
4. Comprehensive literature search,
5. Duplicate screening,
6. Duplicate data extraction,
7. List of excluded studies with justification,
8. Adequate description of included studies,
9. Adequate risk of bias assessment,
10. Report sources of funding,

11. Appropriate use of meta-analysis,
12. Risk of bias assessment for meta-analysis,
13. Allowance for risk of bias in discussing findings,
14. Analysis of heterogeneity,
15. Analysis of publication bias,
16. Report conflicts of interest.

Seven domains can critically affect the validity of a review and its conclusions (Critical items - 2, 4, 7, 9, 11, 13, and 15). The study's overall confidence ratings of the quality are high if there is no more than one non-critical weakness, medium if there is no critical weakness but more than one noncritical weakness, and low if there are one or more critical weaknesses.

We did not critically appraise the quality of the included impact evaluations but collected data on study design.

5. Results

5.1 Description of studies

5.1.1 Results of the search

The database search identified 5,325 of which 211 were duplicates, leaving 5,191 studies for title and abstract screening. Of these, 458 studies were screened for full text. We have excluded 146 studies at the full-text screening stage.

Finally, we have included 312 studies for coding. We excluded 40 studies due to study methodology, location, and intervention at the coding stage. This left 272 included studies of which 250 are impact evaluations and 22 systematic reviews. This is identified as Phase 1 in the PRISMA diagram (Figure 3).

Phase 2 of the search is based on the grey literature search of the various organizational websites, hand searches of journals, and bibliographic searches. As a result of these searches, we included an additional 383 studies for coding. Of these 45 studies were from the grey literature search, 61 studies from back referencing, and 149 studies included from hand searches from 19 journals. A further 128 studies were identified from the road safety intervention EGM (Mohan et al., 2020). The majority of these studies (213) were included on closer examination at coding stage, resulting in 170 additional studies in the map (see Figure 3).

As a result of both phases, we have included 442 studies that met our inclusion criteria: 414 impact evaluations and 28 systematic reviews (Figure 4).

Figure 4: Overview of included studies

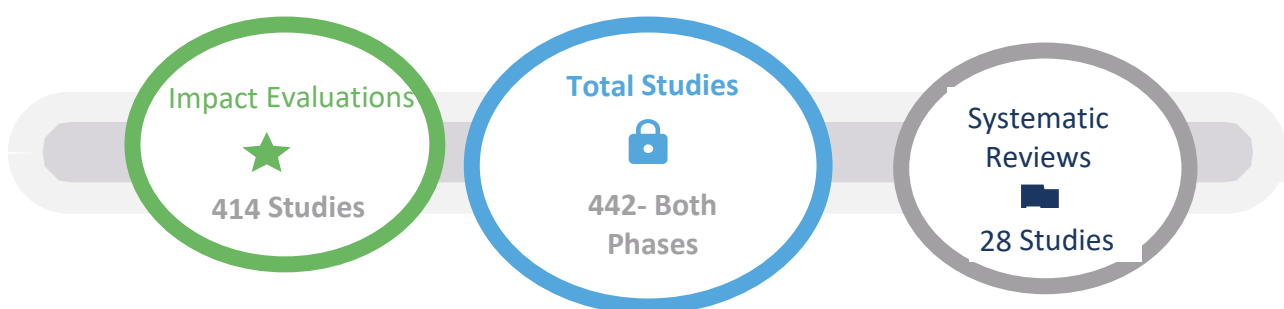
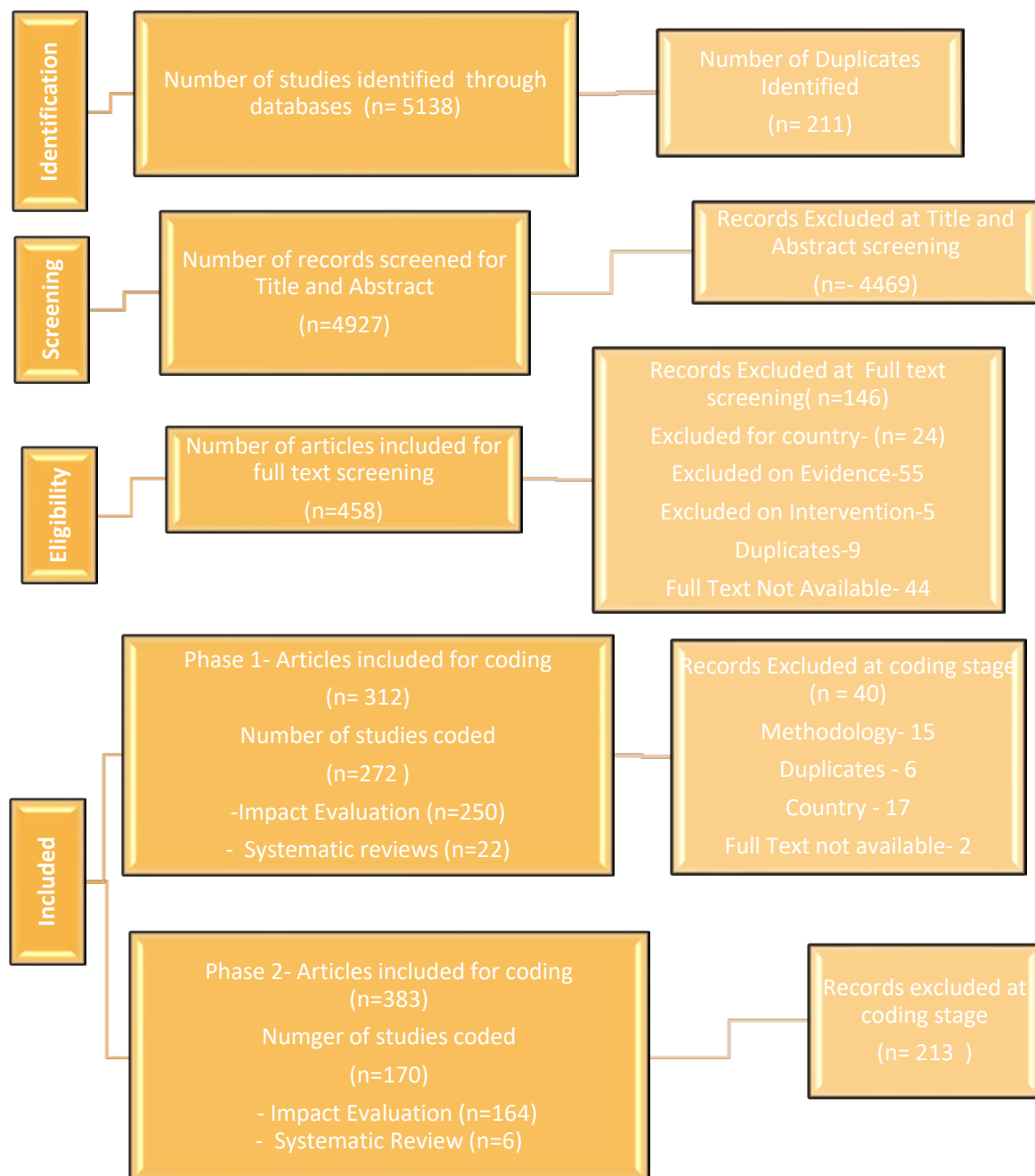


Figure 5: PRISMA Flow chart



5.1.2 Overview – Interventions and Outcomes

In the aggregate map (Table 3a) we present the aggregate map by intervention category (mode of transport) and outcomes. The most striking finding is that the dominance of studies on roads, bridges and paths (which are mainly roads). There is a reasonable number of studies on rails and trams (which, as shown below, are mostly from East Asia, mainly China). There are very few studies indeed on transport by air, sea and inland waterways, reflecting in part the neglect of these as a transport system.

Waterways remain an underused means of transport in Africa and South Asia. The Ganges saw little growth in freight traffic from 1945-95, with modest growth thereafter. Freight on the Congo remained stagnant from 1945 to 2015. By contrast, traffic on the Yangtze increased more than fourfold over the same period (Wang et al., 2020). Of course, there is undoubtedly endogeneity: economic development increases freight transport as well as better waterways facilitating economic development. Given the exogenous placement of waterways, analyzing their impact is a tractable problem, but there is no paper presenting this analysis. The closest study to this issue is that of Limi et al. (2015) showing that access to ports substantially increases exports of cash crops such as coffee, tea, tobacco, and cotton in African countries.

Table 3a Aggregate map, number of studies by transport category and outcome category: total studies and systematic reviews (in brackets)					
	Roads, bridges and paths	Rails and trams	Ports, sea and inland waterways	Civil aviation	Total
Transport infrastructure, services, and use	292 (14)	58 (1)	5 (1)	9 (2)	329
Economic impact	175 (6)	47 (4)	10 (2)	5 (3)	211
Health and education	131 (16)	8 (0)	2 (1)	3 (2)	136
Culture	4 (0)	0 (0)	0 (0)	0 (0)	4
Environment	56 (7)	10 (0)	0 (0)	2 (2)	63
Economic and equity analysis	33	5	0	0	36

	(2)	(0)	(0)	(0)	
Total	383	79	12	13	442

The most commonly reported outcomes are access to transport, economic impact, and health and education in that order. Hence the most heavily evidenced cells – with over 100 studies per cell - are the three cells for these outcomes for roads, bridges and paths. Much of the map has few, or even no, entries, pointing to substantial evidence gaps. As already noted, these affect transport modes (air and water) and some outcomes, notably culture, but also economic and equity outcomes, environment and, health and education for all transport modes other than roads.

The distribution of the systematic reviews follows roughly the same pattern as primary studies. Most reviews are about roads, with few on other means of transport. However, the main outcome is health – which is common for reviews as they are best established in health reviews. But there are also a reasonable number of reviews on economic development. A useful follow-on product from this map would be an overview of reviews contained in the map, one output of which would be to identify (in conjunction with additional analysis as to what is covered by the primary studies in the map) a list of potential topics for additional systematic reviews.

