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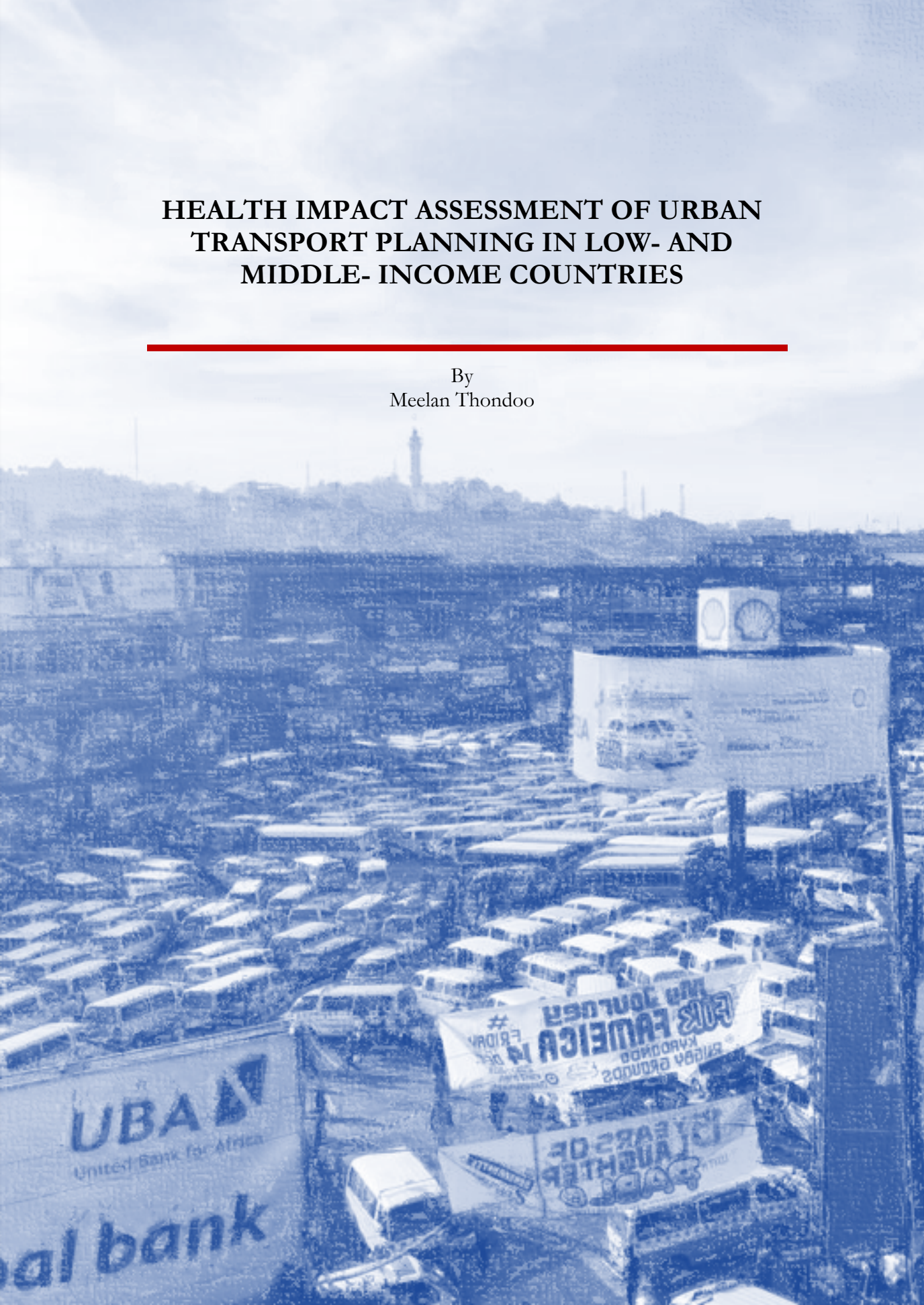
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HEALTH IMPACT ASSESSMENT OF URBAN TRANSPORT PLANNING IN LOW- AND MIDDLE- INCOME COUNTRIES

By
Meelan Thondoo



HEALTH IMPACT ASSESSMENT OF URBAN TRANSPORT PLANNING IN LOW- AND MIDDLE- INCOME COUNTRIES

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Dit proefschrift is tot stand gekomen in het kader van het ‘International Doctorate in Transdisciplinary Global Health Solutions- Erasmus Mundus Joint Doctorate Trans Global Health Programme’, met als doel het behalen van een gezamenlijk doctoraat. Het proefschrift is voorbereid aan de Faculteit der Maatschappij- en Gedragwetenschappen van de Universiteit van Amsterdam en in het Institut de Salut Global de Barcelona (ISGlobal) van de Universitat de Barcelona.

This thesis has been written within the framework of the ‘International Doctorate in Transdisciplinary Global Health Solutions- Erasmus Mundus Joint Doctorate Trans Global Health Programme’, with the purpose of obtaining a joint doctorate degree. This thesis was prepared in the Faculty of Social and Behavioral Sciences at the University of Amsterdam and in the Barcelona Institute of for Global Health at the University of Barcelona

In loving memory of my mother

Lin San Keow Thondoo a.k.a 'Zine'
(1957-2019)



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'To the mind that is still, the whole universe surrenders'

SUMMARY

Urban transport contributes to the development of cities in Low-and-Middle Income Countries (LMICs) by generating economic growth, competitiveness and social progress. While rapid urbanization and mass motorization are often considered as measures for economic success, they are two key trends responsible for negative health impacts of transport. These impacts are likely to increase disproportionately in LMICs where 90% of 2.5 billion new urbanites will have migrated to by 2050. Already, poor countries bear 80% of global non-communicable disease (NCD) deaths, 92 % of pollution-related deaths and 90% of traffic-related deaths in the world. Hence, new methods to assess how urban transport influences population health in LMICs are urgently needed.

Health Impact Assessments (HIAs) are known as evaluation tools to assess the overall burden of mortality and morbidity related to urban transport development in cities. HIAs can be used by policy makers to mitigate risks and increase benefits by estimating effects of transport policies on health and economic costs. Yet, only 6% of HIAs are conducted in LMICs. They cover limited areas and their purpose is restricted to approving privately led projects rather than integrating health into non-health sectors. Few LMICs regulate HIA with legislation and guidelines. No studies currently show how HIAs of urban transport planning can contribute to wider development policy agendas even if sustainability is stipulated as a ground value of HIA. Finally, few studies focus on participatory quantitative HIA (PQHIA) that combines stakeholder participation with quantitative HIA modelling and promotes evidence-based policy making. No peer-reviewed PQHIA of urban transport planning has been conducted in Africa.

This thesis examines and fills the practice, policy and theoretical gaps related to HIAs in LMICs. The overall aim of the thesis is to bring health into the agenda of urban transport by developing and testing a full chain PQHIA of urban transport planning policy applicable to LMICs. The main research question is: How can Health Impact Assessments of urban transport planning contribute to inclusive development in low- and middle- income countries? The research took place on the island of Mauritius located in sub-Saharan Africa, where the mismatch between urban population growth, exposure to environmental pollutants and limited resources are exacerbating urban health risks. The thesis is presented in 9 chapters. Chapters 1-3 present the general introduction, theoretical background and overall methods. Chapters 4-8 present five published/submitted papers and respective results used to respond to the main aim of the thesis. Chapter 9 discusses the main findings and implications for the advancement of HIA in LMICs.

This thesis applied a transdisciplinary approach and utilized qualitative and quantitative methods to conduct PQHIA. The theoretical lens applied to the thesis combines the DPSEEA model (Driver-Pressure-State-Exposure-Effect-Action), the Inclusive Development theory (ID) and the HIA approach. The former traces the process by which a problem is caused and action is taken to address it. The latter looks at the degree to which the action taken accounts for social, ecological and relational inclusiveness. DPSEEA accommodates for the complex correlation between environmental indicators

(e.g. air pollution) and health outcomes (e.g. death) while detailing the multistage and cumulative nature of health risks potentially generated by urban transport. As a policy-driven tool, HIAs can point out that the cost of inaction may be higher than the cost of action. This cost may have an economic value but may also carry social, political and ecological dimensions - justifying the relevance of inclusive development theory to the thesis. Inclusive development provides a strong foundation to examine how LMICs can garner tools such as HIA to compensate for unequal distribution of death and disease within larger processes of urbanisation and motorisation.

The thesis started by investigating the state of art of HIA practice and policy in LMICs (chapter 4-5). In chapter 4, a systematic literature review was performed to identify the trends in HIA practice across 156 countries in the world. In total, 57 HIA case studies were identified in 26 countries. They varied significantly in purpose and methods. No study reported the time, money, and staff used to perform HIAs. Most HIAs were quantitative (72%), none of which were participatory (no PQHIAs). Barriers to HIA implementation included limited transparency in process, weak participation, and inconsistent delivery of recommendations. This paper was published in IJERPH journal. In chapter 5, a content analysis of policy was conducted to sketch the global HIA policy landscape and examine links with sustainable development. Currently, 25 LMICs have some form of policy, guideline or framework regulating HIA. Benefits of HIA policy include the use of integrative approaches, the promotion of regulatory processes, and the uptake of cost evaluation outcomes. Challenges for HIA policy include the lack of uniformity in HIA practice, the power dynamics around health integration, and the mismatch between policy frameworks and technical objectives. Adapted HIA legislation provides an opportunity for LMICs to achieve the Sustainable Development Goals (SDGs). This paper was published in RECIEL journal. Findings from chapter 4 and 5 provided a comprehensive overview of trends in HIA theory, practice and policy in LMICs.

The thesis then proceeded to examine the urban transport planning context in Mauritius (chapter 6) before designing, testing and conducting a full chain PQHIA of urban transport in the capital city of Port Louis (chapter 7-8). Chapter 6 examined the alignment between urban transport policies and citizen needs. It also identified which population groups were most likely to be affected by possible misalignments. Policies in Mauritius emphasize an economic agenda focused on transport infrastructure rather than addressing public needs geared towards integrating urban transport planning in social life. There was an uneven distribution of urban transport needs across population groups (age, gender, socio-economic status). Policies catered for needs most likely to be expressed by the poor. Policies did not promote social and health agendas.

Findings from chapter 6 were used to design and deploy the full chain PQHIA in Port Louis. Chapter 7 reported the process and results of the aforementioned PQHIA. It identified major risk exposures and estimated health impacts derived from urban transport planning policies. The PQHIA indicated that policies to reduce cars are not sufficient to increase physical activity, decrease traffic fatality and decrease air pollution exposure. Strong policies should aim to restrict all forms of motorization with particular measures to reduce motorcycle use and increase active travel (walking, cycling).

Out of three scenarios, an ideal scenario can lead to 20% savings on the total government budget spent on road accidents and traffic congestion. Finally, chapter 8 integrated results from chapters 4-7 and proposed a final framework for conducting PQHIA in settings with scarce data, restricted budget and limited technical capacity.

In summary, the thesis succeeded in bringing health into the agenda of urban transport planning by developing and testing a novel PQHIA model in a LMIC setting. The case study model was designed based on a comprehensive examination of HIA practice and policy in LMICs. HIAs in LMICs are scarce and unevenly distributed. HIA practice can increase if adequate legislation is established. The case study reveals that PQHIA can clarify the nature of health trade-offs in policies and therefore can be used as an advocacy tool for evidence-based policy making. It indicates that pro-health transport policies should be strong and aim for significant decrease in all-forms of motorization with a special focus on decreasing the use of motorcycles. Policies aiming at car-reduction will not be sufficient to achieve health benefits in LMICs.

Participatory approach in quantitative HIA is novel and useful to contextualise quantitative modelling, co-design HIA with local stakeholders and influence the uptake of HIA outcomes, thereby providing opportunities for inclusive development (more specifically relational inclusiveness). Engaging stakeholders at every stage of PQHIA provided an avenue for them to identify and assess the magnitude of transport-related health risks, which they would not have done otherwise.

HIAs can highlight that the cost of inaction is greater than the cost of action by indicating the number of lives that can be saved and costs that can be reduced. However, to bring health benefits, HIAs need to be properly integrated through transparent reporting processes, adapted legislation, good governance and strong evidence-based policy-making. Policy implications of this thesis can involve the integration of an indicator on HIAs in the SDG Agenda 2030 in order to monitor HIA implementation at national levels, afford comparability across countries and establish a roadmap for integrating health effectively in decision-making. HIA practitioners in LMICs can widely benefit from future research addressing quantitative and qualitative challenges for scaling methods to more complex and dense urban areas and transport systems.

Keywords

Participatory Quantitative Health Impact Assessment (PQHIA), Inclusive Development, Urban transport planning policies, LMICs.

COMPENDIUM OF ARTICLES

- Chapter 4 Thondoo, M., Rojas-Rueda, D., Gupta, J., De Vries, D.H., Nieuwenhuijsen, M.J. (2019). ‘Systematic Literature Review of Health Impact Assessments in Low and Middle-Income Countries’. *International Journal of Environmental Research and Public Health* 16 (11).
- Chapter 5 Thondoo, M. and Gupta, J. (2020). ‘Health Impact Assessment Legislation: The Path to Sustainable Development in Developing Countries?’ *Review of European, Comparative & International Environmental Law (RECIEL)* 00:1–11.
- Chapter 6 Thondoo, M., Marquet, O., Marquez, S., and Nieuwenhuijsen, M.J., (2020). ‘Small Cities, Big Needs: Urban transport planning in Cities of Developing Countries’. *Journal of Transport & Health* 19 (100944).
- Chapter 7 Thondoo, M., Mueller, N. Rojas-Rueda, D., Gupta, J., De Vries, D.H., Nieuwenhuijsen, et al. (2020). ‘Participatory Quantitative Health Impact Assessment of Urban Transport Planning in Africa: Mauritius as a case study’. *Environment International* 144 (106027).
- Chapter 8 Thondoo, M., De Vries, D.H., Rojas-Rueda, D., Gupta, J., Ramkalam, Y.D., Verlinghieri, E., and Nieuwenhuijsen, M.J. (2020). ‘Framework for Participatory Quantitative HIA’. *International Journal of Environmental Research and Public Health* 17 (7688).