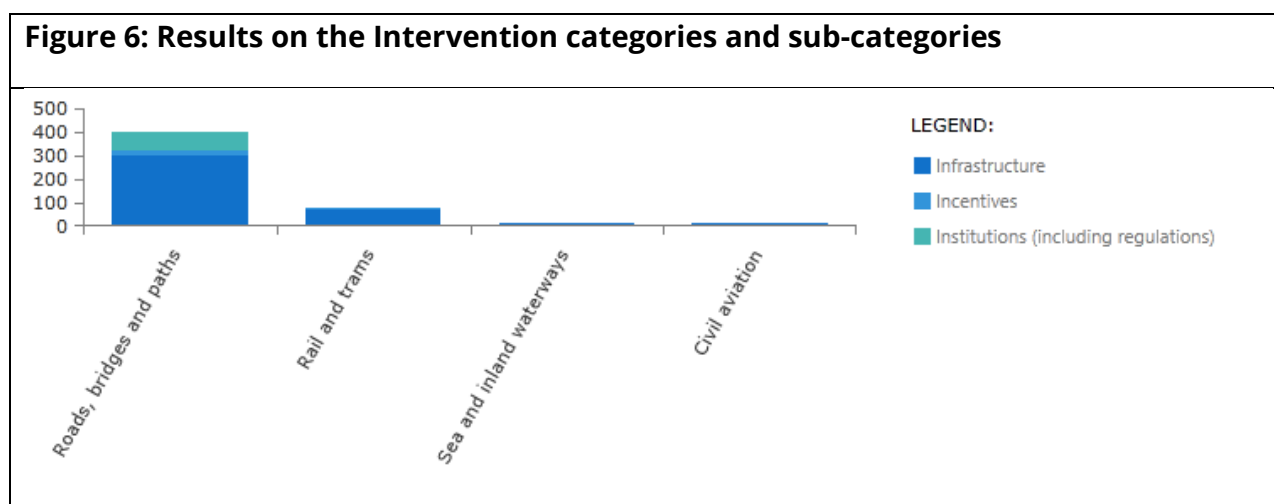
Table 3b shows the aggregate map by the sub-categories of infrastructure, incentives and institutions. This shows that the most well evidenced area is infrastructure across the main outcome categories already noted. There are a reasonable number of studies on institutions, mostly about transport use. There are the fewest on incentives, and again mostly on transport use.

Table 3b Aggregate map, number of studies by intervention category and outcome category				
	Infrastructure	Incentives	Institutions (including regulations)	Total
Transport infrastructure, services, and use	258	22	62	329
Economic impact	194	7	17	211
Health and education	118	3	21	136
Culture	4	0	0	4
Environment	44	2	21	63
Economic and equity analysis	29	0	10	36
Total	419	22	67	442

In all these tables the totals do not sum since a study may appear in more than one cell.

5.1.3 Evidence-base by intervention

Figure 6 shows the above findings graphically. The dominance of studies on roads is clear, as is the preponderance studies on infrastructure: 85% of the included studies are about infrastructure as an intervention, and the majority is about road infrastructure (72%). We find very few studies on ports and shipping or civil aviation.



In road infrastructure, there are many studies related to Bus Rapid Transit (BRT) systems. This is a high- quality bus-based transit system and provides dedicated lanes to buses. Figure 7 shows an example from Quito, Ecuador.

There are 79 studies in the map on rail, trams and monorail. Sixty (79%) of these studies are from East Asia, mainly China. This focus on railway studies reflects the rapid growth of the Chinese railway system in recent years, both within and between cities. The number of cities with urban rail lines in use or under construction grew from 25 in 2008 to 63



Figure 7: Bus rapid transit bus stop in Quito, Ecuador

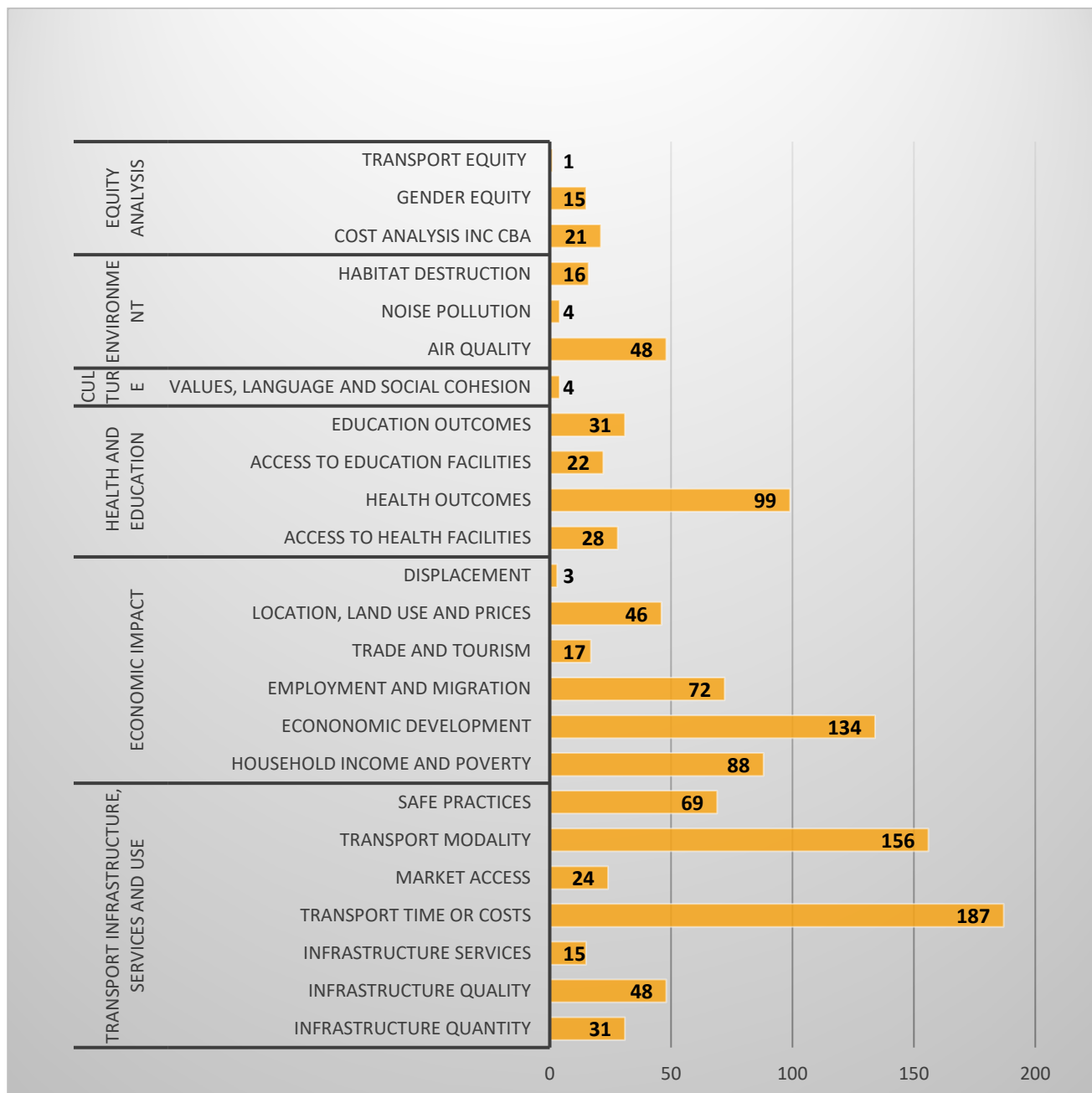
in 2015, with the length of line in use quadrupling from 803 km to 3,293 km (Lu et al., 2016). Under the 14th Five Year Plan (2021-25) an additional 10,000 km of rail will be built.³

5.1.4 Evidence-base by outcome category and sub- category

The evidence base is largest for the outcomes related to transport time or cost and transport modality (Figure 8). There are also many studies reporting economic development which includes growth, firm and enterprise development, and agricultural production. Other well-studied economic outcomes are household income and poverty, employment, and migration. Other outcomes with reasonable evidence are health outcomes, air quality and road safety. As already noted, there are few studies of cultural effects. There are also few studies on the adverse outcomes of displacement and habitat loss.

³ <https://www.china-briefing.com/news/china-rail-network-10000-km-domestic-expansion-link-key-city-clusters/>

Figure 8: Result of the outcome categories and sub- categories

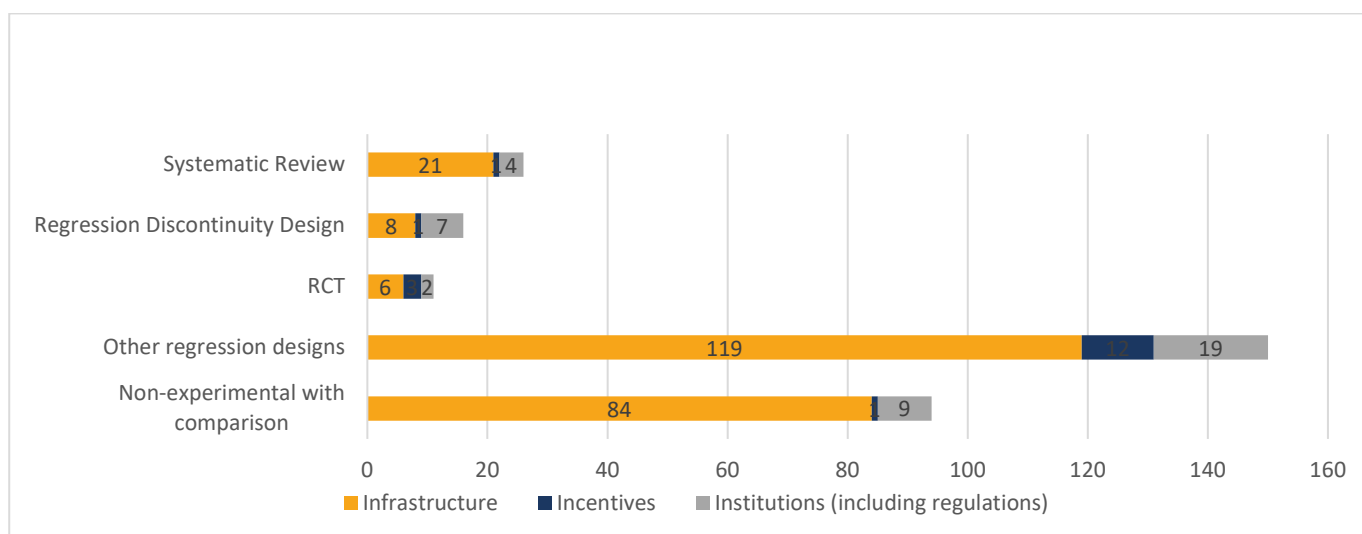


5.1.5 Secondary dimensions of the map

Study design

Of the 442 studies on the map, the most common design are regression studies (150 studies; Figure 9), and another 94 studies with non-experimental designs with a comparison group. There are very few randomized controlled trials (11 studies).

Figure 7: Number of studies as per the study design and intervention sub- categories

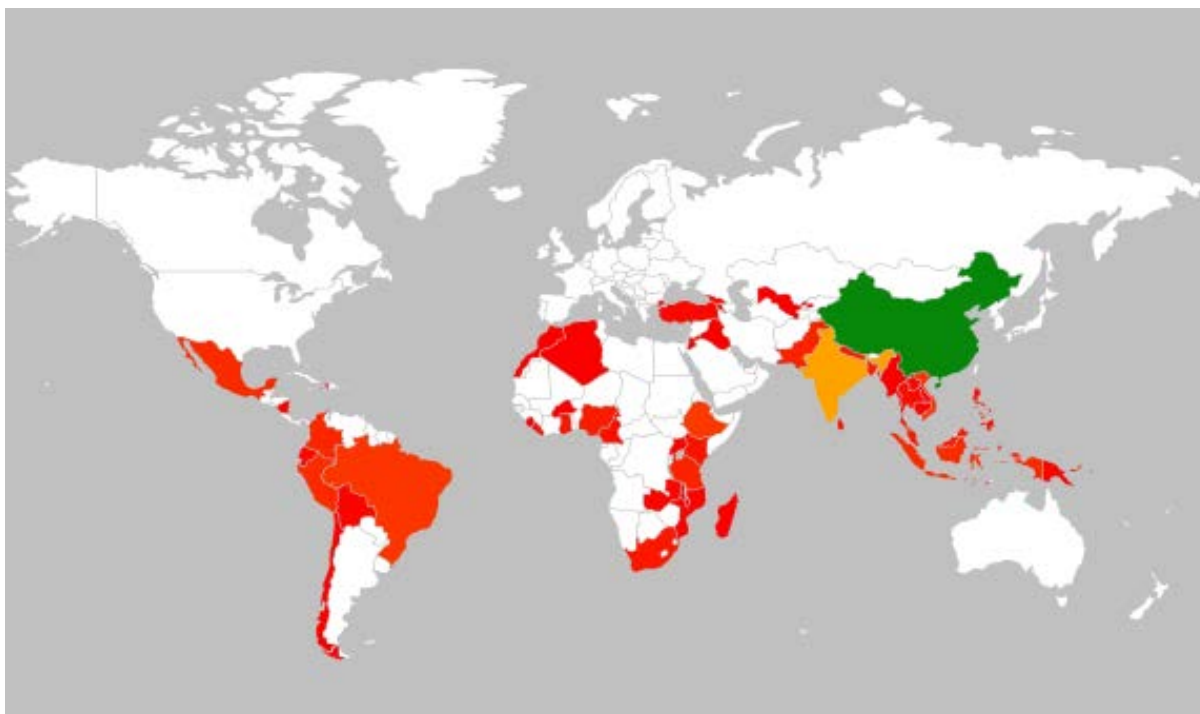


Systematic reviews make up just seven per cent (29 out of 442) studies in the map. This is a low percentage compared to most other maps. For example, the disability map has 59 reviews out of a total of 166 studies, that is 36% (Saran et al., 2020). Transport is thus an under-reviewed area. As proposed above, the map should be used to identify additional systematic reviews which would be of interest to decision-makers.

Region

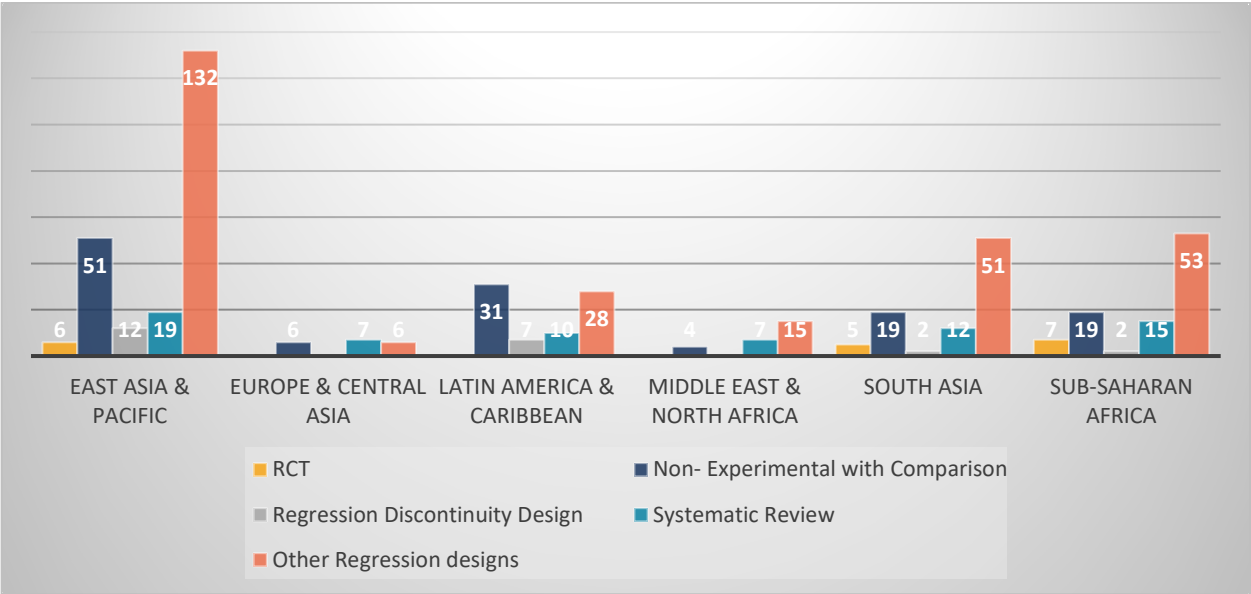
The most well-represented region in the map is East Asia and the Pacific (214 studies, 42%), which is more than double the share of the next most well-represented region (sub-Saharan Africa with 94 studies). Amongst East Asia and the Pacific countries, the majority of the studies are from China (141 studies/ 65%; Figure 10). There are very few studies from Europe and Central Asia and the Middle East and North Africa. There are 79 studies from South Asia with the most studies from India (44 studies). The countries with the highest evidence concentration are China, mentioned above (141 studies), next is India (44 studies), and Ethiopia (16 studies).

Figure 8: Geographical Heat Map of the studies included in EGM



Region-wise study design: In East Asia and Pacific the most used study designs are – as for the map as whole - is other regression design, followed by non-experimental designs with a comparison group. The same pattern is seen in other regions except for Latin America and Caribbean, where comparison group designs are most common (Figure 11).

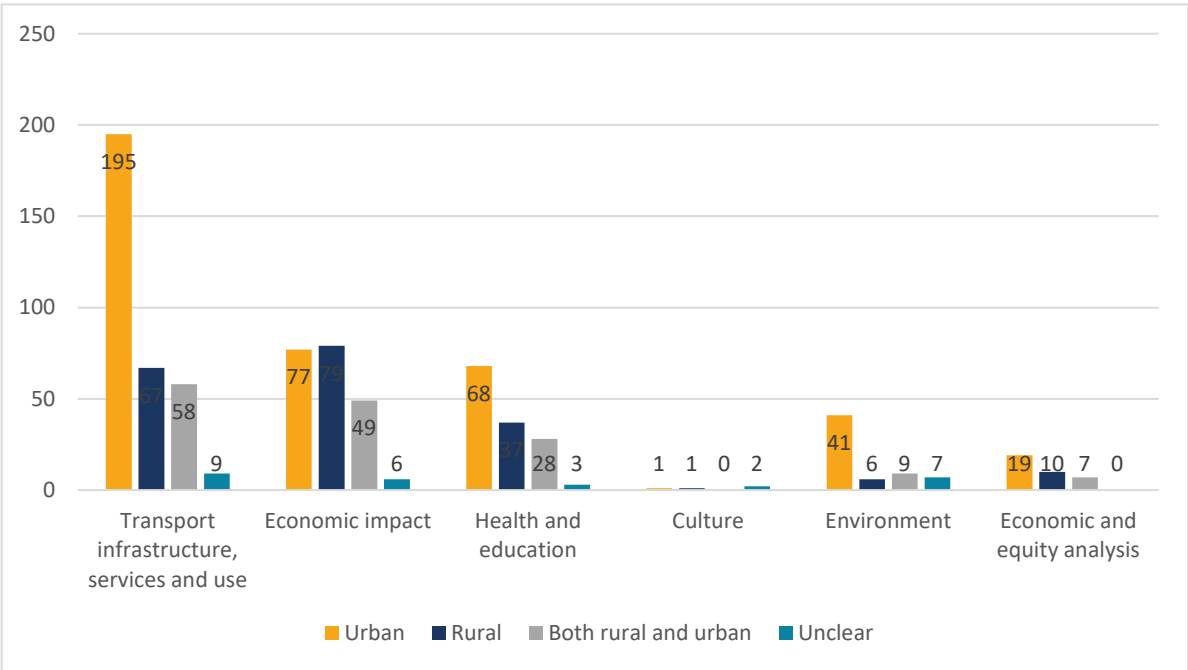
Figure 9: Number of studies by study design by region



Population groups

The effects of transport was studied for the urban population in a bit more than half of the studies (57% of total 442 studies), compared to under quarter (21%) considering rural population, and 18% covering both rural and urban. Urban studies look disproportionately at transport use, whereas rural studies are more concerned with economic impact (Figure 12).