PREFACE

The present thesis was written at the Barcelona Institute for Global Health (ISGlobal), AISSR Department of the University of Amsterdam and in collaboration with the University of Mauritius as a third-party institute. It was completed from September 2017-September 2020 and was supervised by Prof. Mark Nieuwenhuijsen, Prof. Joyeeta Gupta, Dr. David Rojas-Rueda and Dr. Daniel de Vries. The present thesis consists of a compilation of five scientific articles first-authored by the PhD candidate according to the procedures of the Doctorate in Medicine and Translational Research at the University of Barcelona, Spain. The present thesis contributes to (1) the understanding of HIA practice and policy in low- and middle- income countries (LMICs) (2) the quantification of health impacts associated with urban and transport planning policy in an African city (3) the use of participatory methods to calculate, interpret and disseminate the health impacts, and finally (4) the presentation of possible policy factors to facilitate participatory quantitative implementation in LMICs.

Apart from two review papers and three original research papers included in the present thesis, the PhD candidate was responsible for the data collection in Mauritius, data preparation, statistical analyses, interpretation of findings, writing of the articles and submissions for publication. The PhD candidate co-authored four further publications and a book related to health in cities (Annex A, pg. 265). She also published media materials for dissemination of findings (e.g. Annex B, pg. 266). Moreover, she completed academic training in Environmental Epidemiology at the University of Pompeu Fabra, in Transdisciplinary Research at the VU Open University and in Qualitative and Mixed-Methods Research at the Institute of Tropical Health in Antwerp. She also collaborated with researchers from the MRC Epidemiology Unit of Cambridge University on different HIA modelling techniques applicable to LMICs (Tigthat Project).

The PhD candidate presented papers at various conferences organised by the International Society for Environmental Epidemiology (ISEE) and International Conference on Urban Health (ICUH). She is a member of the ISEE Africa Chapter and contributes to different panels on the continent. She also conducted workshops on urban health collaboration with Next Leaders in Sustainability in Lagos (Nigeria), Tokyo (Japan), and Helsinki (Finland) and with the African Association for Health and Wellness in Nairobi (Kenya). Finally, she contributed to a workshop for building an African Urban Observatory aimed at increasing evidence-based decision-making for Cities in Africa.

ABBREVIATIONS

AB	Attributable burden
AP	Air Pollution
CI	Confidence interval
CO ₂	Carbon dioxide
CVD	Cardiovascular disease
DALYs	Disability-adjusted life-years
EBD	Environmental Burden of Disease
EC	European Commission
GBD	Global Burden of Disease
GIS	Geographic information system
HEAT	Health Economic Assessment Tool
HIA	Health impact assessment
PHIA	Participatory health impact assessment
PQHIA	Participatory quantitative health impact assessment
ICD-10	International classification of disease, version 2010
ITHIM	Integrated Transport and Health Impact
MET	Metabolic equivalent of task
OECD	Organization for Economic Cooperation and Development
P	Proportion
PA	Physical activity
PAF	Population attributable fraction
PM _{2.5}	Particulate matter with aerodynamic diameters less than 2.5 µm
RR	Relative risk
S	Scenario
SD	Standard deviation
SDGs	Sustainable Development Goals
TRAP	Traffic-related air pollution
UHI	Urban heat island
UN	United Nations
VoSL	Value of Statistical Life
WHO	World Health Organization

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Chapter 1: GENERAL INTRODUCTION

1. General Introduction

Urban transport can facilitate economic growth, competitiveness and social progress but can also cause death and disease through different environment and lifestyle determinants. Negative health impacts of transport are likely to increase in cities of Low- and Middle- Income Countries (LMICs) where rapid urbanization and mass motorization are occurring at unprecedented rates. This thesis aims to bring health into the agenda of urban transport by developing and testing a full chain Participatory Quantitative HIA (PQHIA) of urban transport planning policies applicable to LMICs. The thesis explores the global context of Health Impact Assessment (HIA) practice and policy in LMICs (chapter 4 and 5), presents a HIA case study and proposes a PQHIA framework that can be used in LMICs (chapter 6, 7 and 8). The case study was conducted on the island of Mauritius located in sub-Saharan Africa, where the mismatch between urban population growth, increased exposure to environmental pollutants and limited resources are giving rise to health challenges. This thesis applies a trans-disciplinary approach and utilizes qualitative and quantitative methods.

1.1 Problem statement

Urban transport can have positive and negative effects on health (see section 1.2) yet, in LMICs, health remains largely in-existent on urban transport policy agendas(1). Given strong evidence that policies and interventions deployed in non-health sectors affect health (2,3), there is an urgent need to counter political and institutional decisions taken without considering transport- related health impacts (4). In LMICs particularly, health risks will grow as more people move to fast developing cities (5). By 2050, 90% of 2.5 billion new urbanites will have migrated from rural to urban areas in Africa and Asia (6). Already by 2030, the number of African cities with more than half a million people will have increased by 80%, making Africa the continent with the highest annual urban population growth rates in the world (7). Cities of LMICs are facing rapid and unplanned urbanization causing overcrowded housing, unsafe working conditions, lack of access to clean water and decent sanitation, social exclusion, increased motorization, and cumulative poor transport planning. These factors lead to health inequities that are unevenly distributed across the globe. Currently, LMICs have 80% of global non-communicable disease (NCD) deaths, 92 % of pollution-related deaths and 90% of traffic-related deaths in the world (8–11). Transport systems and policies that are not geared toward healthy and sustainable goals can increase the toll of disease and deaths in LMICs.

There is a lack of tools to quantify the health effects of urban transport planning policies in LMICs. Tools such as HIA (see section 2.1) are known to support the integration of health into wider urban development and transport policy agendas(12,13). HIAs are tools to systematically judge the potential health effects a proposed policy, programme, or particular intervention might have on population health and the distribution of those effects within a population. They have gained popularity in high income countries (HICs) but little is known about their practical implementation in LMICs (14).

Indeed, an increasing number of scholars have called for urgent practice of HIA in LMICs (50,53,54). Only 6% of HIAs are conducted in poorer countries, with lack of clarity on trends in practice (1).

In Africa, HIAs remain restricted to large development projects (1,16,18,19) and in Latin America, HIA application has largely been limited to approval mechanisms for privately-led projects rather than for strategically integrating health into other sectors (20,21). In stark contrast with high income countries (HICs) (22–24), there are few sector-specific HIA of urban transport planning conducted in LMICs (chapter 4). While urban transport planning provides a promising ground to induce pro-health behaviours, outcomes and policies (25), it is unclear to what extent current quantitative HIA methodology (see section 2.1) to assess impacts of urban transport planning is applicable to LMIC settings (1,15–17).

Even if quantitative HIAs have proven to successfully assess transport-related health impacts and inform policy-making(13,22,26,27), they remain rare and generally limited to research and academic purposes (28). They are often not adapted to local contexts and needs due to communication gaps that hinder the assessment of scenarios that are plausible, realizable and acceptable to local stakeholders (28).Applying participatory approaches in HIA has been proposed as a solution for HIAs to include local insights, increase impact of outcomes and better guide policies (29–31), yet few quantitative HIAs are designed to be participatory (28,32). The historical and reference Gothenburg consensus paper establishing HIA norms (33) promotes participation as a crucial component of HIA. While HIA practitioners in OECD countries conduct participatory HIAs (PHIAs)(34), few of them are participatory quantitative HIAs (PQHIA)(28) (PQHIA, see section 2.1). Finally, very few studies report PHIAs in LMICs (35,36)and as far as we know, none of them have produced evidence on PQHIA specifically (chapter 7 and 8).

1.2 Urban transport planning and pathways to health

Urban transport planning is an important tool of economic growth while also playing a crucial role in preserving or degrading human health. Transportation facilitates the movement of people and goods, necessary for fuelling social grids and economic engines (37). As an integral part of development in LMICs, the transport sector is located at the crossroads of environmental (noise and air pollution, green and blue spaces, etc.), economic (employment, household income, etc.) and social (education, social network, etc.) realities (38,39). Transport interventions and policies impact on land use, built environment, infrastructure, mode choice and technologies. Transport affects health in beneficial ways including mobility-related physical activity (walking and cycling) and by enabling social interactions, access to services and opportunities. Transport can also be detrimental to health by exposing humans to environmental exposures such as air pollution, noise and temperature levels and to motor vehicle crashes (MVC) (see figure 1, source (40)). These different pathways to health and the inequitable way they are distributed across population groups and settings can cause disease and deaths due to transportation.

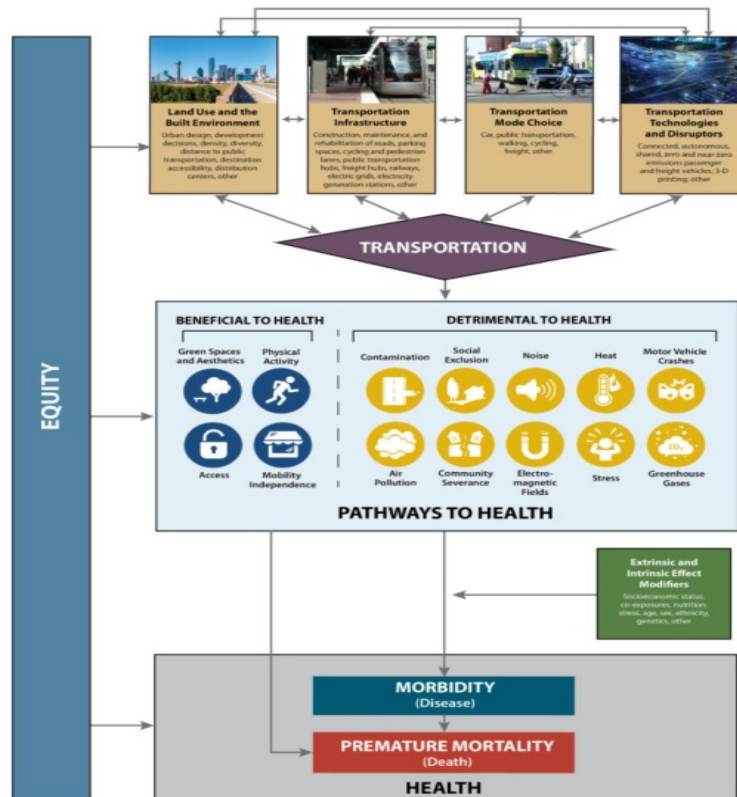


Figure 1: Transport and Pathways to health

Rapid urbanization and mass motorization are two key trends responsible for negative health impacts of transport (41). The undervaluation of health in transport agendas is a global phenomenon fuelled by car-centric urbanisation and a tendency of policy to favour car mobility (42). Mass motorisation in LMICs has started later than in high income settings, yet it is growing more rapidly, affecting health and environment in dramatic ways (43–45). The dependence on motor vehicles (including two- or more-wheelers) and pro-motorization policies are rapidly gaining traction, exacerbating the negative health impacts of the transport systems in poor countries(46–49). The move towards car-dependency in LMICs presents several challenges and contradictions. First, cities are deploying strategies to favour cars at the expense of other modes of urban mobility while more developed settings are now committing to diversify transport modes. Second, car-dependent designs stand in stark contradiction with the main means of mobility (cycling and walking) adopted by majority of urban dwellers in LMICs. Third, many cities of LMICs are new or yet to be built, therefore cities could aim at providing fair, affordable and sustainable options to improve citizen lives (49). Current studies in LMICs cities showthat transport causes premature mortality and morbidity through road crashes, sedentary lifestyles, and traffic related environmental exposures (37,50).

Some studies have reported successful quantitative health impact of these three exposure pathways: air pollution, traffic deaths and physical activity(51–58).

Air Pollution

As a major by-product of urbanization and motorization, air pollution (AP) is the largest environmental cause of disease and deaths across the world. AP causes cerebro-vascular disease, chronic obstructive pulmonary disease, lung cancer and lower respiratory infections. AP was responsible for an estimated 9 million premature deaths in 2015. It triggers substantial economic loss in LMICs, decreasing the national gross domestic product (GDP) by up to 2% per year. AP -related diseases drain nearly 7% of total GDP earmarked for health-care compared to only 1.7% in high income countries. Overall, exposure to industrial, vehicular and chemical pollutants causes three times more deaths than AIDs, tuberculosis and malaria combined(10).

About 90% of urban air pollution in rapidly growing cities in LMICs is attributable to motor vehicle emissions (9), this is also the case for sub Saharan Africa (SSA) (46). It is estimated that CO₂ emissions from transport increased by 53.7 % between 1990 and 2010 in Africa (ibid). As the fourth leading cause of disease in SSA (59), air pollution in African cities alone costs 2.7% of GDP (60). AP-related cardiovascular and cerebro-vascular diseases and respiratory infections (61–64) causes approximately 626 000 DALYs (disability-adjusted life years) per year (65). East and south East Asian countries disproportionately suffer from health-related burden of air pollution claiming 59% of all 4.2 million deaths and 103.1 million DALYs (disability-adjusted life-years) caused by exposure to particulate matter (PM) 2.5 (one amongst other health risk factors including SO₂, NO₂, and O₃) (66).

Physical activity

Globally, more than 2 million premature deaths per year are caused by insufficient physical activity (67). The lack of data and the complexity involved in measuring physical activity levels has limited the study of physical activity in developing countries (68). Across 22 African countries urbanization has led to decreasing physical activity (69) inducing lifestyle related diseases such as diabetes (70,71), high blood pressure (72) and obesity (73).

Traffic-related deaths

Road traffic injuries are ranked the eighth leading cause of death in the world and the first cause of death in young adults (15-24 years) (74). Motorized cities claim 1.25 million deaths per year; twice the amount of people dying from malaria (11). The death burden has increased by 46 % over the last two decades with 1.9 million deaths per year predicted by 2030. When not accompanied with adequate infrastructure, regulations and road safety measures, the increase in motorized vehicles poses a serious threat to human health. The number of people having purchased a vehicle increased from 39 million to 63 million between 1990 and 2012 (75). There are currently an estimated 1 billion motor vehicles worldwide and by 2050 there will be more than 2.1 billion cars on the planet (11). With unprecedented urbanization, commuting populations in Africa are exposed to unsafe roads (76). Road injuries have increased by 33% between 1990 and 2015 (77).

Currently, Africa has the highest rate of fatalities from road traffic injuries worldwide at 26.6 per 100 000 population (78).

1.3 Policy Relevance of the thesis

The unequal distribution of transport-related exposures and health deepens the process of growing inequality between high-, low- and middle- income countries, affecting the development of the latter and hindering their ability to achieve social, economic, and environmental goals. By addressing health impacts of non-health sectors such as transport, it is possible to focus on the multiple causes of vulnerability that operate simultaneously from global to local levels. Impact assessments were originally designed in the late 1960s to focus on the environmental impacts of proposed projects (79), but more recently they account for wider negative consequences on the environment, society, public health and sustainable development. Unfortunately, several types of impact assessments have been criticised for not responding to health issues (80) and failure to consider health impacts of social and economic determinants in non-health sectors. This is particularly true for Environmental impact assessment (EIA) (81) (see chapter 5), but also for Social impact assessment (SIA), the Strategic environmental impact assessment (SEA), Sustainability impact assessment, and the Sustainability appraisal (SA) (82)(see Annex C, pg. 272).

Health as useful to connect impact assessments to international policy development agendas (83,84). HIAs lay a strong foundation for global agendas aiming for sustainable development in poorer areas of the world (85,86) (chapter 5). Indeed, health is aspired to be a determinant, outcome and indicator of sustainable development. After the adoption of “Transforming our World: The 2030 Agenda for Sustainable Development” in 2015 (87), the community of development and environmental scholars have invested efforts to meet the Sustainable Development Goals (87), a framework of 17 universal goals and 169 targets. Health cross cuts ten out of 16 goals, shaping 28 health-related targets with a total of 47 health-related indicators (88). Yet, few scholars have assessed urban-related health impacts within the SDG framework (12). Even fewer impact assessment research focuses on target 11.2 of SDG 11 (make cities and human settlements inclusive, safe, resilient and sustainable) aiming that ‘by 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons’ (87).

1.4 Outline of the thesis

The first three chapters of the thesis describe the background of the study, the theoretical underpinnings and research methods. **Chapter 1** states the thesis aim and the current problems. It introduces the complex linkages between transport and health. **Chapter 2** reflects on models, frameworks and approaches that underpin the research. **Chapter 3** presents a summary of the research methods applied throughout the thesis. **Chapter 4** presents the findings of the systematic literature review on HIA in LMICs. **Chapter 5** presents the landscape of HIA policies in the world and examines their links with sustainable development. **Chapter 6** explores the alignment between current urban transport policies and citizen needs and preferences in Port Louis, the case study site. **Chapter 7** presents the results of the full chain PQHIA of urban transport planning. **Chapter 8** presents a final framework for PQHIA and proposes areas of opportunities for facilitating HIA implementation in LMICs. **Chapter 9** concludes the thesis by summarizing findings and discussing their implications for future research and practice.

Chapter 2: THEORETICAL LENS

2. Theoretical Lens

This chapter describes the theoretical lens (model, framework and approach) used to frame this thesis. It presents a general figure (figure 2) combining the HIA approach (box B3), the DPSEEA framework (box B1) and the Inclusive Development theory (box B2). HIAs can be qualitative, quantitative or participatory quantitative (mixed-methods). They can be applied to project, programs or policies and can assess a range of outcomes including diseases and death. This thesis focuses on participatory quantitative HIA applied to policy and estimates outcomes in terms of mortality and economic value (Box B3). In view of PQHIA, the variables from the DPSSEA model (B1) accommodate for the complex correlation between environmental indicators (e.g. air pollution) and health outcomes (e.g. death). They are also useful to depict the multistage and cumulative nature of health risks and effects potentially generated by urban transport. The application of the inclusive development theory is wide (B2) and frames the participatory dimension of the thesis. Some aspects of inclusivity (eg. inclusion of marginalised groups) were not applied to this thesis.

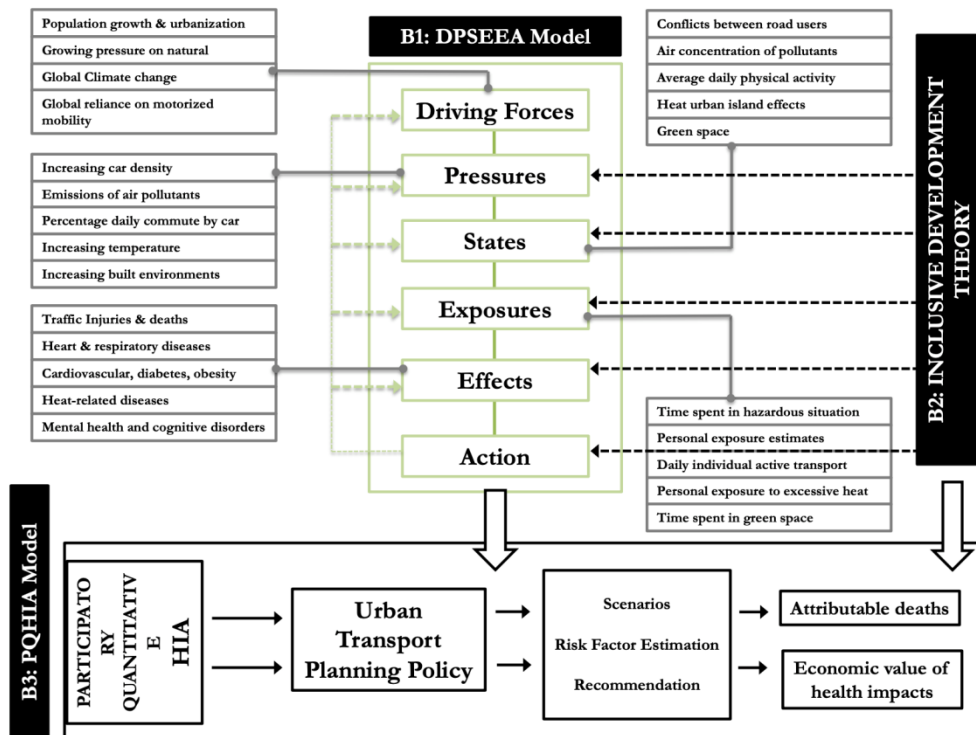


Figure 2 Theoretical lens for HIA, environmental exposures and health of urban transport planning, and inclusive development (created by author)

2.1 Health Impact Assessment Approach

Health Impact Assessments (box B3) combine mixed-methods to systematically judge the potential health effects a proposed policy, programme, or particular intervention might have on population health and the distribution of those effects within a population (33). HIAs provide mortality and morbidity estimates that support stakeholders to make informed decisions before, during, and after interventions or policies are framed and implemented. They encourage inter-sectorial collaboration and assessment of health in all policies (89). They also provide an estimation of health costs attributable to changes in built environments or systems (90). HIAs are multidisciplinary and examine both negative and positive health effects (91). HIA have several strengths and limitations discussed later in the context of this thesis (section 9.4).

HIA steps

Despite different methods to conduct HIA (16,92), HIAs normally follow 6 basic steps: screening, scoping, appraisal, reporting, recommending and monitoring (33)(see Figure 2). Screening determines whether HIA is relevant and needed in a particular policy context or project. Scoping sets the limits and focus of the assessment by identifying data sources, populations to cover, key health-related concerns and methodology to employ. Assessing relies on evidence (health profile of population, prediction for exposure levels, literature reviews and baseline conditions) to assess the health impacts. Recommending involves generating a series of recommendations on how to maximise health benefits while considering constraints on decision makers. Reporting is used to disseminate findings and lessons learnt, often using media material, written reports and press releases. Finally, monitoring and evaluating consist of monitoring implemented recommendations and evaluating progress and partnerships that have been formed.

HIA types

HIA types are defined by their scope: desk-based, rapid, intermediate and comprehensive and timescale: prospective, concurrent and retrospective (before, during and after interventions or policies are deployed)(93). Desk-based HIAs are conducted

Figure 3: The 6-step HIA Process

based on existing secondary data only. Rapid HIAs are the most commonly applied type of HIA, usually conducted for short turn around projects. They may or may not include stakeholder participation; if they do, workshops are the most common input techniques. They are generally less resource intensive than intermediate HIA that involves the collection of new data and more extensive use of available data (94). Comprehensive HIAs are used for large, well-planned interventions with enough time and resources to support intensive fieldwork, analysis, and dissemination work.

Community input strategies include surveys and focus groups discussions (not often used in rapid HIAs) (95). Comprehensive HIAs are important tools because they bring together all available evidence of potential impacts of transport on health(96).

HIA approaches

HIA approaches are defined by the datasets used. Qualitative approaches are of ethnographic nature in contrast with quantitative approaches of epidemiologic nature. Participatory quantitative HIA (PQHIA) approaches merge qualitative and quantitative approaches. PQHIA provides a comprehensive assessment of scientific evidence on environmental and health issues while following the rationale for evidence-based decision-making, promotion of cross-sectorial work, advocacy, sustainable development and inequality reduction (97).

PQHIA adopts participatory approaches to quantify health impacts (98,99). Similarly to qualitative HIA, PQHIA is based on local knowledge (100) and engagement of a wide range of professionals, stakeholders and citizens already acting towards improving health in cities (28). The participation of local communities affords the PQHIA with contextual political and social circumstances to widen knowledge, effectiveness and impact (101,102). Primary data for qualitative HIA approaches is usually collected through focus groups, telephone surveys, Delphi exercises, and semi-structured interviews, according to the scope of the work. Purposive and snowball sampling are often used to establish appropriate stakeholder maps from which representatives and community members are selected for participation (103). For desktop or rapid HIAs, secondary qualitative data as part of literature review can be used as a proxy for stakeholder participation. The health outcomes commonly address risk factors perceived and reported by respondents (104). Qualitative approaches are valuable for in depth description of health determinants, can contribute prioritisation of impacts in communities and provide a perspective on health inequalities and health equity (103). They can be resource intensive and require skills in facilitation.

In contrast with purely qualitative HIA, PQHIA also applies quantitative approaches and quantitative assessment models. PQHIA incorporates quantitative estimates and qualitative input data. Purely quantitative HIAs are based on secondary quantitative (numerical) data such as epidemiological reports within literature searches and indicator data during community profiling. They involve mathematical prediction/modelling of the health effects of an intervention or policy and follow a comparative risk assessment approach estimating the baseline situation (in terms of disease and exposure) in a particular population and comparing it with a scenario where this baseline situation is modified (improved or worsened). This process requires (1) compilation of exposure data (limited to specific determinants of a policy or project, for example, the effects of noise and air pollution on people living near airports) (2) a systematic review of evidence from epidemiology and other scientific disciplines addressing the association between environmental factors and human health and (3) the combination of exposure data with exposure-response information. The different steps of quantitative HIA, from specifying baseline situation and counterfactual scenarios to selecting exposure-response relationships are described in detail in chapter 7 (see figure 8, Chapter 7.2 Conceptual Framework for Participatory HIA, pg 146).

With quantification of health effects, decision makers can appreciate the size of an effect, distinguish between main issues and details, in turn facilitating in decision making processes (32).

2.2 The DPSEEA Model

The DPSEEA model (105) is one of the most widely used frameworks for linking environment to health (106,107). It is grounded in the definition of environmental health as “aspects of the physical environment that can influence human health” (108) and as one of the main shapers of the HIA approach (109). It systematically categorises environmental health indicators that can be evaluated using exposure-response relationships (see chapter 7). Such indicators are ‘a measurement, statistic value that provides a proximate gauge or evidence of the effects of environmental management programs or the state or conditions of the environment’ pg. 149 (105). As a linkage-based framework, DPSEEA is known to facilitate decision-making and is useful for conceptualizing indicators, framing problems, and identifying areas for intervention (38,105).

In contrast with earlier models such as the Pressure-State- Response (PSR) model of environmental change (106) and the Driver-Pressure-State-Impact-Response (DPSIR) framework (110), the DPSEEA presents exposure and state variables separately (potential avenues for action are increased) (Figure 4 box B1). The DPSEEA framework considers that health impacts originate from driving forces, which lead to pressures on the environment (for e.g. in form of production, consumption, waste generation etc, and their consequent releases into the environment. These contribute to changes in states of the environment (for e.g. environmental pollution). Exposures occur when humans come into contact with these hazards, leading to potential health effects. Policy and other actions can be taken to control adverse health effects and this can be done on either variable simultaneously (111). This is useful for HIA in urban and transport planning because action can be targeted at state (high air pollution, average daily physical activity) and exposure factors (high exposure to air pollution, sedentary lifestyles) separately and simultaneously. In the same way, pressures (high car traffic density, increasing temperatures) induced by driving forces (rising economic activity, population growth) can also be acted upon with rigor (38).

2.2 The Inclusive Development Theory

With a focus on LMICs, this thesis connects PQHIA to the concept of ‘inclusive development’- a word often used in international development policy (112). Indeed, PQHIA here addresses impacts of mass motorization and transboundary challenges such as air pollution exposure, which are at the crux of wider global development issues. Inclusive Development focuses on social wellbeing and protection of ecosystems through redefining political priorities (113).

It underlines inclusiveness of people, sectors and countries in social, political and economic processes for increased human well-being, social and environmental sustainability, and empowerment (114).

Critical literature illustrates that the concept of ‘inclusivity’ in inclusive development can be understood in various ways by different disciplines, scholars and

policymakers(113,114). Inclusivity is not a self-evident and universal notion but it can be applied as a starting point for contextualising development projects or research. Inclusivity in this sense, is useful to critically reflect on how actors are involved in setting agendas and priorities, as well as defining the limitations of particular interventions or policies (115).

Two conceptual insights on inclusive development are of particular relevance to the focus and limits of this thesis. The first, advanced by Roodsaz and Van Raemdonck (2018) is a constructive understanding of inclusive development as a way to stimulate dialogue and encourage two-way interaction between beneficiaries (112). This approach challenges hegemonic transmission of knowledge and decreases the risk of missing out on valuable sources of knowledge and underestimating the agency of beneficiaries. The second insight, advanced by Gupta and Pow (2016), is a pragmatic understanding of inclusive development as a way of enhancing ecological and social wellbeing while applying them to economic issues (115). The improvement of human wellbeing should be done according to people's own priorities(113). Inclusivity in this sense requires policies and activities to be contextually sensitive, promote participation and capacity building. This process would contribute to 'relational inclusiveness', a term defined by Gupta and Pow as a component of inclusivity that implies the participation of all actors, at all levels, in activities such as legal reforms, lobbying and advocacy (115). Relational inclusiveness recognises that social and ecological problems (e.g. poverty, environmental degradation) are often results of actions taken by others; an important perspective when considering how to bring health into the agenda of non-health sectors.