Figure 10: Distribution of urban and rural studies by outcome



5.1.6 Status of included studies

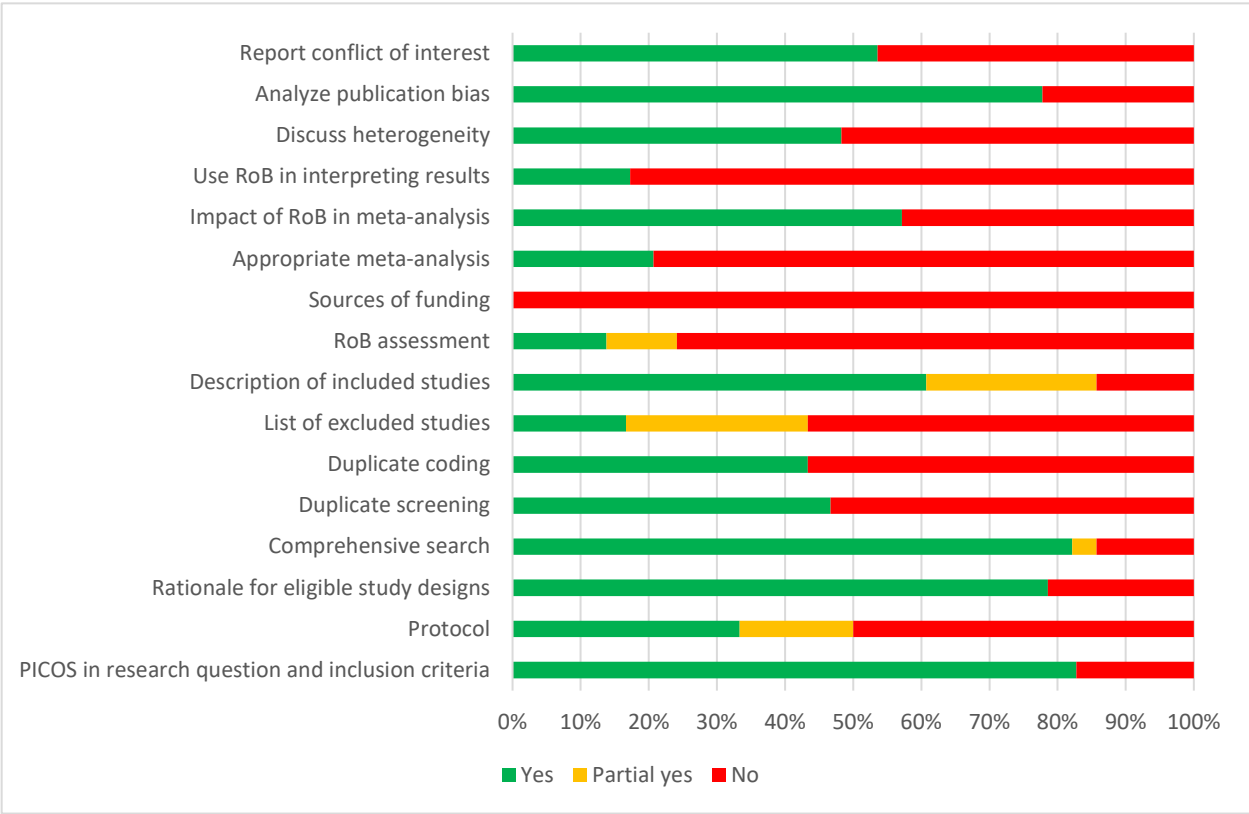
There are 437 completed studies and 5 ongoing studies included in the map.

5.1.7 Risk of bias in included reviews

There are 28 systematic reviews. We critically appraised the quality of the reviews by using AMSTAR-2. Among the included reviews, 85% of the systematic reviews rated as low and 11% rated as medium confidence in study findings. Only one review was rated as high confidence.

As shown in Figure 13, major limitations were the absence of risk of bias analysis, not undertaking meta-analysis, failure to use two screeners and coders (or at least a failure to report doing so), failure to have a protocol, and not declaring sources of funding. This assessment of the shortcomings in existing reviews reinforces the case for commissioning a new programme of reviews of transport studies.

Figure 11: AMSTAR2 assessment



6. Discussion and Gaps in Evidence

6.1 Summary of main results

This map has 442 studies, of which 28 are systematic reviews.

The majority of the studies are about road-related interventions and on infrastructure development. Most of the studies measured the impact of the intervention on transport cost and time and mode of transport used.

The East Asia and Pacific region accounts for the largest share of studies (42%), with most of these coming from China. Just over half of studies concern the urban population (57%).

Sectors other than roads are relatively neglected in the evidence base. Whilst there are a sizeable number of studies on railways, most of these are from one country (China). There is very little evidence on waterways, whose potential remains unrealized especially in sub-Saharan Africa.

There is very little evidence on equity analysis and culture. Only four studies among 442 about culture outcomes, and only four studies measured noise pollution. Only 15 studies measured the effects of transport on gender equity, 21 studies applying ex post cost-benefit analysis, and one study reported findings for transport equity.

The low ratio of reviews to primary studies makes this an under-reviewed area. Moreover, most the reviews have methodological shortcomings, such as a failure to conduct and use risk of bias analysis and to undertake meta-analysis where appropriate.

6.2 Areas of major gaps in the evidence

There are many blank cells in the intervention categories in civil aviation, and outcome categories related to culture. Most of the studies are concentrated on specific regions and countries. There is a need for more studies from Sub-Saharan Africa, Europe & Central Asia, and the Middle East and North Africa. And there is a lack of experimental studies on transport sector intervention even in areas where this may be possible such as incentives.

We found notable gaps in the evidence related to the intervention on the ports, shipping and no evidence on waterways. The evidence is very much concentrated on infrastructure development and use, economic impact, and health outcomes. There is a striking gap in studies that focus on the effects of transport on cultural heritage and diversity. There is a lack of evidence on outcomes such as noise pollution, values, language, and social cohesion transport equity and displacement.

There is very little evidence on environmental outcomes such as air quality. There are also few studies on equity issues such as gender equity.

6.3 Potential biases in the mapping process

In terms of biases, in the selection process, we have selected evidence available in the English language. And we have only included experimental (RCT), Quasi-experimental and regression study design. We have excluded before versus after studies with no comparison group.

6.4 Limitations of the EGM

- i. Eligible studies were restricted to those published in English.
- ii. Searching the grey literature is challenging, and, consequently, some eligible studies may have been missed.

6.5 Stakeholder Engagement throughout the EGM process

We have engaged stakeholders on the evidence matrix at the various organization that work on transport sector interventions. These include TERI University, Department of Civil Engineering, IIT-Delhi, and Independent Council for Road Safety International (ICORSI).

The draft report will be shared with World Bank, ADB, and African Development Bank as well as transport economics experts in a range of low-income countries including Africa. We will also reach out to key leading global university transport research centres including the University of Sydney, University of Leeds, and LET, University of Lyon.

7. Authors' conclusions

The mapping exercise has two goals:

- Facilitate access to, and use of, research on the effectiveness of transport interventions through the online interactive visualization of the map and accompanying list of references; and
- Identify priority areas for systematic reviews and impact evaluations for transport.

7.1 Implications for research, practice, and/or policy

The map points to several gaps in the evidence base with respect to primary studies. It also points to the lack of reviews, and the methodological shortcoming in most existing reviews. Some of the implications for further research are:

- Efforts are also needed to reach a consensus to identify priority areas for research with weak evidence synthesis by key funders and researchers in the field.
- Future research should study the interventions related to incentives and institutions and regulations in railways, port, shipping and waterways, and civil aviation.
- To fill the important gaps in this sector, there is a need for more studies on the areas of environment, education, culture, gender equity, and transport equity.
- The geographical base of evidence needs to be expanded, the majority of the studies to date are from East Asia and Pacific.

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Contributions of authors

The lead author is the person who develops and co-ordinates the EGM team, discusses and assigns roles for individual members of the team liaises with the editorial base and takes responsibility for the ongoing updates of the EGM.

Content expertise:

Nina Blöndal has conducted several impact evaluations of transport interventions and authored a chapter on transport impact evaluation for the ADB Guidebook. Dr. Howard White co-edited a special issue of the Journal of Development Effectiveness on infrastructure impact evaluations including contributing a paper on mixed methods in infrastructure studies.

Systematic review method expertise:

All authors are experienced systematic reviewers, which means that they are proficient in conducting various processes in an EGM, such as screening, quality assessment and coding. Howard White will provide technical support for the conducting the review.

EGM methods expertise:

Howard White as CEO provides technical and strategic support for the development of the EGM.

All team members have previous experience in systematic review methodology, including search, data collection, statistical analysis, theory-based synthesis, which mean they are proficient in carrying out the various processes in an EGM, such as search, eligibility screening, quality assessment and coding.

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John Eyers is a trained information retrieval specialist and has experience of supporting over 50 systematic maps and reviews in social sciences areas

Acknowledgements

We would like to acknowledge UK Department of International Development (DFID) under its support for the Centre for Excellence for Development Impact and Learning (CEDIL)

Declarations of interest

Howard White is the CEO of the Campbell Collaboration. He has no role in the editorial process for this EGM.

Plans for updating the EGM

We plan to update the map (or support others in doing so) when sufficient further studies and resources become available.

Differences between protocol and map

None

Sources of support

This EGM is supported by the UK Foreign, Commonwealth and Development Office (FCDO) under its support for the Centre for Excellence for Development Impact and Learning (CEDIL).