2.3 Overview of Theoretical lens

The overall theoretical lens represented in Figure 4 combines the HIA approach (box B3), the DPSEEA framework (box B1) and the Inclusive Development theory (box B2). The synergy between these three components is useful to compensate for limitations in theory that would emerge if they were considered separately and individually.

The DPSEEA framework has been criticised for being too linear, neglecting how more complex factors such as socioeconomic status, socio-political environment, lifestyle determinants and behaviours influence features of the urban environment (38). The framework is limited in considering population sensitivity or vulnerability that are involved in environmental and health risks spread in time and space (116). This shortcoming is addressed by the concept of inclusivity (B2). DPSEEA framework has also been criticised for inadequately addressing physical risks and exposures that are difficult to quantify and interpret (e.g. pressures such as emissions of air pollutants). This shortcoming is addressed by quantitative assessment conducted in PQHIA (B3).

The concept of inclusivity (addressed under the umbrella of the inclusive development theory) is useful to address aspects of social realities overlooked in DPSEEA. Inclusivity in the context of HIA is useful to focus on social, health and ecological aspects of development while considering economic impacts (B3: HIA outcomes are expressed in mortality and economic values).

Moreover, inclusivity encourages participatory development, one of the main rationales of HIA (chapter 8). The proposed PQHIA is applied to policy, not program or projects. Therefore, the concept of relational inclusivity is used as a critical lens to examine participation of local stakeholders in policy making. In the context of this thesis, participation is considered as ‘the identification of a large number of relevant people, groups and organizations [...] and the implication of stakeholders in a meaningful way, allowing their messages to be heard’ (28). It addresses inclusivity as a foundation for progress according to local stakeholders’ priorities and does not claim to account for wider community participation and perspectives. It also does not address inclusiveness towards socially marginalized populations and their role in policy-making (see section 9.5 for limitations).

Keeping in mind the theoretical underpinnings of this research, the following chapter clarifies the focus and limits of the thesis by stating the research questions (section 3.1), the study approach (section 3.2) and methodology (section 3.3).

Chapter 3: RESEARCH DESIGN

3. Research Design

This chapter introduces the research aims and objectives as well as research questions (section 3.1). It describes the overall methodology (section 3.2) and concludes on the research ethics (3.4). The thesis provides insights across the fields of environmental sciences, public health, social sciences and urban development. In the attempt to bridge the gaps between health and transport planning sectors, the thesis is transdisciplinary by nature. The work invested in testing and developing a PQHIA framework involved merging two disciplinary fields guiding HIA processes: epidemiology and public policy (118). To maximize the impact of the findings in society, the thesis applied qualitative and quantitative methods to involve participants across different fields and sectors.

3.1 Research Aims and Objectives

The overall aim of the thesis is to bring health into the agenda of urban transport planning by developing and testing a full chain participatory quantitative HIA model for urban transport planning applicable to LMICs. The main research question is: How can Health Impact Assessments of urban transport planning contribute to inclusive development in low- and middle- income countries?

The overall aim of the thesis and main research question respond to the current problems previously described (chapter 1). Namely that (1) Urban transport planning has negative effects on health but in LMICs, health is still inexistent on urban transport planning policy agendas and (2) There is a lack of tools for quantification of transport-related health impacts and existing ones are not adapted to local contexts.

To address the overall aim of the thesis, five specific objectives were set. Five research sub-questions, corresponding to papers (I-V) and chapters (4-8) were used to respond to each specific study objective (see table 2).

OVERALL AIM	RESEARCH QUESTION		
The overall aim of the thesis is to bring health into the agenda of urban transport planning by developing and testing a full chain participatory quantitative HIA model for urban transport planning applicable to LMICs.	How can Health Impact Assessments of urban transport planning contribute to inclusive development in low- and middle- income countries?		
Specific objectives	Research sub-questions	Paper	Chapters
Review, characterize, and evaluate HIA activity in LMICs	What are the best practices, strengths, opportunities and limitations of conducting HIAs in LMICs?	I	4
Examine how HIA legislation can help developing countries to achieve sustainable development	What role can HIA legislation play in addressing environmental health in LMICs and thereby contribute to SDGs?	II	5
Assess the alignment between urban transport policies and self-reported citizens' needs in Port Louis city (Mauritius)	To what extent do current urban transport policies satisfy population needs in the case study site (Port Louis- Mauritius)?	III	6
Assess the health impacts of transport scenarios in Port Louis (city of 119,018 inhabitants in Mauritius) using a full chain participatory HIA model	What are the major risk exposures and health impacts derived from urban planning transport policies in Mauritius?	IV	7
Propose an exploratory framework for participatory quantitative HIA in LMICs including integration of results back into society after the HIA is conducted.	What are the technical and financial components of a participatory model that can promote HIA implementation LMICs?	V	8

Table 1: Research questions, related aims and objectives and corresponding thesis chapters

3.2 Methods

Research Setting

In response to the main thesis question, a case study was conducted in sub-Saharan Africa, on the island of Mauritius, experiencing rapid and unprecedented urbanization and motorization. It is estimated that three in five people in urban areas of sub-Saharan Africa suffer from poor urban-related conditions (housing, overcrowding, lack of access services, pollution, lack of secure tenure, etc.) in contrast to one in three people in Asia and one in five people in Latin America and the Caribbean(11). As a small island developing state (SID) of 1.2 million population, Mauritius has the highest population density in Africa with an urban population rate that has doubled in the last 50 years (119,120). The prevalence of non-communicable diseases is particularly high, with 15% prevalence of diabetes and 30% prevalence of hypertension in adult population aged between 20-74 years old(120). Additionally, Mauritius faces severe consequences of the mismatch between economic growth and limited resources, and vulnerability to climate impacts including cyclones, flooding and rise in sea levels.

Rapid urbanization currently causes several urban and transport challenges including urban sprawl, traffic congestion, inadequate planning, increase in vehicle ownership and deteriorating transport infrastructure and services (49). The motorization rate has grown rapidly over the last decades with a national vehicle fleet estimated to have increased by 625% between 1972 and 2000 (121). There are no policies to restrict traffic growth in Mauritius and fiscal policy related to private motorization does not exist (122). There is no legislative framework for HIA Mauritius although the island adopted formal procedures and legislation for EIA since 1991 (123).

Port Louis, the capital, presents unforeseen opportunity for HIA, and may become the case serving generalization and critical theory forming. Port Louis qualifies as small cities and may provide very valuable insight into how health in urban areas of LMICs will evolve. It is predicted that the bulk of future urban population growth will occur in small cities while megacities will experience decline (6). In fact, most urban residents in LMICs currently reside in urban settlements of fewer than 500,000 residents (124). In 2015, estimates showed that just under 9% of the world's urban population lived in cities of 10 million or more, while cities under half a million accounted for over half of the total urban population (124). The pace of urbanization in cities like Port Louis is also faster, requiring that health challenges be addressed more swiftly and efficiently.

The management of complex issues may be facilitated given smaller governing structures and less exorbitant funds needed to address health risks. Finally, a smaller size city offers critical opportunity to apply methods and technology that may not have worked previously or may have failed in higher income or larger cities.

Overview of methods per study

Five different studies were developed to respond to the thesis research sub-questions. The methods for each study are summarized in Table 3.

Paper	Approach	Method	Data Source	Sample	Setting
I	Systematic Literature Review	Systematic literature review following PRISMA guidelines	5 databases; 156 countries	57 studies	Global
II	Policy assessment	Non-systematic literature review	National legislation	25 countries	Global
III	Needs-gap analysis	Inductive thematic analysis Secondary data analysis Logistic regression modelling	Policy documents, 'Map mo Port Louis' dataset	N= 1523	Mauritius
IV	Full chain participatory quantitative HIA model	Primary data collection Risk assessment modelling Knowledge translation	IDIs, FGDs, validation exercises, local surveys and international datasets.	N= 14 N= 614	Mauritius
V	Qualitative analysis of participatory data	Primary data analysis Deductive thematic analysis	IDIs, FGDs, validation exercises, field memos.	N=14	Mauritius

Table 2: Methodology for each study

To identify the trends in HIA practice, we conducted a systematic review of HIA in 156 countries across 5 databases and in 4 languages (Paper I). We applied PRISMA guidelines to review HIAs across all topics, sectors, and types. No timeline was applied. The data was extracted from Scopus, Medline, Web of Science, Sociological abstracts, and LILACs databases. The systematic database searches were performed by two independent researchers and augmented by bibliographic review and expert consultation. The search was streamlined using targeted search terms, region specification and bibliographies of recent key publications. A process evaluation assessment of eligible studies was conducted to verify variation in six different process criteria.

To sketch HIA policy landscape and examine the link with sustainable development, the study focused on a non-systematic review of national legislation on HIA across the world (Paper II). We categorised policies by legislation, guideline and framework and defined whether policies were national or sub national and whether they were part of stand-alone HIAs or Integrated in EIAs. An argumentative, discursive approach was used to discuss the link between HIA and sustainable development.

To examine the alignment between urban transport policies and public needs, we used a needs-gap analysis approach (Paper III). We analysed one public policy document and extracted citizen needs from an existing dataset. This dataset was collected in 2016 during an online national survey entitled 'Map mo Port Louis'. The survey adopted a participatory approach to investigate citizens' perceptions on urban development in Port Louis. Residents and non-residents of the capital were randomized for selection. Triangulation methods were used to determine whether current policies are aligned with citizen self-reported needs.

To pilot a full chain participatory quantitative HIA of urban transport Planning, we applied a mixed methods approach (Paper IV). The data were collected during fieldwork in Mauritius between June and October 2018. The primary dataset consisted of qualitative data obtained from recurrent meetings with a defined group of informants (n=14) and quantitative data from a survey (n=600, age range 18-75). Qualitative data was obtained using semi-structured guides during individual interviews (IDIs), focus groups (FGDs) and feedback exercises. Purposive sampling was used to recruit 14 participants. Data was recorded electronically, transcribed verbatim, translated, and analysed using ATLAS.ti (version 8.4.18). Thematic analysis was applied. Quantitative data was collected with a survey available in three languages and filled by 12 fieldworkers using electronic devices and applying the CAPI (computer-assisted personal interviewing) method. Randomized sampling was used to recruit survey participants. We used Askia Face Android Software, Microsoft Excel 16.16.21 (2018) and R Studio 1.1.463 to manage and analyse data. Raw data is available at <https://doi.org/10.17632/p6xkw92rfw.1>. Data analysis methods included statistical analysis and risk assessment modelling. The secondary dataset consisted of baseline exposure data extracted from exposure and epidemiological databases: global surveillance systems (including GBD) for morbidity and mortality trends, national surveillance systems, government-owned databases, local police records and hospital data entries (table 4).

The consent sheet contained key information on the study protocol, the research purpose and steps to the dissemination of findings (see annexes in chapter 7 and 8). Participants were indicated to agree whether they (1) understood the purpose of the research (2) wanted to participate willingly (3) would commit to the whole study. Anonymity was guaranteed alongside consent, including for public figures. No minor (less than 18 years old) participants were recruited. Participants were informed on how data would be used, aggregated, reported and where it would be accessible. All participants were allowed to withhold their consent and retrieve from participating at any point in the research. Based on the previous, the thesis supports that the process of gathering, analysing, disseminating, and archiving data caused no potential harm to the participants.

Chapter 4: HIA PRACTICE IN LMICS

4. HIA Practice in LMICS

Health Impact Assessments (HIAs) motivate effective measures for safeguarding public health. There is consensus that HIAs in LMICs are lacking, but no study systematically focuses on those that have been successfully conducted across all regions of the world, nor do they highlight factors that may enable or hinder their implementation. The objectives of this chapter are to (1) systematically review, geographically map, and characterize HIA activity in LMICs; and (2) apply a process evaluation method to identify factors which are important to improve HIA implementation in LMICs. Of 3178 hits, 57 studies across 26 countries were retained. Most of the HIAs reported quantitative approaches (72%), focused on air pollution (46%) and appraised policies (60%). No study reported the time, money, and staff used to perform HIAs. Only 12% of all HIAs were based on participatory approaches. Scaling and improving HIA implementation in low and middle-income countries in the upcoming years will depend on expanding geographically by increasing HIA governance, adapting models and tools in quantitative methods, and adopting better reporting practices.

4.1 Introduction

In the last 30 years, Health Impact Assessments (HIA) have been promoted as a key instrument to safeguard public health (1,2). HIAs combine mixed-methods to systematically judge the potential health effects a proposed policy, program, or project might have on population health and the distribution of those effects within a population (3). HIAs are useful to predict the impact of interventions (interventions are defined as either policy, program, or project in this paper) in shaping health determinants before they are framed and implemented. They have been promoted as an important tool to achieve health equity. HIAs have been successfully and extensively used in cities of high income countries (HICs) to assess the impacts of air pollution (4), urban planning (5), and transport (6,7). Yet, their implementation at the global level remains hampered by the disparity in practice between high and low and middle-income countries (LMICs), also referred to as low resource countries in this paper (8).

There is more scientific understanding on the potential rather than implementation of HIAs in low and middle-income countries (LMICs). Literature examining HIAs in LMICs has focused on gaps in policy rather than gaps in practice (9,10). Evidence shows that compared to HICs, very few LMICs have regulatory policy frameworks on HIA. In some Asian countries, HIA legislation at national and subnational level exists. Thailand has institutionalized HIA in its Constitution, while Laos, Cambodia, and Malaysia have integrated HIA as part of the Environmental Impact Assessment (EIA) processes (10). Vietnam is in the process of incorporating the HIA framework in its Health Action Plan (11). In Latin America, only Mexico and Brazil have published national-level guidelines on HIA (12). No African country actively promotes or regulates HIA (10,13). While the presence of firm policy frameworks is a major requirement for HIA, it does not necessarily imply that one country is more effective in implementing HIA than another (14).