Online supplements

List of online supplements

[Link to online interactive EGM](#)

Appendix A: Framework

Intervention categories and sub-categories

Category	Sub-categories	Examples
Roads and pathways (including cycle paths)	Infrastructure	Construction and upgrading of roads, and highways Infrastructure maintenance
	Incentives	Road pricing and tolls Subsidies and taxes
	Institutions (including regulations)	Road legislation and agencies Vehicle and driving regulations Public private partnership (PPP)
Rail and trams	Infrastructure	Construction and upgrading Maintenance
	Incentives	Pricing structure Subsidies to rail operators
	Institutions (including regulations)	Regulatory framework Public private partnership (PPP) Nationalisation/privatisation
Ports, shipping and waterways	Infrastructure	Port and inland waterway construction and rehabilitation including modernization Maintenance
	Incentives	Tolls and other charges

		Taxes and subsidies
	Institutions (including regulations)	Port authorities
Civil Aviation	Infrastructure	Airports
	Incentives	Taxes and subsidies
	Institutions (including regulations)	Airport authorities

Outcomes

Domain	Sub-domain
Transport infrastructure, services and use	Infrastructure quantity Infrastructure quality (inc. safety assessment) Infrastructure services Transport time or costs (inc. congestion and VOC) Market access Transport modality (inc. car ownership) Safe practices
Economic Impact	Household income and poverty Economic Development Employment and migration Trade and tourism Location (land use) and prices Displacement
Health and education	Access to health facilities Health outcomes Access to education facilities Education outcomes
Culture	Values, language and social cohesion Cultural heritage Cultural diversity
Environment	Air quality Noise pollution Habitat destruction

Economic and equity analysis	Cost effectiveness or CBA Gender equity Transport equity ⁴
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⁴ Transportation equity or justice usually refers to the fairness with which the impacts of transportation such as benefits and costs are distributed. Horizontal equity, also called fairness and egalitarianism, is concerned with the distribution of impacts between individuals and groups considered equal in ability and need; vertical equity is concerned with the distribution of impacts between individuals and groups that differ in abilities and needs, for example by income or social class (also called social justice, environmental justice and social inclusion) or in transportation ability and need otherwise known as universal design (Litman, 2018)

Appendix B: Search terms

Intervention search term

- DE "TRANSPORTATION" OR DE "AIR travel" OR DE "AUTOMOTIVE transportation" OR DE "BUS transportation" OR DE "CARRIAGES & carts" OR DE "CARRIERS" OR DE "CHOICE of transportation" OR DE "COMMUTING" OR DE "DEEP sea passenger transportation" OR DE "DELIVERY of goods" OR DE "DRAYAGE" OR DE "EMERGENCY transportation" OR DE "EMPLOYER-sponsored transportation" OR DE "FERRIES" OR DE "FERRY routes" OR DE "FREIGHT & freightage" OR DE "GROUND passenger transportation" OR DE "HARBORS" OR DE "HIGH speed ground transportation" OR DE "INTERNATIONAL transit" OR DE "OCEAN travel" OR DE "PASSES (Transportation)" OR DE "PUBLIC transit" OR DE "RAILROAD travel" OR DE "RAILROADS" OR DE "ROADS" OR DE "ROUTE surveying" OR DE "RURAL transportation" OR DE "SHIPPING (Water transportation)" OR DE "SHUTTLE services" OR DE "SUSTAINABLE transportation" OR DE "TAXI service" OR DE "TRANSPORTATION demand management" OR DE "TRANSPORTATION management system" OR DE "TRANSPORTATION of school children" OR DE "URBAN transportation" OR DE "VEHICLES" OR DE "WAGON trains" OR DE "WATERWAYS" OR DE "FINANCING of transportation" OR DE "PUBLIC transit commissions" OR DE "TRANSPORTATION accidents" OR DE "TRANSPORTATION agencies" OR DE "TRANSPORTATION departments" OR DE "TRANSPORTATION industry" OR DE "TRANSPORTATION laws" OR DE "TRANSPORTATION policy"
- (DE "inland transport" OR DE "international transport" OR DE "long distance transport" OR DE "air transport" OR DE "rail transport" OR DE "refrigerated transport" OR DE "road transport" OR DE "bus transport" OR DE "airports" OR DE "railways" OR DE "roads" OR DE "transport costs" OR DE "transporting quality" OR DE "water transport" OR DE "waterways" OR DE "transport") OR DE "rural transport"
- TI ((Infrastructur* OR maintenance or maintain* OR repair* OR construction OR upgrade OR upgrading]) N6 (road* OR rail* OR tram* OR port OR ports OR ship* OR ships OR shipping OR waterway* OR aviation OR aircraft* OR "mass transport*" OR subway* OR transportation OR busway OR highway OR taxi* OR auto* OR "public trans*" OR

- "commuter trans*" OR "mass transit" OR "commuter train*" OR "passenger trans*" OR "passenger train*" OR trucks OR trucking OR freight OR lorry OR lorries OR vehicles)))
OR AB ((Infrastructur* OR maintenance or maintain*) N6 (road* OR rail* OR tram* OR port OR ports OR ship* OR ships OR shipping OR waterway* OR aviation OR aircraft* OR "mass transport*" OR subway*)) OR SU ((Infrastructur* OR maintenance or maintain*) N6 (road* OR rail* OR tram* OR port OR ports OR ship* OR ships OR shipping OR waterway* OR aviation OR aircraft* OR "mass transport*" OR subway*)))
- TI ((Incentiv* OR price OR prices OR pricing OR tariff* OR toll*) N6 (road* OR rail* OR tram* OR port OR ports OR ship* OR ships OR shipping OR waterway* OR aviation OR aircraft* OR "mass transport*" OR subway*)) OR AB ((Incentiv* OR price OR prices OR pricing OR tariff* OR toll*) N6 (road* OR rail* OR tram* OR port OR ports OR ship* OR ships OR shipping OR waterway* OR aviation OR aircraft* OR "mass transport*" OR subway*)) OR SU ((Incentiv* OR price OR prices OR pricing OR tariff* OR toll*) N6 (road* OR rail* OR tram* OR port OR ports OR ship* OR ships OR shipping OR waterway* OR aviation OR aircraft* OR "mass transport*" OR subway*)))
 - TI ((institution* OR organiz* OR organis* OR regulat*) N6 (road* OR rail* OR tram* OR port OR ports OR ship* OR ships OR shipping OR waterway* OR aviation OR aircraft* OR "mass transport*" OR subway*)) OR AB ((institution* OR organiz* OR organis* OR regulat* * OR policy OR policies OR law OR laws OR legislat* OR agencies OR "public private partnership" OR privatization OR privatisation OR nationalization OR nationalisation) N6 (road* OR rail* OR tram* OR port OR ports OR ship* OR ships OR shipping OR waterway* OR aviation OR aircraft* OR "mass transport*" OR subway*)) OR SU ((institution* OR organiz* OR organis* OR regulat*) N6 (road* OR rail* OR tram* OR port OR ports OR ship* OR ships OR shipping OR waterway* OR aviation OR aircraft* OR "mass transport*" OR subway*)))
 - TI (public private partnership OR PPP) OR (transport) N6 (access* OR services) OR (HDM-4) OR (road OR bridge OR congestion OR emission OR planning) N6 (toll OR charge OR tax)

Study design search terms

-
- TI (((quantitativ* N5 synthes*) OR "mixed method*" or mixed-method*)) OR AB (((quantitativ* N5 synthes*) OR "mixed method*" or mixed-method*)) OR SU (((quantitativ* N5 synthes*) OR "mixed method*" or mixed-method*))
 - TI ((random\$ or RCT or "double difference" or "regression discontinuity" or "propensity score" or matching or "comparison group" or "control group" or "instrumental variable*" or heckmann)) OR AB ((random\$ or RCT or "double difference" or "regression discontinuity" or "propensity score" or matching or "comparison group" or "control group" or "instrumental variable*" or heckmann)) OR SU ((random\$ or RCT or "double difference" or "regression discontinuity" or "propensity score" or matching or "comparison group" or "control group" or "instrumental variable*" or heckmann))
 - TI (("meta regression" or "meta synth*" or "meta-synth*" or "meta analy*" or metaanaly* or meta-analy* or metanaly* or "metaregression" or meta-regression or "methodologic* overview" or "pool* analys*" or "pool* data" or "quantitative* overview" or "research integration")) OR AB (("meta regression" or "meta synth*" or "meta-synth*" or "meta analy*" or metaanaly* or meta-analy* or metanaly* or "metaregression" or meta-regression or "methodologic* overview" or "pool* analys*" or "pool* data" or "quantitative* overview" or "research integration")) OR SU (("meta regression" or "meta synth*" or "meta-synth*" or "meta analy*" or metaanaly* or meta-analy* or metanaly* or "metaregression" or meta-regression or "methodologic* overview" or "pool* analys*" or "pool* data" or "quantitative* overview" or "research integration"))
 - TI (((systematic* or synthes*) N3 (research or evaluation* or finding* or thematic* or report or descriptive or explanatory or narrative or meta* or review*)) or (map N3 (evidence or gap))) OR AB (((systematic* or synthes*) N3 (research or evaluation* or finding* or thematic* or report or descriptive or explanatory or narrative or meta* or review*)) or (map N3 (evidence or gap))) OR SU (((systematic* or synthes*) N3 (research or evaluation* or finding* or thematic* or report or descriptive or explanatory or narrative or meta* or review*)) or (map N3 (evidence or gap)))

LMIC search terms-

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- TI (("transitional countr*" or "emerging econom*" or "global south")) OR AB (("transitional countr*" or "emerging econom*" or "global south"))
 - TI ((Imic or Imics or "third world" or "lami countr*")) OR AB ((Imic or Imics or "third world" or "lami countr*"))
 - TI (low N1 middle N1 countr*) OR AB (low N1 middle N1 countr*)
 - TI ((low* N1 (gdp or gnp or "gross domestic" or "gross national"))) OR AB ((low* N1 (gdp or gnp or "gross domestic" or "gross national")))
 - TI (((developing or "less* developed" or "least developed" or "under developed" or underdeveloped or "middle income" or "low* income" or underserved or "under served" or deprived or poor* or "resource limited" or "resource constrained") N1 (economy or economies))) OR AB (((developing or "less* developed" or "least developed" or "under developed" or underdeveloped or "middle income" or "low* income" or underserved or "under served" or deprived or poor* or "resource limited" or "resource constrained") N1 (economy or economies)))
 - TI (((developing or "less* developed" or "least developed" or "under developed" or underdeveloped or "middle income" or "low* income" or underserved or "under served" or deprived or poor* or "resource limited" or "resource constrained") N1 (countr* or nation? or population? or world or state*))) OR AB (((developing or "less* developed" or "least developed" or "under developed" or underdeveloped or "middle income" or "low* income" or underserved or "under served" or deprived or poor* or "resource limited" or "resource constrained") N1 (countr* or nation? or population? or world or state*)))
 - TI ((Afghanistan or Albania or Algeria or Angola or Argentina or Armenia or Armenian or Azerbaijan or Bangladesh or Benin or Byelarus or Byelorussian or Belarus or Belorussian or Belorussia or Belize or Bhutan or Bolivia or Bosnia or Herzegovina or Hercegovina or Botswana or Brazil or Bulgaria or "Burkina Faso" or "Burkina Fasso" or "Upper Volta" or Burundi or Urundi or Cambodia or "Khmer Republic" or Kampuchea or Cameroon or Cameroons or Cameron or Camerons or "Cape Verde" or "Central African Republic" or Chad or China or Colombia or Comoros or "Comoro Islands" or Comores or Mayotte or Congo or Zaire or "Costa Rica" or "Cote d'Ivoire" or "Ivory Coast" or Cuba or Djibouti or

"French Somaliland" or Dominica or "Dominican Republic" or "East Timor" or "East Timur" or "Timor Leste" or Ecuador or Egypt or "United Arab Republic" or "El Salvador" or Eritrea or Ethiopia or Fiji or Gabon or "Gabonese Republic" or Gambia or Gaza or "Georgia Republic" or "Georgian Republic" or Ghana or Grenada or Guatemala or Guinea or Guiana or Guyana or Haiti or Honduras or India or Maldives or Indonesia or Iran or Iraq or Jamaica or Jordan or Kazakhstan or Kazakh or Kenya or Kiribati or Korea or Kosovo or Kyrgyzstan or Kirghizia or "Kyrgyz Republic" or Kirghiz or Kirgizstan or "Lao PDR" or Laos or Lebanon or Lesotho or Basutoland or Liberia or Libya or Macedonia or Madagascar or "Malagasy Republic" or Malaysia or Malaya or Malay or Sabah or Sarawak or Malawi or Mali or "Marshall Islands" or Mauritania or Mauritius or "Agalega Islands" or Mexico or Micronesia or "Middle East" or Moldova or Moldovia or Moldovian or Mongolia or Montenegro or Morocco or Ifni or Mozambique or Myanmar or Myanma or Burma or Namibia or Nepal or "Netherlands Antilles" or Nicaragua or Niger or Nigeria or Muscat or Pakistan or Palau or Palestine or Panama or Paraguay or Peru or Philippines or Philipines or Phillipines or Phillippines or "Papua New Guinea" or Romania or Rumania or Roumania or Rwanda or Ruanda or "Saint Lucia" or "St Lucia" or "Saint Vincent" or "St Vincent" or Grenadines or Samoa or "Samoan Islands" or "Navigator Island" or "Navigator Islands" or "Sao Tome" or Senegal or Serbia or Montenegro or Seychelles or "Sierra Leone" or "Sri Lanka" or "Solomon Islands" or Somalia or Sudan or Suriname or Surinam or Swaziland or Eswatini or "South Africa" or Syria or Tajikistan or Tadjhikistan or Tadjikistan or Tadjhik or Tanzania or Thailand or Togo or "Togolese Republic" or Tonga or Tunisia or Turkey or Turkmenistan or Turkmen or Uganda or Ukraine or Uzbekistan or Uzbek or Vanuatu or "New Hebrides" or Venezuela or Vietnam or "Viet Nam" or "West Bank" or Yemen or Zambia or Zimbabwe)) OR AB ((Afghanistan or Albania or Algeria or Angola or Argentina or Armenia or Armenian or Azerbaijan or Bangladesh or Benin or Byelarus or Byelorussian or Belarus or Belorussian or Belorussia or Belize or Bhutan or Bolivia or Bosnia or Herzegovina or Hercegovina or Botswana or Brazil or Bulgaria or "Burkina Faso" or "Burkina Fasso" or "Upper Volta" or Burundi or Urundi or Cambodia or "Khmer Republic" or Kampuchea or Cameroon or Cameroons or Cameron or Camerons or "Cape Verde" or "Central African Republic" or Chad or China or Colombia or Comoros or "Comoro Islands" or Comores or Mayotte or Congo or Zaire or "Costa Rica" or "Cote d'Ivoire" or "Ivory Coast" or Cuba or Djibouti or "French Somaliland" or Dominica or "Dominican Republic" or "East Timor" or "East Timur" or "Timor Leste" or Ecuador or Egypt or "United Arab Republic" or "El Salvador" or Eritrea or Ethiopia or Fiji or Gabon or "Gabonese Republic" or Gambia or

Gaza or "Georgia Republic" or "Georgian Republic" or Ghana or Grenada or Guatemala or Guinea or Guiana or Guyana or Haiti or Honduras or India or Maldives or Indonesia or Iran or Iraq or Jamaica or Jordan or Kazakhstan or Kazakh or Kenya or Kiribati or Korea or Kosovo or Kyrgyzstan or Kirghizia or "Kyrgyz Republic" or Kirghiz or Kirgizstan or "Lao PDR" or Laos or Lebanon or Lesotho or Basutoland or Liberia or Libya or Macedonia or Madagascar or "Malagasy Republic" or Malaysia or Malaya or Malay or Sabah or Sarawak or Malawi or Mali or "Marshall Islands" or Mauritania or Mauritius or "Agalega Islands" or Mexico or Micronesia or "Middle East" or Moldova or Moldovia or Moldovian or Mongolia or Montenegro or Morocco or Ifni or Mozambique or Myanmar or Myanma or Burma or Namibia or Nepal or "Netherlands Antilles" or Nicaragua or Niger or Nigeria or Muscat or Pakistan or Palau or Palestine or Panama or Paraguay or Peru or Philippines or Philipines or Phillipines or Phillippines or "Papua New Guinea" or Romania or Rumania or Roumania or Rwanda or Ruanda or "Saint Lucia" or "St Lucia" or "Saint Vincent" or "St Vincent" or Grenadines or Samoa or "Samoan Islands" or "Navigator Island" or "Navigator Islands" or "Sao Tome" or Senegal or Serbia or Montenegro or Seychelles or "Sierra Leone" or "Sri Lanka" or "Solomon Islands" or Somalia or Sudan or Suriname or Surinam or Swaziland or Eswatini or "South Africa" or Syria or Tajikistan or Tadzhikistan or Tadjikistan or Tadjhik or Tanzania or Thailand or Togo or "Togolese Republic" or Tonga or Tunisia or Turkey or Turkmenistan or Turkmen or Uganda or Ukraine or Uzbekistan or Uzbek or Vanuatu or "New Hebrides" or Venezuela or Vietnam or "Viet Nam" or "West Bank" or Yemen or Zambia or Zimbabwe)) OR ((Afghanistan or Albania or Algeria or Angola or Argentina or Armenia or Armenian or Azerbaijan or Bangladesh or Benin or Byelarus or Byelorussian or Belarus or Belorussian or Belorussia or Belize or Bhutan or Bolivia or Bosnia or Herzegovina or Hercegovina or Botswana or Brazil or Bulgaria or "Burkina Faso" or "Burkina Fasso" or "Upper Volta" or Burundi or Urundi or Cambodia or "Khmer Republic" or Kampuchea or Cameroon or Cameroons or Cameron or Camerons or "Cape Verde" or "Central African Republic" or Chad or China or Colombia or Comoros or "Comoro Islands" or Comores or Mayotte or Congo or Zaire or "Costa Rica" or "Cote d'Ivoire" or "Ivory Coast" or Cuba or Djibouti or "French Somaliland" or Dominica or "Dominican Republic" or "East Timor" or "East Timur" or "Timor Leste" or Ecuador or Egypt or "United Arab Republic" or "El Salvador" or Eritrea or Ethiopia or Fiji or Gabon or "Gabonese Republic" or Gambia or Gaza or "Georgia Republic" or "Georgian Republic" or Ghana or Grenada or Guatemala or Guinea or Guiana or Guyana or Haiti or Honduras or India or Maldives or Indonesia or Iran or Iraq or Jamaica or Jordan or Kazakhstan or Kazakh or Kenya or Kiribati or Korea or

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- TI ((Africa or Asia or Caribbean or "West Indies" or "South America" or "Latin America" or "Central America")) OR AB ((Africa or Asia or Caribbean or "West Indies" or "South America" or "Latin America" or "Central America")) OR ((Africa or Asia or Caribbean or "West Indies" or "South America" or "Latin America" or "Central America"))
- DE "Developing Countries" OR DE "Argentina" OR DE "Aruba" OR DE "Bahamas" OR DE "Bahrain" OR DE "Barbados" OR DE "Belize" OR DE "Bermuda" OR DE "Bolivia" OR DE "Bonaire" OR DE "Brazil" OR DE "British Virgin Islands" OR DE "Brunei Darussalam" OR DE "Cameroon" OR DE "Cayman Islands" OR DE "Chile" OR DE "China" OR DE "Christmas Island" OR DE "Cocos Islands" OR DE "Colombia" OR DE "Congo" OR DE "Cook Islands" OR DE "Costa Rica" OR DE "Cote d'Ivoire" OR DE "Crozet Islands" OR DE "Cuba" OR DE "Curacao" OR DE "Cyprus" OR DE "Dominica" OR DE "Dominican Republic" OR DE "Easter Island" OR DE "Ecuador" OR DE "Egypt" OR DE "El Salvador" OR DE "Falkland Islands" OR DE "Federated States of Micronesia" OR DE "Fiji" OR DE "French Guiana" OR DE "Gabon" OR DE "Gambier Islands" OR DE "Ghana" OR DE "Grenada" OR DE "Guadeloupe" OR DE "Guam" OR DE "Guatemala" OR DE "Guyana" OR DE "Honduras" OR DE "India" OR DE