Understanding and addressing barriers to HIA in LMICs is imperative for ensuring equity in HIA practice across the globe. The value for equity weighs even more so as low and middle-income countries absorb an unequal burden of health impacts generated from accelerated environmental anthropogenic changes. Compared to HICs, LMICs are disproportionately exposed to modern health hazards such as water, urban air and noise pollution, deforestation, land degradation, waste management, and climate change (15). Most of the 7 million people (92%) dying from exposure to air pollution across the globe live in LMICs. The same countries also claim 90% of 1.25 million traffic-related deaths and 80% of 56.9 million deaths caused by non-communicable diseases, per year, in the world (16–19). Yet, Erlanger et al. identified that only 6% of all HIA publications were conducted in LMICs (8). HIA is an uncommon and inconsistent practice in Latin American and Caribbean countries (LACs) (20) where it is limited to approval mechanisms for privately-led projects (21,22). Other studies confirm that the focus on private rather than public projects also drives HIA in Africa (23,24). Such trends stand in stark contrast with the consistent and mostly regularised HIA practice in high income countries. Reviews focusing on HIA in the USA (25), Europe (26,27), Australia (28,29), and New Zealand (30) show that HIAs in HICs focus on diverse topics, are used in both public and private realms, are led by varied institutions and professionals, and apply different types of quantitative and qualitative methods to calculate health outcomes.

To our knowledge no review has addressed detailed HIA trends in LMICs. While some reviews (8–10,12,31–36) have reached consensus that HIAs in low resource countries are lacking, there is no systematic review of case studies that have been successfully conducted in LMICs and there is very little understanding of how they were conducted. As far as we know, no systematic method or process evaluation assessment has been used to define exactly where and how HIAs are being conducted, by whom, and for what purpose, in LMICs across all regions of the world.

Process evaluations provide information on why and how HIAs are conducted (37); they are useful to determine ways for improving methods and expanding HIA practice, but so far, they have been completed in high income countries only (38–41). Hence, this study had two objectives. First, we performed a systematic literature review of HIAs to identify and audit HIA activity across LMIC geographical settings. Second, we conducted a process evaluation assessment based on six criteria to identify factors that enabled or hindered implementation of HIA in LMICs. The process evaluation addressed the 'how' aspects of HIA case studies (who conducted, on what topic, where, which outcomes, stakeholders involved, when, etc.) via research questions and by reporting issues across eligible peer-reviewed papers only. Due to the scarcity of cases per country and lack of rigorous methods to assess HIA impact (42), we did not address the 'why' aspects (impact evaluation) of HIA, and we state the limitations of our approach in sections 4.3 and 4.5.

4.2 Materials and Methods

Systematic Review

A systematic review method was used, complying with the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) (43) (see Supplementary File 1). The systematic review has been registered in the PROSPERO database (registration number: crd420118102715) since 8 August 2018. PROSPERO is an international database of prospectively registered systematic reviews in health and social care (see <http://www.prisma-statement.org/Protocols/Registration>). Articles were systematically screened from five online databases—Scopus, Medline, Web of Science, Sociological abstracts, and LILACs—from inception until 13 May 2018. In total, the review included 156 low and middle-income countries, classified as ‘Emerging Market and Developing Economies’ (EMDE) in the World Economic Outlook 2016 (44) and referred to as ‘LMICs’ for the purpose of this paper.

The review included standalone HIA case studies (original articles) conducted in low and middle-income countries and published in peer-reviewed papers. General articles discussing the state-of-the-art of HIA, methodological concerns, as well as opinion papers were not considered. No time restriction was applied, and grey literature was not included. The search was conducted in English, Portuguese, French, and Spanish. The search string combined #health impact assessment, #country, #study, type, and #city specifier (see Figure 1). The city specifier was added in order to identify city-level HIAs that may not have mentioned national level proposals or approaches. To ensure the thoroughness of peer-reviewed studies, additional records were identified via manual sources: a manual bibliographic review (checking reference lists of selected papers), internet searches, and expert consultation. Two independent researchers (M.T. and D.R.R.) performed all levels of screening and resolved discrepancies by consensus.

#1 Health Impact Assessment

health impact assessment/ OR (health impact* OR (health AND impact assess*)) AND

#2 Emerging Markets and Developing Economies (IMF, World Economic Outlook, 2016)

developing countries/ OR africa, northern/ OR africa south of the sahara/ OR africa, eastern/ OR africa, southern/ OR central america/ OR south america/ OR asia, central/ OR asia, southeastern/ OR (developing countr* OR low income countr* OR middle income countr* OR sub-sahara* OR subsahara* OR latinamerica OR caribbean OR south east asia OR southeast asia OR west indies OR *list of individual country names AND

#3 Study Type

(scenario* OR case OR policy OR project* OR program*).ti,ab,kf. AND

#4 Extra Study Type

(city OR cities).ti,ab,kf.

Figure 4: Search string used for the systematic review

Eligibility Criteria

HIAs were included if they reported a clear intervention and health outcome to be assessed. Additionally, case studies were included if:

1. The appraisal provided a comparison between different situations and brought an assessment that would change the status quo.
2. There was a clear statement and description of an intervention to be assessed. The intervention could be a program, project, or policy.
3. The intervention triggered a 'before and after' situation: It reported a change in the distribution of exposure for at least one health pathway.
4. The intervention addressed one or more problems in a specified population: It reported a change in at least one health outcome.

Data Extraction

We extracted data from eligible studies using an Excel-based extraction tool (Supplementary File 2) split in two parts: general characteristics and process evaluation assessment. The general characteristics enabled a descriptive analysis of HIA case studies: author, title, year of publication, country, level at which conducted, type of object appraised, data type used, self-identification as HIA, topic of HIA. The process evaluation assessment consisted of six process evaluation criteria justified in the extraction tool.

Process Evaluation Assessment

We conducted the process evaluation assessment by selecting and adapting five questions from Quigley and Taylor (2004) (37):

1. What data were used and what types of outcomes were calculated?
2. What resources (financial, human, time) were needed to complete the HIA?
3. Who and how were different stakeholders involved and engaged in the process?
4. How and when were the recommendations delivered to the relevant decision makers?
5. What collaborations existed that led to the publication of the HIA?

We then searched for the process evaluation criteria most likely to respond to the previous questions by reviewing HIA methodological literature (34,45–53) and existing reviews (8–10,12,31–34,36). Based on this non-systematic review, we defined six evaluation criteria: (I) access to baseline local data; (II) resources used; (III) based on participatory approaches; (IV) consider multiple outcomes; (V) provide recommendation; and (VI) foster cross-national collaboration (see Table 5). In regards to the last criteria, shared authorship and first author affiliation to a local institution were considered as a research output on HIA from the local country. The affiliations of each collaborating author were not detailed; however, the presence of shared authorship with a foreign institution was checked for. The presence of foreign collaboration is reported as an existing recommendation for HIAs to build cross-national scientific ties that in turn encourage the increase and expansion of HIA implementation (54). A series of associated factors were inductively generated and systematically applied to all case studies. The reporting or non-reporting of each criteria were useful to identify factors enabling or hindering implementation of HIAs in LMICs.

Question No.	Criteria	Associated Factors	Description
I	Accessed baseline local data	1.1. Use of existing database 1.2. Primary data collection	Yes or no Yes or no
II	Reported resources used	2.1. Human 2.2. Time 2.3. Money	Yes or no Yes or no Yes or no
III	Based on participatory approaches	3.1. Stage of participation activity 3.2. Participant profile described	Screening, scoping, etc. Yes or no
I	Considered multiple outcomes	4.1. Multiple outcomes 4.2. Coverage per outcome	Yes or no By mortality, morbidity, cost, social outcomes
IV	Provided recommendation	5.1. Format 5.2. Timing of delivery	Brief, separate section Early, mid and later stages
V	Fostered cross-national collaboration	6.1. Shared authorship (local & foreign) 6.2. Local affiliation of first author	Yes or no Yes or no

Table 5: Criteria and associated factors for process evaluation.

4.3 Results

Our search yielded 3178 records initially (excluding 902 duplicates). After title screening (retaining 339 records) and abstract screening (resulting in 147 studies), we conducted a full-text eligibility assessment and discarded 90 records not satisfying the inclusion criteria. The final dataset included 57 studies (see Figure 2 for PRISMA flowchart and Supplementary File 3 for the list of studies). We present the results as follows. We first describe the general characteristics of HIAs in LMICs. We then specify the geographic and regional distribution of HIAs. Finally, we report on each process evaluation criteria separately.

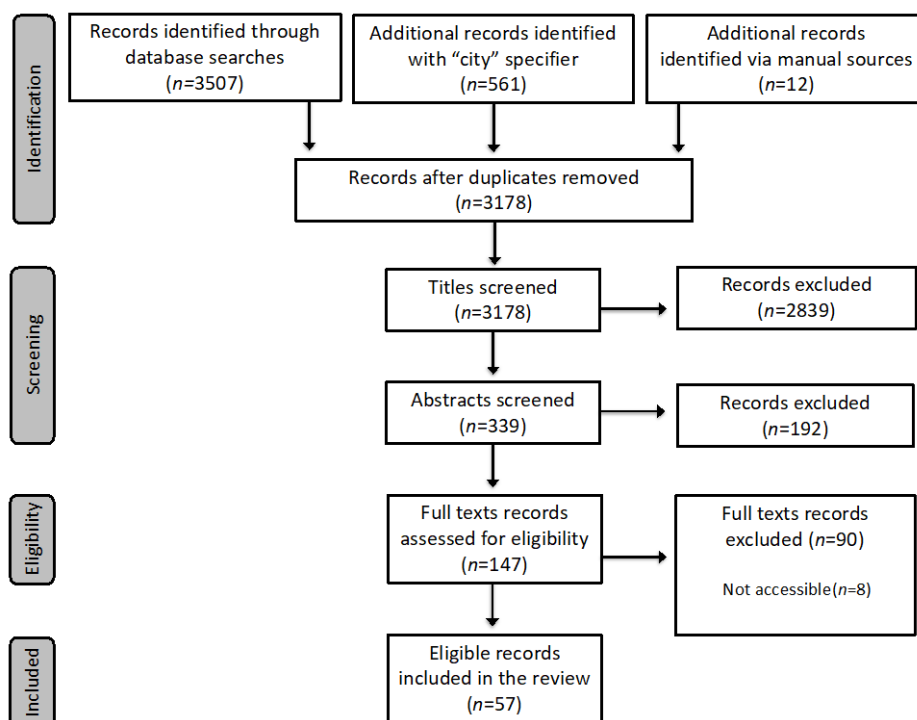


Figure 5: Study selection flowchart

HIA General Characteristics

The eligible papers are dated from 1997 to 2018, of which 75% ($n = 40$) were published after 2010. A larger number of HIAs were conducted at city levels ($n = 21$) as opposed to national ($n = 15$), sub-national ($n = 11$), project ($n = 7$), regional ($n = 2$), and global ($n = 1$) levels. Sub-national HIAs included both urban and rural HIAs. More HIAs were used to estimate the effects of policies ($n = 34$) rather than programs ($n = 12$) or projects ($n = 11$). Quantitative HIAs were the most common, covering 72% of cases ($n = 41$). The remaining cases were split evenly in mixed-methods and qualitative HIAs (each $n = 8$).

Only 30% of cases self-identified as HIAs by either defining HIA itself or clearly describing the stages used to perform HIA. Other cases defined themselves as epidemiological or health risk assessment studies.

Geographic Distribution and Affiliation

HIAs were conducted in 26 of the 156 countries reviewed (16%). They were unevenly distributed across regions: Asia (46%, $n = 25$), Africa (18%, $n = 10$), Europe (18%, $n = 10$), and Americas (16%, $n = 9$). All single-country studies were conducted in the Global South except for one completed in Hungary (55). The number of HIAs varied across countries, with the highest number of HIAs conducted in China (see Table 6). HIA topics also differed across regions, with Asia leading on the wider diversity of topics: 9 in total.

In contrast, Africa, Europe/Middle East, and Americas covered 5, 6, and 5 topic categories, respectively (see Table 7). Air pollution ($n = 26$) is the most common, and it is the only topic for HIA that spread across all regions and a larger number of countries. Out of the 10 studies conducted in Africa, half focused on development projects. To date, Africa is the only region where no HIAs on urban transport planning have been published. By order of importance, the three leading topics for HIA in LMICs (number of times it occurred in the data) were air pollution, development projects, and urban transport planning (see Table 8). Overall, the first author was affiliated to a local institution in 49% of cases ($n = 27$). First author affiliation varied across continents: In Africa, it involved 20% of cases ($n = 2/10$), versus 42% in Asia ($n = 11/25$), 56% in the Americas ($n = 5/9$), and 90% in the Europe/Middle East region ($n = 9/10$).

Single-Country Location	Number of HIAs	Reference
China	15	(56–70)
Thailand	4	(71–74)
Brazil	4	(75–78)
India	3	(79–81)
Iran	3	(82–84)
Turkey	3	(85–87)
Algeria	2	(88,89)
Kenya	2	(90,91)
Bangladesh	1	(92)
Cameroon	1	(93)
Cuba	1	(94)
Congo	1	(95)
Hungary	1	(96)
Jordan	1	(97)
Laos	1	(98)
Mexico	1	(99)
Mongolia	1	(100)
Peru	1	(101)
Philippines	1	(102)
Puerto Rico	1	(103)
Uganda	1	(104)
Zimbabwe	1	(105)
Multi-Country Location	Number of HIAs	Reference
Cameroon-Chad	2	(23,106)
Chile-Brazil-Mexico	1	(107)
Israel-India	1	(108)
Lithuania-Slovakia-Hungary-Bulgaria	1	(96)
Korea-Singapore-VietNam	1	(109)
101 countries across the globe	1	(110)

Table 6: Number of studies by country

HIA TOPIC	Asia	Africa	Europe/Middle East	Americas
Air Pollution (AP)	15	2	4	4
Construction	1	-	-	-
Development Project	1	5	-	1
Diabetes	1	-	1	-
Excreta management	1	-	-	-
Golden rice	1	-	-	-
Public & Green space	1	-	-	-
Urban Transport Planning	3	-	1	1
Vaccination	1	-	1	-
Homosexuality Bill	-	1	-	-
Infectious Diseases	-	1	-	-
Clinical Waste	-	1	-	-
Housing	-	-	2	-
Salt consumption	-	-	1	-
Cigarette smoking	-	-	-	2
Investment program	-	-	-	1
Total number of studies	25	10	10	9

Table 7: Number of studies by region and by topic.