"Indonesia" OR DE "Iran" OR DE "Iraq" OR DE "Jamaica" OR DE "Jordan" OR DE "Kenya" OR DE "Kerguelen Archipelago" OR DE "Korea Democratic People's Republic" OR DE "Korea Republic" OR DE "Kuwait" OR DE "Least Developed Countries" OR DE "Lebanon" OR DE "Libya" OR DE "Malaysia" OR DE "Marquesas Islands" OR DE "Marshall Islands" OR DE "Martinique" OR DE "Mauritius" OR DE "Mayotte" OR DE "Mexico" OR DE "Midway Islands" OR DE "Mongolia" OR DE "Montserrat" OR DE "Morocco" OR DE "Namibia" OR DE "New Britain" OR DE "New Caledonia" OR DE "New Ireland" OR DE "Nicaragua" OR DE "Nigeria" OR DE "Niue" OR DE "Northern Mariana Islands" OR DE "Oman" OR DE "Pakistan" OR DE "Panama" OR DE "Papua New Guinea" OR DE "Paraguay" OR DE "Peru" OR DE "Philippines" OR DE "Algeria" OR DE "Puerto Rico" OR DE "Qatar" OR DE "Reunion" OR DE "Saba" OR DE "Saint Helena" OR DE "Saint Kitts and Nevis" OR DE "Saint Lucia" OR DE "Saint Vincent and the Grenadines" OR DE "Saudi Arabia" OR DE "Senegal" OR DE "Seychelles" OR DE "Singapore" OR DE "South Africa" OR DE "Sri Lanka" OR DE "Suriname" OR DE "Swaziland" OR DE "Syria" OR DE "Tahiti" OR DE "Thailand" OR DE "Tokelau" OR DE "Tonga" OR DE "Angola" OR DE "Anguilla Island" OR DE "Trinidad and Tobago" OR DE "Tuamotu" OR DE "Tubuai Islands" OR DE "Tunisia" OR DE "Turkey" OR DE "Turks and Caicos Islands" OR DE "United Arab Emirates" OR DE "Uruguay" OR DE "Venezuela" OR DE "Vietnam" OR DE "Wallis and Futuna" OR DE "Western Sahara" OR DE "Zimbabwe" OR DE "Antigua and Barbuda"

- DE "Caribbean" OR DE "Bahamas" OR DE "Turks and Caicos Islands" OR DE "Antilles" OR DE "French West Indies" OR DE "Guadeloupe" OR DE "Martinique"
- DE "Pacific Islands" OR DE "Macquarie Island" OR DE "Melanesia" OR DE "Micronesia" OR DE "Norfolk Island" OR DE "Polynesia" OR DE "Wake Island" OR DE "French Polynesia" OR DE "Gambier Islands" OR DE "Marquesas Islands" OR DE "Society Islands" OR DE "Tuamotu" OR DE "Tubuai Islands" OR DE "Oceania" OR DE "Australasia" OR DE "Micronesia" OR DE "Polynesia"
- DE "South East Asia" OR DE "Brunei Darussalam" OR DE "Indochina" OR DE "Indonesia" OR DE "Malaysia" OR DE "Myanmar" OR DE "Philippines" OR DE "Singapore" OR DE "Taiwan" OR DE "Thailand" OR DE "West Asia" OR DE "Armenia" OR DE "Azerbaijan" OR DE "Iran" OR DE "Iraq" OR DE "Israel" OR DE "Jordan" OR DE "Kazakhstan" OR DE "Kyrgyzstan" OR DE "Lebanon" OR DE "Afghanistan" OR DE "Oman" OR DE "Palestine" OR DE "Persian Gulf States" OR DE "Republic of Georgia" OR DE "Saudi Arabia" OR DE "Syria" OR DE "Tajikistan"

OR DE "Turkey" OR DE "Turkmenistan" OR DE "Uzbekistan" OR DE "Yemen" OR DE "East Asia" OR DE "China" OR DE "Japan" OR DE "Korea Democratic People's Republic" OR DE "Korea Republic" OR DE "Mongolia" OR DE "South Asia" OR DE "Bangladesh" OR DE "Bhutan" OR DE "India" OR DE "Nepal" OR DE "Pakistan" OR DE "Sri Lanka" OR DE "Central Asia" OR DE "Kazakhstan" OR DE "Kyrgyzstan" OR DE "Mongolia" OR DE "Afghanistan" OR DE "Tajikistan" OR DE "Turkmenistan" OR DE "Uzbekistan" OR DE "Xinjiang"

- DE "Mexico"
- DE "South America" OR DE "Argentina" OR DE "Bolivia" OR DE "Brazil" OR DE "Chile" OR DE "Colombia" OR DE "Ecuador" OR DE "Falkland Islands" OR DE "French Guiana" OR DE "Guyana" OR DE "Paraguay" OR DE "Peru" OR DE "Amazonia" OR DE "Suriname" OR DE "Uruguay" OR DE "Venezuela" OR DE "Latin America" OR DE "Argentina" OR DE "Bolivia" OR DE "Brazil" OR DE "Chile" OR DE "Colombia" OR DE "Costa Rica" OR DE "Cuba" OR DE "Dominican Republic" OR DE "Ecuador" OR DE "El Salvador" OR DE "Guatemala" OR DE "Honduras" OR DE "Mexico" OR DE "Nicaragua" OR DE "Panama" OR DE "Paraguay" OR DE "Peru" OR DE "Puerto Rico" OR DE "Uruguay" OR DE "Venezuela" OR DE "Central America" OR DE "Belize" OR DE "Costa Rica" OR DE "El Salvador" OR DE "Guatemala" OR DE "Honduras" OR DE "Nicaragua" OR DE "Panama"
- DE "Africa" OR DE "Francophone Africa" OR DE "Africa South of Sahara" OR DE "North Africa" OR DE "Portuguese Speaking Africa" OR DE "Anglophone Africa"

Appendix C: Coding Tool

Study design	<ul style="list-style-type: none"> ○ RCT ○ Quasi-experimental study ○ Cluster-quasi RCT ○ Systematic Review ○ Regression Discontinuity Design ○ Controlled before and after study ○ Cost-effectiveness analysis ○ Cost benefit analysis ○ Economic Impact ○ Transport equity/justice
Publication status	<ul style="list-style-type: none"> ○ Completed ○ Ongoing
Study Methods	<ul style="list-style-type: none"> ○ Difference in difference ○ Propensity Score Matching ○ Instrument Variable/Heckmann selection ○ Multivariate/covariate adjusted analysis (e.g. ANCOVA analysis) ○ Bivariate analysis/comparison of means
Population	<ul style="list-style-type: none"> ○ Rural ○ Urban ○ Both rural and urban
Region	<ul style="list-style-type: none"> ○ East Asia & Pacific ○ Latin America & Caribbean ○ Middle East & North Africa ○ South Asia ○ Sub-Saharan Africa ○ Europe & Central Asia

Intervention	<ul style="list-style-type: none"> • Infrastructure <ul style="list-style-type: none"> ■ Roads ■ Rail, trams, monorail ■ Ports, shipping, and waterways ■ Civil Aviation ○ Incentives <ul style="list-style-type: none"> ■ Roads ■ Rail, trams, monorail ■ Ports, shipping, and waterways ■ Civil Aviation ○ Institutions (including regulations) <ul style="list-style-type: none"> ■ Roads ■ Rail, trams, monorail ■ Ports, shipping, and waterways
Outcome	<ul style="list-style-type: none"> ○ Transport infrastructure, services and use <ul style="list-style-type: none"> ■ Infrastructure quantity ■ Infrastructure quality ■ Infrastructure services ■ Transport time and costs ■ Market access ■ Transport modality ■ Safe practices ○ Economic impact <ul style="list-style-type: none"> ■ Household income and poverty ■ Economic development ■ Employment and migration ■ Trade and Tourism ■ Location, land use and prices ■ Displacement ○ Health and Education <ul style="list-style-type: none"> ■ Access to health facilities ■ Health outcomes ■ Access to education facilities ■ Education outcomes ○ Culture <ul style="list-style-type: none"> ■ Values, language and social cohesion

	<ul style="list-style-type: none"> ■ Cultural heritage ■ Cultural diversity ○ Environment <ul style="list-style-type: none"> ■ Air Quality ■ Noise pollution ■ Habitat destruction ○ Economic & equity analysis <ul style="list-style-type: none"> ■ Cost analysis inc CBA ■ Gender equity ■ Transport equity
Study type	<ul style="list-style-type: none"> ○ Impact evaluations ○ Systematic review

AMSTAR-2 for systematic reviews

- 1) Did the research questions and inclusion criteria for the review include the components of PICO?
 - i) Yes
 - (1) Population
 - (2) Intervention
 - (3) Comparator group
 - (4) Outcome
 - (5) Time frame for follow-up (optional)
 - ii) No

- 2) Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol?
 - i) Yes: The authors state that they had a written protocol or guide that included ALL the following
 - (1) Review question
 - (2) Search strategy
 - (3) Inclusion/exclusion criteria
 - (4) a risk of bias assessment
 - (5) a meta-analysis/synthesis plan, if appropriate,
 - (6) a plan for investigating causes of heterogeneity
 - (7) justification for any deviations from the protocol

- ii) Partial Yes: The authors state that they had a written protocol or guide that included ALL the following
 - (1) review question(s)
 - (2) a search strategy
 - (3) inclusion/exclusion criteria
 - (4) a risk of bias assessment
 - iii) No
- 3) Did the review authors explain their selection of the study designs for inclusion in the review?
 - i) Yes: If the review satisfy ONE of the following
 - (1) Explanation for including only RCTs
 - (2) OR Explanation for including only NRSI
 - (3) OR Explanation for including both RCTs and NRSI
 - ii) No
- 4) Did the review authors use a comprehensive literature search strategy?
 - i) Yes: Should have all the following
 - (1) searched at least two databases (relevant to research question)
 - (2) provided key word and/or search strategy
 - (3) justified publication restrictions (e.g. language)
 - (4) searched the reference lists / bibliographies of included studies
 - (5) searched trial/study registries
 - (6) included/consulted content experts in the field
 - (7) where relevant, searched for grey literature
 - (8) conducted search within 24 months of completion of the review
 - ii) Partial yes: All the following
 - (1) searched at least two databases (relevant to research question)
 - (2) provided key word and/or search strategy
 - (3) justified publication restrictions (e.g. language)
 - iii) No
- 5) Did the review authors perform study selection in duplicate?
 - i) Yes, either ONE of the following
 - (1) at least two reviewers independently agreed on selection of eligible studies and achieved consensus on which studies to include
 - (2) two reviewers selected a sample of eligible studies and achieved good agreement (at least 80 percent), with the remainder selected by one reviewer.
 - ii) No
- 6) Did the review authors perform data extraction in duplicate?

- i) Yes: either ONE of the following
 - (1) at least two reviewers achieved consensus on which data to extract from included studies
 - (2) two reviewers extracted data from a sample of eligible studies and achieved good agreement (at least 80 percent), with the remainder extracted by one reviewer
 - ii) No
- 7) Did the review authors provide a list of excluded studies and justify the exclusions?
- i) Yes: if it includes the following
 - (1) provided a list of all potentially relevant studies that were read in full-text form but excluded from the review
 - (2) Justified the exclusion from the review of each potentially relevant study
 - ii) Partial Yes if:
 - (1) provided a list of all potentially relevant studies that were read in full-text form but excluded from the review
 - iii) No
- 8) Did the review authors describe the included studies in adequate detail?
- i) Yes: should also have ALL the following
 - (1) described population in detail
 - (2) described intervention in detail (including doses where relevant)
 - (3) described comparator in detail (including doses where relevant)
 - (4) described study's setting
 - (5) timeframe for follow-up
 - ii) Partial Yes: should have the following
 - (1) described populations
 - (2) described interventions
 - (3) described comparators
 - (4) described outcomes
 - (5) described research designs
 - iii) No
- 9) Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?
- i) RCTs
 - (1) Yes: must have assessed RoB from
 - (a) allocation sequence that was not truly random, and
 - (b) selection of the reported result from among multiple measurements or analyses of a specified outcome
 - (2) Partial Yes: must have assessed RoB from
 - (a) unconcealed allocation, and

- (b) lack of blinding of patients and assessors when assessing outcomes (unnecessary for objective outcomes such as all-cause mortality)
 - (3) No
 - ii) NRSI
 - (1) Yes: must also have assessed RoB from
 - (a) methods used to ascertain exposures and outcomes, and
 - (b) selection of the reported result from among multiple measurements or analyses of a specified outcome
 - (2) Partial Yes: must have assessed RoB
 - (a) from confounding, and
 - (b) from selection bias
 - (3) No
- 10) Did the review authors report on the sources of funding for the studies included in the review
- i) Yes: Must have reported on the sources of funding for individual studies included in the review. Note: Reporting that the reviewers looked for this information but it was not reported by study authors also qualifies
 - ii) No
- 11) If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results?
- i) RCTs
 - (1) Yes if
 - (a) The authors justified combining the data in a meta-analysis
 - (b) AND they used an appropriate weighted technique to combine study results and adjusted for heterogeneity if present.
 - (c) AND investigated the causes of any heterogeneity
 - (2) No
 - (3) No meta-analysis conducted
 - ii) For NRSI
 - (1) Yes if
 - (a) The authors justified combining the data in a meta-analysis
 - (b) AND they used an appropriate weighted technique to combine study results, adjusting for heterogeneity if present
 - (c) AND they statistically combined effect estimates from NRSI that were adjusted for confounding, rather than combining raw data, or justified combining raw data when adjusted effect estimates were not available
 - (d) AND they reported separate summary estimates for RCTs and NRSI separately when both were included in the review
 - (2) No
 - (3) No meta-analysis conducted
- 12) If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?

- i) Yes if
 - (1) included only low risk of bias RCTs
 - (2) OR, if the pooled estimate was based on RCTs and/or NRSI at variable RoB, the authors performed analyses to investigate possible impact of RoB on summary estimates of effect
- ii) No
- iii) No meta-analysis conducted

13) Did the review authors account for RoB in individual studies when interpreting/ discussing the results of the review?

- i) Yes if
 - (1) included only low risk of bias RCTs
 - (2) OR, if RCTs with moderate or high RoB, or NRSI were included the review provided a discussion of the likely impact of RoB on the results
- ii) No

14) Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?

- i) Yes if
 - (1) There was no significant heterogeneity in the results
 - (2) OR if heterogeneity was present the authors performed an investigation of sources of any heterogeneity in the results and discussed the impact of this on the results of the review
- ii) No

15) If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?

- i) Yes if
 - (1) performed graphical or statistical tests for publication bias and discussed the likelihood and magnitude of impact of publication bias
- ii) No
- iii) No meta-analysis conducted

16) Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?

- i) Yes if
 - (1) The authors reported no competing interests OR
 - (2) The authors described their funding sources and how they managed potential conflicts of interest
- ii) No

b) Overall study quality

- i) High: No or one non-critical weakness
the systematic review provides an accurate and comprehensive summary of the results of the available studies that address the question of interest

- ii) Moderate: More than one non-critical weakness
- iii) Low: One critical flaw* with or without non-critical weaknesses

Appendix D Definitions of Interventions and Outcome

Terms	Definition
Transport infrastructure, services and use-	Transport infrastructure (e.g. roads, railways, ports, or airports), upgrading existing links and technology, or improving transport services, such as public bus services. Services available, introduced and usage of the available transport infrastructure.
Infrastructure quantity	Infrastructure increase or growth
Infrastructure quality (inc. safety assessment)	Quality of the available infrastructure (Road quality)
Infrastructure services	Logistics- transportation of the agricultural products, goods and other materials.
Transport time or costs (inc. congestion and VOC)	Access to transport infrastructure, travel time, time taken to access the available transport infrastructure, frequency of service, connectivity, travel cost and Congestion. Congestion in transport is a major problem in both developed and developing countries involving high opportunity costs
Market access	Access to market by the population and it also include the access by the enterprises or farmers to sell their goods in the market.
Transport modality (inc. car ownership)	Modes of transportation and it include ownership (Car)
Safe practices	Safe practices such as speed limits, use of helmets and other practices.
Economic Impact-	Economic impact analysis is an exercise to determine how a transport intervention project or policy affects the amount and type of economic activity in a region. Provision of transport as a service to reduce poverty by increasing economic efficiency and enhancing opportunities. Transport allows people to reach out to job or its effects on Employment opportunities and migration.

Household income and poverty	Increase in household income, Poverty
Economic Development	Enterprise development (Profitability), GDP and Agricultural production
Employment and migration	Increase in Employment opportunities Road accessibility has impact on population movements.
Trade and tourism	Transfer of goods and services, trade activities and tourism development and affects.
Location (land use) and prices	Locations of the firm or the household. Effects on the prices of the property.
Displacement	Displacement of the population due to transport infrastructure. (Construction, other infrastructure development projects)
<p>Health and education- Transport can affect health, both positive (access to health services, higher income, availability of more diversified diet etc.) and negative (road traffic injuries, air pollution, and spreading disease).</p> <p>Education also affected by the transport, it gives access to educational facilities and lack of transport infrastructures affect the educational status of the population.</p>	
Access to health facilities	Health facilities- Health centres (Primary and secondary) and Emergency services (Obstetric)
Health outcomes	Health related outcomes- Improved health status, improvement in health conditions disease. Spread of disease - Transport systems can also help spread infectious diseases, such as the recent Ebola epidemic (World Bank, 2014) and Covid-19 Road traffic injuries- Rise in fatalities and road injuries especially in LMICs due to poor quality of roads and road safety regulations
Access to education facilities	Education facilities such as Schools, college or vocational centres.

Education outcomes	Educational status – School enrolment, attendance rate, dropout rates.
Culture- Cultural effects, both positive and negative consequences of increased mobility within and between nations.	
Values, language and social cohesion	Effects on the social cohesion, values of the population (Due to forced displacement and migration)
Cultural heritage	
Cultural diversity	Different cultural, its diversity
Environment- Transport system may also disturb ecosystem through deforestation, biodiversity loss, pollution, road kill, and blocking of seasonal migration patterns of wildlife	
Air quality	Air pollution caused by vehicle emissions, from increased traffic volumes.
Noise pollution	Sounds of Vehicle and Industrial areas (Transport Hub)
Habitat destruction	<i>Habitat loss</i> and <i>habitat</i> reduction due to improved transport infrastructure
Economic and equity analysis	
Cost Analysis inc CBA	CBA- Cost benefit/benefit-cost analysis is an exercise to determine the social welfare effects of transport sector interventions in comparison to costs.
Gender equity	Promoting women travellers, provision or benefits to women in transport infrastructure, Gender promotion.
Transport equity ⁵	Transportation equity or justice usually refers to the fairness with which the impacts of transportation such

⁵ Transportation equity or justice usually refers to the fairness with which the impacts of transportation such as benefits and costs are distributed. Horizontal equity, also called fairness and egalitarianism, is

	as benefits and costs are distributed. Horizontal equity, also called fairness and egalitarianism, is concerned with the distribution of impacts between individuals and groups considered equal in ability and need; vertical equity is concerned with the distribution of impacts between individuals and groups that differ in abilities and needs, for example by income or social class (also called social justice, environmental justice and social inclusion) or in transportation ability and need otherwise known as universal design
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concerned with the distribution of impacts between individuals and groups considered equal in ability and need; vertical equity is concerned with the distribution of impacts between individuals and groups that differ in abilities and needs, for example by income or social class (also called social justice, environmental justice and social inclusion) or in transportation ability and need otherwise known as universal design (Litman, 2018)