Country	Air Pollution	Development Projects	Urban Transport Planning
Algeria	2	-	-
Bangladesh	1	-	-
China	11	-	1
India	1	1	1
Mongolia	1	-	-
Thailand	2	-	-
Iran	2	-	1
Turkey	2	-	1
Brazil	2	-	1
Chile-Brazil-Mexico	1	-	-
Mexico	1	-	-
Chad-Cameroon	-	2	-
Zimbabwe	-	1	-
Kenya	-	1	-
Puerto Rico	-	1	-
Laos	-	1	-
Democratic Republic of Congo	-	1	-

Table 8: Number of studies by region and by topic.

Results from the Process Evaluation

The process evaluation shows important variations in the way that HIAs were conducted, and there is low uniformity in the reporting of the six process evaluation criteria (see Table 9).

Process Evaluation Criteria	No. Of Studies	Associated Factors	No. Of Studies
Accessed baseline local data	57	Use of existing databases	43
		Primary data collection	14
Reported resources used	0	Open Access to publication	40
		Reporting on HIA stages	17
		Participatory stage	6
Based on participatory approaches	7	Stakeholder profile	7
		Mortality outcomes	33
Considered multiple outcomes	53	Morbidity outcomes	43
		Social determinant outcomes	11
		Cost outcomes	17
		Brief (as part of conclusion)	29
Provided recommendation	35	Separate sections	6
		Data timing of delivery	7
		Local affiliation of first author	27

Table 9: Process evaluation results

Access to Baseline Local Data

All HIA studies accessed local baseline data to estimate health impacts, of which 75% ($n = 43$) used existing baseline datasets. Via the assessment, access to data was not reported as problematic; however, studies reported the lack of quality in baseline data of quantitative HIAs as a major limitation. Several quantitative HIAs reported that using weak quality datasets made it difficult to estimate accurate differences among cities, variations in emission scenarios, and changes in population distributions (56,75,82,86,101). Even when primary datasets were collected from scratch (25%, $n = 14$), important assumptions on data validity had to be made (89). In Bejaia for instance, Benaissa et al. collected data on exposure to particulate matter (PM₁₀) but had to assume that estimates remained constant despite seasonal variations (88). Kahn et al. had to complement local data with disease data from neighboring Uganda to estimate the impact of a multi-disease prevention campaign in Kenya (90). Mestl et al. used data from Bangladesh to estimate indoor air pollution impacts in a rural area of China (67).

Furthermore, the treatment of local quantitative datasets using non-local dose-response functions or incidence rates were reported to skew HIA outcomes because they were not applicable for different levels of exposures, local population sensitivity, and age distribution. Studies in Chile (111), China (56), Peru (101), Brazil (75), Iran (83), and Turkey (86) show that consequences include the underestimation of health effects, limitations to primary (rather than secondary) impact assessments of indicators, and restriction in the selection of health endpoints.

Reporting Resources Used

No study reported the time, money, and staff used to perform HIA. The lack of information on the resources used for the studies made it difficult to assess what is needed in terms of cost, time, and human resources to conduct HIA in a lower resource setting.

Based on Participatory Approaches

Only 12% ($n = 7$) of HIAs were based on participatory approaches, all of which were either mixed-methods or qualitative HIAs. No quantitative HIA reported stakeholder participation. All participatory-based HIAs provided the stage at which participatory activity occurred and described the profile of stakeholders involved in the participation (81,91,96,104,112–114). The participatory approaches in the process of HIA was unclear in 50 studies, i.e., 87% of cases did not conduct or report participatory activities. It is unclear if and why stakeholders were not effectively engaged in HIAs. However, wherever present, authors reported that stakeholder participation was valuable to set the boundaries of the assessment (96), to clarify expectations and disaggregate different determinants of health (112), and to identify and concretize collaboration (113). Participation was conducted via qualitative interviews, focus group discussions, and during field visits at screening and scoping stages (91,96,104,112,113) or at reporting stages (81). Only one study reported participation (consulting for stakeholder feedback) after the HIA was conducted (112).

Considered Multiple Outcomes

92% of HIAs considered multiple outcomes. Morbidity outcomes were calculated in 75% ($n = 43$) of studies across 25 countries. Mortality outcomes were calculated in 58% ($n = 33$) of studies across 15 countries. Cost outcomes were calculated in 31% ($n = 18$) of studies across 11 countries and social determinant outcomes in 11% ($n = 11$) of studies across 13 countries (see Table 10). Although Brazilian scholars reported that calculating mortality outcomes remains the best choice (more robust and of high quality) in a city like Sao Paulo (75), the majority of studies (92%, $n = 53$) assessed at least two or more health impact outcomes (including mortality) and reported benefits of considering multiple outcomes. Only one study calculated all four outcomes simultaneously (101).

No. Studies/ No. of Countries	Mortality	Morbidity	SDH ¹	Costs	Mortality Morbidity	Mortality Morbidity SDH	Mortality Morbidity SDH Costs
No. Studies	33	44	11	17	24	3	1
No. of Countries	15	25	13	11	12	3	1

¹ *Social Determinants of Health (144).*

Table 10: No. of studies and countries by outcome.

Some examples of morbidity outcomes were respiratory and cardiac hospitalizations in Algeria (88); total mortality, cardiovascular mortality, respiratory mortality, respiratory disease, hospital admission, and cardiovascular disease in Iran (83); avoidable traffic deaths in China (115); and HIV (Human Immunodeficiency Virus) cases in Chad-Cameroon (23). Examples of cost outcomes were calculated economic loss (as a share of Thailand's Gross Domestic Product) due to exposure to PM₁₀ emissions from transportation (73), and in monetary terms of health benefits (less mortality and less hospitalizations) of the flue-gas desulphurization units of a coal-fired power plant in Turkey. Studies show that aiming for different outcomes encourages cross-sectorial and transdisciplinary work. A HIA conducted in Bangladesh showed that estimating the health impacts of brick construction should be accompanied by an assessment of social and labor issues (92). In India, a multilateral sectoral approach combining mining and transport was adopted to estimate health impacts of air pollution (particulate matter 10), resulting in wider options for risks mitigation involving energy efficiency, cleaner technology, and enforcement of control policies (80).

Provided Recommendations

In general, 63% ($n = 43$) of HIAs provided recommendations. However, the delivery of recommendations was inconsistent, ranging from HIAs providing specific, brief, or no recommendations at all. Specific recommendation sections were found in 16% ($n = 9$) of studies. Brief recommendations incorporated in the conclusion section were reported in 56% ($n = 33$) of studies in the format of one-sentence ($n = 7$) and less-than-one-paragraph ($n = 26$). Two studies reported that separate reports targeted to specific stakeholders were generated from the HIA (these papers were counted as having separate recommendation sections) (106,114). The time at which recommendations were delivered also varied within the 14% ($n = 8$) that provided such indication: early ($n = 2$), mid ($n = 0$), and later stages ($n = 6$). More than half of the studies not providing recommendations (60%, $n = 9/14$) were conducted on air pollution.

Fostered Cross-National Collaborations

The opportunity to foster cross-national scientific collaborations was reflected in the fact that more than half of the HIAs were published by teams based in different countries. Indeed, evaluating shared authorship showed that 61% ($n = 35$) of HIAs were published jointly by local and foreign researchers. The remaining HIAs were published exclusively by local teams (32%, $n = 18$) or by foreign teams (10%, $n = 6$). Foreign-led HIAs (HIAs led by non-local teams) were either published by small teams of one or two authors (23,102) or by larger teams working on quantitative HIAs in China (59,65,67) and Thailand (73). Locally-led HIAs were conducted in Brazil, China, India, Iran, Thailand, Turkey, and Mexico (9,10,12,57,117), but other HIA studies within the same countries also showcased local-foreign co-authorships. In this regard, Chinese case studies stood out. Six out of 15 studies were published by first authors affiliated with Chinese academic or research institutes. The 9 remaining studies were published by first authors affiliated with academic or research institutes in Norway, Netherlands, Germany, Switzerland, UK, USA, and Belgium, of which 3 studies included no China-based authors.

4.4 Discussion

Peer-reviewed HIAs were conducted in 26 of 156 LMICs (16%) and were unevenly distributed across regions. A larger number of HIAs used quantitative approaches, focused on air pollution, appraised the effect of policies, and were conducted at the city level. The process evaluation shows important variations in the way that HIAs are conducted and low uniformity in the reporting of six process evaluation criteria. This study fills an important gap by mapping, comparing, and critically evaluating HIAs conducted in LMICs. It uses empirical evidence reported by HIA case studies and adds value to rare studies that attempt to examine HIA activity in developing regions of the world (8,10,12,14). The study provides solid baseline information about the characteristics of HIAs and their limitations. The search selection bias of case studies was reduced by combining databases from different regions and fields. Time restrictions were removed, and language barriers reduced. Adopting a systematic search strategy with wide inclusion criteria (see Supplementary File 1) was also efficient for ensuring all relevant scientific evidence on the topic was gathered.

Geographic Scaling

This review showcases the inequitable distribution of HIAs among low and middle-income countries of the world, reasonably questioning the role of equity as one of the four ground values of HIA practice (1). Geographic scaling is one solution to address this imbalance; however, the consideration of factors justifying weak implementation in these regions is crucial. Scholars have previously identified the lack of simplified tools, inadequate policy guidelines, poor governance, weak capacity, no solid environmental baseline databases, and lack of scientific collaboration as barriers to scaling HIA practice (10,14,99). Our findings, however, indicate that local teams are initiating and completing HIA processes despite these vast challenges by adapting traditional methods of data collection and analysis.

Existing academic work showed that in 2005, quantification was comparatively rare in HIA (33), which contrasts with our current findings that a significant share of HIAs in LMICs were quantitative. Studies reported that the use of quantitative methods in geographical settings where datasets were of weak quality called for adapted solutions. In our review, studies showed alternative avenues for impact modelling, for instance, to make up for the lack of incidence data (86,97).

In qualitative HIAs, different data collection methods were employed, including the use of participatory approaches such as stakeholder e-interviews (112), and news virtual tools such as Google Earth were applied (119). In existing literature, both Abah (2011) and Winkler et. al (2012) have suggested that complementing existing datasets with newly conducted, comprehensive health surveys and cross-sectional studies can compensate for the lack of reliable data (120,121). Particularly, Winkler et al. (2012) encourage the use of tools such as the gap analysis to assess availability as well as quality of existing data before deciding to do a HIA (121). Other scholars have argued the importance of strengthening local governance structures and policy frameworks to facilitate HIA practice in challenging contexts (2,120,122).

Interestingly, our findings show that countries where at least two HIAs were conducted are the same ones known to host some form of HIA legislation, regulation, or framework. Such are the cases of Brazil, China, India, Iran, Thailand, and Turkey (9,10,12,57) . Additionally, this exact set of countries, adding Mexico, corresponded to where HIAs were conducted and published by exclusively local teams (no foreign teams were mentioned in authorship or acknowledgements), suggesting some level of local governance as well as the presence of a technical and resource capacity at the country-level.

In addition to the presence of policy frameworks, Joffe and Mindell (2002) suggested that focusing on the right HIA sectors (i.e., those most affecting health) would lead to HIAs that have significant scientific, environmental, social, and political relevance (123). They suggested that HIAs should focus on the sectors most urging for assessments in LMICs: transport, nutrition, and housing (123). Yet, in the 10 studies of Africa alone, none of these are touched upon; focus has been cast, rather, on air pollution, waste, dam and mining projects, homosexuality bills, and infectious diseases (23,89–91,93,95,104–106,124). This suggests that the proposal made by Joffe and Mindell (2002) is either outdated or not adapted to LMICs. In contrast, our review shows that exposure to air pollution is the only area of focus assessed in all four regions and by the most amount of countries. Our findings show that LMICs have a significant interest in the topic of development projects, which other authors have justified previously (22,125). However, despite the increasing amount of road-related deaths in Africa (127), our findings show that Africa is the only region where no HIAs on urban and transport planning has been published so far.

Methods

HIAs showed significant differences in the application of process evaluation criteria. Similar variations were identified in the USA (128), indicating that strict compliance to guidelines and standards may be a luxury that HIA teams worldwide find challenging to afford. Additionally, the diversity in process confirms that the criteria and pre-requisites for ensuring effective HIA implementation can be difficult to define (53,129). This challenges the idea that a set of core universal principles can ensure the effectiveness of HIA as suggested by Fakhri et al. (52), because the level of compliance with a set of standards is not necessarily representative of effectiveness or quality (29).

The criteria assessing to what extent HIAs are based on participatory approaches is a good example illustrating that process criteria may be, but are not necessarily, reflexive of effectiveness or quality. Our review shows that participatory approaches were reported exclusively in qualitative or mixed-methods studies. Yet, it is difficult to assess whether that means that they are of better quality or higher effectiveness than quantitative studies not reporting participatory approaches. Current literature urgently calls for quantitative HIAs to integrate participatory approaches as part of their frameworks (130). Benefits include the involvement of communities most affected by projects, programs, or policies; inducing stakeholder engagement at different levels of actions; increasing public acceptability of interventions; and tackling complex issues of the urban realm. While several papers confirm the benefits of involving different profiles of participants in the physical vicinity of projects (24,114) with particular ethnic backgrounds (131) or with specific expertise (93), there is not enough information to assess the quality of the participatory approaches used. This confirms recent findings that HIA authors need to use more rigorous methods when conducting and reporting participatory approaches such as sampling methods, time and scale of participation, and objectives, etc. (32).

The lack of recommendations emerged as a major methodological problem in this review. Literature supports that bad delivery or report of recommendations influence the integration of HIA in policy making (40,132–134). Davenport et al. (2005) found that providing realistic and non-controversial recommendations, fitting in political timeframes, are important enablers to the integration of HIA findings into the decision-making process (40). Harris et al. (2014) go further by stating that adequate recommendations define whether HIA becomes relevant and absorbed into policy decision-making (134). Even further, authors of a previous HIA evaluation study excluded upfront cases with no clear recommendations and considered the latter a pre-requisite to scientifically relevant HIAs (29).

We were therefore surprised to observe that no recommendations were formulated in 26% ($n = 14$) of studies. The inconsistency in the timing and format of delivery made it hard to assess if recommendations effectively led to evidence-based policy actions. However, studies presenting a separate and specific section with recommendations provided more insight on the policy implications of their findings (60,93,103,135) and provided information on the expert panel towards whom the recommendation report was aimed at (23).

Other practical and action-oriented recommendations were provided for a dam in Zimbabwe (105), a mosquito-borne program in India (81), a homosexuality bill in Uganda (104), and a mining project in the Democratic Republic of Congo (95).

Reporting

A major consequence of bad reporting is a serious lack of transparency in the methods and the difficulty in detecting HIAs upfront. Our experience confirms that HIAs can be very difficult to identify because there is no single framework or detailed checklist procedure to qualify what actually constitutes a HIA (136). The lack of definition and clarity of what processes were adopted significantly challenged the identification and comparison of HIA processes across settings.

This was aggravated by the low percentage of cases self-identifying as HIAs (either by defining HIA itself or clearly describing the stages used to perform HIA) to start with. Some authors declared having done HIA without referring to any HIA standard guideline or standards (137) and were excluded. Others performed HIA without claiming or defining it as such (56,102), and the term HIA was not always used in the same sense across studies. The lack of definition and transparency in HIA processes that came from studies in China, Turkey, and Mongolia (70,87,100) were harder to identify and include; they could have been discarded due to close similarities with health risk assessments (HRAs). HRAs are an integral part of HIAs (often conducted in the appraisal stage) but are not HIAs. Risk assessments could estimate the effects of a particular exposure/risk/danger but do not always assess the impact of a particular change in the current situation due to a clearly stated intervention. The most easily identifiable and analyzable HIA cases described the type of HIA conducted, the data collection approach, and clearly identified the basic procedural stages. Some examples included, but were not limited to, a study in Kenya assessing the impacts of a dam and irrigation projects (91) and a study assessing housing policies in central Europe (131).

No study reported the resources needed to conduct a HIA, limiting our ability to assess what resources could be considered sufficient to successfully complete the process. Having a better idea of such elements is crucial to justify the cost- and resource-effectiveness of HIAs in low and middle-income countries. In HICs, benefits of HIAs have been proven to outweigh the cost of undertaking them and not the contrary (41). However, evidence shows that policy makers decline HIA use because they incorrectly believe that HIAs are ‘expensive and time-consuming’, both in HICs and LMICs (29,138). Earlier, Kemm (2005) reported the need of conducting cost-benefit analysis of HIA as an important element and low-hanging fruit for progress(135) . Other authors have also flagged the lack of information on HIA costs but none address LMICs specifically(136,137). It is crucial to start assessing and reporting the cost of HIAs in LMICs to increase policy dialogue around institutionalization of HIA, not only for the sake of awareness but also to enable to assessment of what benefits actually exist and at what cost.

Recommendations

Based on the empirical review of 57 HIA case studies from LMICs, we provide a simplified “Process Appraisal Checklist” adapted from Parry and Kemm’s criteria for process evaluation (2005) (48) (see Table 11). We adapted the challenges and opportunities identified during the process evaluation and adapted them to each stage of the existing checklist in order to provide more practical guidelines for scholars or professionals interested in conducting HIA in LMICs.

Stage	Prediction	Participation	Decision-Making	Resources
Screening	Clarify the issue at stake jointly with all parties	Conduct thorough stakeholder mapping	Define the role of decision-makers in pushing HIA forward	Report on the costs of screening activities
	Define the expected outcomes of HIA jointly with all parties	Plan outreach strategy to stakeholders		
Scoping	Define topic/sector of interest	Approach institutions and individuals having access to adequate datasets	Define the decision makers agenda Fit the recommendations into adequate political timelines	Report on the costs of scoping activities
	Scope for regions with similar features			
	Identify local data sources and routinely collected data system			
Appraisal	Design HIA framework based on data type available and accessible data management technology	Report on technical working groups and workshops	Check whether involvement of decision-makers led to bias	Report on the costs needed to access the information needed
	Adapt study area, indicators, and outcomes to increase validity and sensitivity of results			
Dissemination	Craft clear and actionable recommendations	Deliver timely and compelling messages to appropriate audiences	Use multiple dissemination methods to access decision-makers	Report on the costs of activating dissemination process

Table 11: Process Appraisal Checklist based on review and adapted from Parry and Kemm (2005) (48).

Based on the reporting of process evaluation factors, we also propose the following recommendations:

1. For quantitative HIAs, assess the data availability and quality at screening and scoping stages so as to plan in advance for solutions to tackle inadequate baseline datasets (either no, insufficient, or bad data). In LMICs, both availability and quality of data should dictate whether a HIA is conducted or not; after which HIA frameworks need to be adapted to what can be done with the resources (human, financial, and time) at hand. A thorough understanding of HIA typologies (see Harris-Roxas (2011))(138) can be helpful to identify the type of HIA most fitting for conducting a quality HIA with available data. For instance, the choice of running a rapid, intermediate or comprehensive HIA can significantly influence the scope, impact, and ultimately the action taken upon HIA estimates.
2. The use and accurate reporting of participatory approaches is encouraged for all types of HIA, including quantitative HIAs.
3. HIA practitioners should ensure that clear recommendations are formulated from the HIA outcomes. Such recommendations should be well-framed and delivered with adequate timing and to the right people.
4. Adopt a transparent process by reporting the staff, cost, time, and training needed to conduct the HIA. This will facilitate knowledge transfer of good practices and comparative studies across countries.
5. Engage into collaboration at local, regional, and international levels. Local collaboration between sectors and institutions is as important as cross-national collaborations for building awareness and increasing technical capacity in the country.
6. Plan for the evaluation of successfully conducted HIAs in order to ensure quality and assess the cost-effectiveness of the process.

Study Limitations

Despite a solid systematic search, all relevant studies may not have been identified. The exclusion of grey literature may have induced publication bias as HIA in lower resource countries is frequently conducted by private or multilateral organizations(23,113,139). It is also possible that HIAs driven for specific interventions on controversial topics and within tighter timelines were not made public or are restricted for use by particular individuals or institutions. Studies with negative findings, bad experiences, or that were unsatisfactorily completed may have been less likely published. The exclusion of non-Latin languages such as Chinese may have excluded some studies. As another limitation, the process evaluation criteria were selected according to the authors' professional judgement and may have impacted on the findings. Furthermore, many published HIAs are not required to include any of those criteria, and even if they did, they may not have reported it, especially if publication space is restricted. The interpretation of evidence must also be done with care as they are mostly based on the subjective assessment of authors. While factors such as outcome calculation, regional distribution and level of implementation are objective to assess, the interpretation of other factors such as participation and recommendation were less evident. For instance, it was difficult to assess whether the absence of participation and recommendation were due to lack of reporting or lack of accomplishment.

4.5 Conclusions

The systematic review with focus on process evaluation of 57 case studies provided a unique opportunity for mapping and assessing HIA activity in LMICs. There is an unequal distribution of HIAs in LMICs. Studies from Asia spearhead in number and diversity of topics. The leading topics of HIA in LMICs are air pollution, development projects, and urban transport planning.

Studies in Africa are significantly lagging behind in terms of first author affiliation. The process evaluation showed important variations in the way HIAs are conducted and low uniformity in the reporting of the six criteria. The limited reporting of resources used, weak participatory approaches, and inconsistent delivery of recommendations were potential limitations to scaling HIA practice in LMICs, while current opportunities to scaling HIAs are driven by access to local baseline data, the consideration of multiple outcomes, and strong cross-national collaborations. Finally, the potential for scaling HIA to low and middle-income countries over the upcoming years will depend on adapting quantitative methods to data availability and quality, adopting better reporting practices, and pushing for policy frameworks that promote HIA, especially in countries where it is most needed.

Supplementary Materials

The following are available online at www.mdpi.com/xxx/s1, Supplementary S1: Protocol for systematic literature review, Supplementary S2: Extraction tool, Supplementary S3: List of studies

Author Contributions

The individual contributions of each authors are as follows: conceptualization, M.T., D.R.-R., J.G., D.H.d.V., and M.J.N.; methodology, M.T. and D.R.-R.; software, M.T.; validation, M.T., D.R.-R., J.G., D.H.d.V., and M.J.N.; formal analysis, M.T.; investigation, M.T. and D.R.-R.; resources, M.T.; data curation, M.T. and D.R.R.; writing—original draft preparation, M.T.; writing—review and editing, M.T., D.R.-R., J.G., D.H.d.V., and M.J.N.; visualization, M.T., D.R.-R., J.G., D.H.d.V., and M.J.N.; supervision, D.R.-R., J.G., D.H.d.V., and M.J.N.; project administration, N.A.; funding acquisition, N.A.

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Conflicts of Interest

The authors declare no conflict of interest.

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Supplementary File 1: Protocol for Systematic Literature review

INFORMATION

Title

Systematic literature review of Health Impact Assessments in low and middle-income countries.

Registration

PROSPERO Database since August 8, 2018

Systematic review registration number: crd420118102715

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Structured Summary

1. Background

There is no systematic review of HIA case studies in low income countries in the last 10 years. There is consensus that HIAs in developing countries are lacking but no study focuses on those that have been successfully conducted, and do not highlight their strengths and limitations.

2. Objective

The main objective of the review is to define and identify all HIA case studies that have been conducted in low income countries. The specific objectives are to (1) review the use of HIAs worldwide and retrieve those conducted in low income countries (2) describe what works, what doesn't, in what types of countries, how, when and why; (3) define if there are differences between regions and countries in terms of use, types, experiences; (4) highlight strengths and limitations of HIA case studies and (5) propose recommendations forward for conducting HIA in low income countries.

3. Data sources

All case studies will be retrieved from peer-reviewed publications. Systematic database searches will be performed by two independent researchers and augmented by bibliographic review and expert consultation.

3.1. Electronic databases

- Scopus
- Medline
- Web of Science
- Sociological abstracts
- LILACs

3.2. Dates of coverage: No limit

3.3. Search Strings

#1 Health Impact Assessment

health impact assessment/ OR (health impact* OR (health AND impact assess*)).ti,ab,kf.

#2 Emerging Markets and Developing Economies (IMF, 2016)

#3 study type

(scenario* or case or policy or project* or program*).ti,ab,kf.

#4 extra study type

(city OR cities).ti,ab,kf.

3.3.1. Example of a full search strategy in Web of Science in English

Thomson Reuters, Web of Science Core Collection

#1 Health Impact Assessment

TS=("health impact*" OR ("health" AND "impact assess*"))

#2 Developing countries

TS=("developing countr*" OR "low income countr*" OR "middle income countr*" OR "sub-sahara*" OR "subsahara*" OR "latin america" OR "caribbean" OR "south east asia" OR "southeast asia" OR "west indies" OR "antigua and barbuda" OR "kitts and nevis" OR "sao tome and principe" OR "st. lucia" OR "trinidad and tobago" OR "vincent and the grenadines" OR "afghanistan" OR "albania" OR "algeria" OR "angola" OR "argentina" OR "armenia" OR "azerbaijan" OR "bahamas" OR "bahrain" OR "bangladesh" OR "barbados" OR "belarus" OR "belize" OR "benin" OR "bhutan" OR "bolivia" OR "bosnia" OR "botswana" OR "brazil" OR "brunei" OR "bulgaria" OR "burkina faso" OR "burundi" OR "cabo verde" OR "cambodia" OR "cameroon" OR "central african republic" OR "chad" OR "chile" OR "china" OR "colombia" OR "comoros" OR "congo" OR "costa rica" OR "cote d'ivoire" OR "croatia" OR "cuba" OR "djibouti" OR "dominica" OR "dominican republic" OR "ecuador" OR "egypt" OR "el salvador" OR "eritrea" OR "ethiopia" OR "fiji" OR "georgia" OR "grenada" OR "guatemala" OR "guinea" OR "guyana" OR "haiti" OR "honduras" OR "hungary" OR "india" OR "indonesia" OR "iran" OR "iraq" OR "jamaica" OR "jordan" OR "kazakhstan" OR "kenya" OR "kiribati" OR "kosovo" OR "kuwait" OR "kyrgyz*" OR "lao" OR "lebanon" OR "lesotho" OR "liberia" OR "libya" OR "macedonia" OR

"madagascar" OR "malawi" OR "malaysia" OR "maldives" OR "mali" OR "marshall islands" OR "mauritania" OR "mauritius" OR "mexico" OR "micronesia" OR "moldova" OR "mongolia" OR "montenegro" OR "morocco" OR "mozambique" OR "myanmar" OR "namibia" OR "nauru" OR "nepal" OR "nicaragua" OR "niger" OR "nigeria" OR "oman" OR "pakistan" OR "palau" OR "panama" OR "paraguay" OR "peru" OR "philippines" OR "poland" OR "puerto ric*" OR "qatar" OR "romania" OR "russia" OR "rwanda" OR "saint lucia" OR "samoa" OR "saudi arabia" OR "senegal" OR "serbia" OR "seychelles" OR "sierra leone" OR "solomon islands" OR "south africa" OR "south sudan" OR "sri lanka" OR "sudan" OR "suriname" OR "swaziland" OR "syria" OR "tajikistan" OR "tanzania" OR "thailand" OR "timor-leste" OR "togo" OR "tonga" OR "tunisia" OR "turkey" OR "turkmenistan" OR "tuvalu" OR "uganda" OR "ukraine" OR "arab emirates" OR "uruguay" OR "uzbekistan" OR "vanuatu" OR "venezuela" OR "vietnam" OR "yemen" OR "zambia" OR "zimbabwe")

#3 study type (case studies)

TS=("scenario*" OR "case" OR "policy" OR "project*" OR "program*")

#4 Extra

TS=("city" OR "cities")

1 AND 2 AND 3: 1.386 results

Extra export: (1 AND 2 AND 4) NOT 3: 225 results

3.3.2. Example of a full search strategy in LILACS in Spanish

Literatura Latinoamericana y del Caribe en Ciencias de la Salud

Link: <http://lilacs.bvsalud.org>

(mh:"Health Impact Assessment" OR ti:(("health impact" OR "impacto en la salud" OR "impactos en la salud" OR "impacto sobre la salud" OR "impactos sobre la salud" OR "impacto na saude" OR "impactos na saude") OR ti:(health "impact assessment") OR (ti:(("evaluacion del impacto" OR "evaluacion del impactos" OR "avaliacao do impacto" OR "avaliacao do impacto") ti:(salud OR saude))) OR (ab:(("health impact" OR "impacto en la salud" OR "impactos en la salud" OR "impacto sobre la salud" OR "impactos sobre la salud" OR "impacto na saude" OR "impactos na saude") OR ab:(health "impact assessment") OR (ab:(("evaluacion del impacto" OR "evaluacion del impactos" OR "avaliacao do impacto" OR "avaliacao do impacto") ab:(salud OR saude))) AND (tw:(scenario* OR case OR policy OR project* OR escenario* OR caso OR política OR proyecto* OR cenario* OR caso OR projeto* OR program*)))

Results: 265

Downloaded: 203

Cities

((mh:"Health Impact Assessment" OR ti:(("health impact" OR "impacto en la salud" OR "impactos en la salud" OR "impacto sobre la salud" OR "impactos sobre la salud" OR "impacto na saude" OR "impactos na saude") OR ti:(health "impact assessment") OR

(ti:(("evaluacion del impacto" OR "evaluacion del impactos" OR "avaliacao do impacto" OR "avaliacao do impacto") ti:(salud OR saude))) OR (ab:(("health impact" OR "impacto en la salud" OR "impactos en la salud" OR "impacto sobre la salud" OR "impactos sobre la salud" OR "impacto na saude" OR "impactos na saude") OR ab:(health "impact assessment") OR (ab:(("evaluacion del impacto" OR "evaluacion del impactos" OR "avaliacao do impacto" OR "avaliacao do impacto") ab:(salud OR saude))) AND (tw:(ciudad OR ciudades OR cidade OR cidades))) NOT (tw:(scenario* OR case OR policy OR project* OR escenario* OR caso OR política OR proyecto* OR cenario* OR caso OR projeto* OR program*))

Results: 2

4. Study inclusion criteria, participants, and interventions

General inclusion criteria

- Individual HIA case studies only (original articles)
- Published and peer reviewed papers only
- In low and income countries only (the selection of the countries were based on the Emerging Markets and Developing Economies according to IMF's definition (IMF, World Economic Outlook, 2016). EMDEs include 156 countries (see Table 1)
- Following PICO table (see Table 2)

Specific inclusion criteria

- The appraisal provides a comparison between different situations and brings an assessment that will change the status quo.
- There is a clear statement and description of an intervention to be assessed. The intervention can be a programme, project or policy.
- The intervention triggers a 'before and after' situation: it reports a change in the distribution of exposure for at least one health pathway.
- The intervention addresses one or more problems in a specified population: it reports a change in at least one health outcome.

5. Study appraisal and synthesis methods

All methods applied PRISMA guidelines except for the meta-analysis section. The literature search, study selection, data extraction and synthesis lasted from May 13, 2018 to October 26, 2018. Appraisal was done by extracting general characteristics and by applying six process evaluation criteria:

5.1. Data items (List of variables for which data will be sought)

General characteristics:

Publication year, online accessibility, level at which conducted, intervention appraised, data type used, HIA self-identification, topic addressed.

Process evaluation criteria:

accessed baseline local data, reported resources used, based on participatory approaches, considered multiple outcomes, provided recommendation, fostered cross-national collaboration

5.2. Prioritization

We do not practice or prioritize based on a quality assessment.

5.3. Risk of bias in individual studies

Risk of bias will be assessed at study level sites.

5.4. Data Synthesis

No quantitative synthesis will be conducted.

5.5. Meta-Bias

This is not applicable.

6. Results

A search yielded 3178 records initially (excluding duplicates). After title screening (retaining 339 records) and abstract screening (resulting in 147 studies), we conducted full-text eligibility assessment and discarded 90 records not satisfying inclusion criteria. The final dataset included 57 studies(see Figure 1).

7. Limitations; conclusions and implications of key findings;

Limitations

Despite a solid systematic search, all relevant studies may not have been identified. The exclusion of grey literature may have induced publication bias as HIA in lower resource countries is frequently conducted by private and/or multilateral organisations (18,209,230). It is also possible that HIAs driven for specific interventions, on controversial topics and within tighter timelines were not made public or are restricted for use by particular individuals or institutions. Studies with negative findings, bad experiences or that were unsatisfactorily completed may have been less likely published. As another limitation, the criteria for evaluation were selected by authors' professional judgement and may have impacted on the findings. The interpretation of evidence must also be done with care as they are mostly based on the subjective assessment of authors. While factors such as outcome calculation, regional distribution and level of implementation are objective to assess, the interpretation of other factors such as participation and recommendation were less evident. For instance, it was difficult to assess whether the absence of participation and recommendation were due to lack of reporting or lack of accomplishment.

Conclusions

The systematic review with focus on process evaluation of 57 case studies provided a unique opportunity for mapping and assessing HIA activity in LICs. There is an unequal distribution of HIAs in LICs. Studies from Asia lead in number and diversity of topics. The leading topics of HIA in LICs are air pollution, development projects and urban transport planning. Studies in Africa are significantly lagging behind in terms of first author affiliation. The process evaluation showed important variations the way HIAs are conducted and low uniformity in the reporting of six criterias. The limited reporting of resources used, weak participatory approaches and inconsistent delivery of recommendations were potential limitations to scaling HIA practice in LICs, while current opportunities to scaling HIAs are driven by access to local baseline data, the consideration of multiple outcomes and strong cross-national collaborations. Finally, this empirical auditing suggests that process evaluations are useful tools to assess what is needed to scale HIA practice to low-income countries and taking a step towards health for all.

Tables

Armenia	Papua New Guinea	Colombia	Iran	Eritrea
Azerbaijan	Guinea	Costa Rica	Iraq	Ethiopia
Belarus	Philippines	Cuba (added)	Jordan	Guinea
Georgia	Samoa	Dominica	Kuwait	Guinea-Bissau
Kazakhstan	Solomon Islands	Dominican Republic	Lebanon	Kenya
Kyrgyz Republic	Sri Lanka	Ecuador	Libya	Lesotho
Moldova	Thailand	El Salvador	Mauritania	Liberia
Russia	Timor-Leste	Grenada	Morocco	Madagascar
Tajikistan	Tonga	Guatemala	Oman	Malawi
Turkmenistan	Tuvalu	Guyana	Pakistan	Mali
Ukraine	Vanuatu	Haiti	Qatar	Mauritius
Uzbekistan	Vietnam	Honduras	Saudi Arabia	Mozambique
Bangladesh	Albania	Jamaica	Sudan	Namibia
Bhutan	Bosnia & Herzegovina	Mexico	Syria	Niger
Brunei	Bulgaria	Nicaragua	Tunisia	Nigeria
Darussalam	Croatia	Panama	United Arab Emirates	Rwanda
Cambodia	Hungary	Paraguay	Yemen	São Tomé and Príncipe
China	Kosovo	Peru	Angola	Senegal
Fiji	FYR Macedonia	Puerto Rico (added)	Benin	Seychelles
India	Montenegro	St. Kitts and Nevis	Botswana	Sierra Leone
Indonesia	Poland	St. Lucia	Burkina Faso	South Africa
Kiribati	Romania	St. Vincent & the Grenadines	Burundi	South Sudan
Lao P.D.R.	Serbia	Suriname	Cabo Verde	Swaziland
Malaysia	Turkey	Trinidad and Tobago	Cameroon	Tanzania
Maldives	Antigua and Barbuda	Uruguay	Central African Republic	Togo
Marshall Islands	Argentina	Venezuela	Chad	Uganda
Micronesia	The Bahamas	Afghanistan	Comoros	Zambia
Mongolia	Barbados	Algeria	DR of the Congo	Zimbabwe
Myanmar	Belize	Bahrain	Congo Republic of the Congo	
Nauru	Chile	Djibouti	Côte d'Ivoire	
Nepal		Egypt	Equatorial Guinea	
Palau				

Table 1: List of EMDE Countries

Inclusion/Exclusion criteria according to PICO		
	Included	Excluded
Population	All	N/A
Intervention	Health impact assessment at city, regional and national level	General and opinionated papers, HIA methodology
Comparison	N/A	N/A
Study Design	Case studies with qualitative and/or quantitative outcomes; and covering a all kind of policy sectors, projects, or programmes including topics such as housing, transport, regeneration and health.	Natural experiments, quasi-experimental studies, policy evaluations, observational studies, trials, protocols. HIA studies that have not been completed yet.
Outcomes	<ul style="list-style-type: none"> • All exposure pathways • All topics • Any sector • Any health outcomes • Affiliation of HIA practitioners • Complexity of HIAs • Duration of HIAs • Cost of HIAs 	Outcomes not included in inclusion criteria.
Publication type	Peer reviewed journal article (original article)	Conference abstracts, conference presentations, study protocols, grey reports, dissertations, books, meetings
Publication year	No limit	No limit
Setting	EMDEs, Low or middle income country	Unspecified setting/population in high income country
Language	English, Portuguese, French, Spanish	All other languages

Table 2: PICO Table

General Characteristics								
Author	Title	Year of publication	Country	Level at which conducted	Type of object appraised	Data type used	Self-identification as HIA	Topic of HIA
				Global Regional National Sub-national Project	Policy Programs Projects	Quantitative Qualitative Mixed methods	HIA definition provided HIA stages described	

Process Evaluation Criteria	
Accessed baseline local data	use of existing database
	primary data collection
Reported resources used	Human
	Time
	Money
Based on participatory approaches	Stage of participation
	Participant profile
Considered multiple outcomes	Multiple outcomes
	Coverage per outcome
provided recommendations	Format
	Timing
fostered cross national collaboration	Shared authorship
	Local affiliation of first author

General characteristics: The descriptives of the following characteristics (Level at which conducted) (Type of object appraised) and (data type used) were extracted from (Krieger 2003)

The process evaluation criteria were defined so as to respond to the five process evaluation questions adapted (Quigley & Taylor, 2004)

SDH : Outcomes that are focused on Social Determinants of Health (Dahlgren and Whitehead 1991)

Author (year)	Title	Country	Topic Addressed
Abe et al. (2016)	Health Impact Assessment of Air Pollution in São Paulo, Brazil	Brazil, Sao Paolo	Exposure to air pollution
Bardach et al. (2016)	Burden of disease of tobacco smoking and impact of increased prices of cigarettes in Peru	Peru	Cigarette smoking
Bell et al. (2006)	The avoidable health effects of air pollution in three Latin American cities: Santiago, Sao Paulo, and Mexico City.	Chile, Brazil, Mexico	Exposure to air pollution
Benaissa et al. (2016)	Short-Term Health Impact Assessment of Urban PM10 in Bejaia City (Algeria)	Algeria, Bejaia City	Exposure to air pollution
Buke and Köne (2011)	Estimation of the health benefits of controlling air pollution from the Yatağan coal-fired power plant	Turkey	Exposure to air pollution: due to energy use
Charemtanyarak et al. (2013)	Health impact assessment of excreta management at Udonthani Municipality, Thailand	Thailand	Excreta management
Chen et al. (2007)	Low-carbon energy policy and ambient air pollution in Shanghai, China: A health-based economic assessment	China, Shanghai	Exposure to air pollution

Chen et al. (2009)	Impact of ambient air pollution on public health under various traffic policies in Shanghai, China	China, Shanghai	Exposure to air pollution: due to transport
Erkoyun et al. (2016)	Predicting the health impact of lowering salt consumption in Turkey using the DYNAMO health impact assessment tool	Turkey	Salt consumption
Garcia Melian et al. (2016)	Evaluación del impacto en salud de proyectos de inversión. Experiencia cubana.	Cuba	Investment (finance)
Gharehchahi et al. (2013)	Health impact assessment of air pollution in Shiraz, Iran: a two-part study	Iran, Shiraz	Exposure to air pollution
Gulis and Mochungong (2013)	Health impact assessment and evaluation of a clinical waste management policy for Cameroon	Cameroon	Clinical waste management
Guttikunda and Khaliquzzaman (2014)	Health benefits of adair pollutionting cleaner brick manufacturing technologies in Dhaka, Bangladesh	Bangladesh, Dhaka	Construction
Hayajneh et al. (2018)	Public health impact and cost effectiveness of routine childhood vaccination for hepatitis a in Jordan: a dynamic model air pollution proach	Jordan	Vaccination
He and QIU (2016)	Transport demand, harmful emissions, environment and health co-benefits in China	China	Exposure to air pollution: due to transport
Hengprair pollutionrom et al. (2012)	Testing a HIA tool by assessing	Thailand, Bangkok	Public and Green space

	community opinion about a public park		
Hill et al. (2017)	Health assessment of future PM2.5 exposures from indoor, outdoor, and secondhand tobacco smoke concentrations under alternative policy pathways in Ulaanbaatar, Mongolia	Mongolia, Ulanbataar	Exposure to air pollution
Hirschberg et al. (2004)	Health and environmental impacts of China's current and future electricity supply, with associated external costs	China	Exposure to air pollution: due to outdoor air pollution
Jahn et al. (2011)	Particulate matter pollution in the megacities of the Pearl River Delta, China – A systematic literature review and health risk assessment	China, Guanzhou	Exposure to air pollution
Jobin and William (2003)	Health and equity impacts of a large oil project in Africa	Chad-Cameroon	Development project: Oil
Kahn et al. (2012)	Integrated HIV Testing, Malaria, and Diarrhea Prevention Campaign in Kenya: Modeled Health Impact and Cost-Effectiveness	Kenya, Western province	Infectious disease: Malaria
Konradson et al. (1997)	The use of health impact assessments in water resources development: a case study from Zimbabwe	Zimbabwe	Development project: irrigation/dam
Kósa et al. (2007)	Rair pollutionid health impact air pollutionpraisal of eviction versus a housing project in a colony-dwelling Roma community	Hungary	Housing

Lacey et al. (2017)	Transient climate and ambient health impacts due to national solid fuel cook stove emissions	101 countries	Exposure to air pollution: due to cook stove emissions
Laid et al. (2006)	Health effects of PM10 air pollution in a low-income country: the case of Algiers	Algeria, Algiers	Exposure to air pollution
Li et al. (2011)	Assessing the co-benefits of greenhouse gas reduction: Health benefits of particulate matter related inspection and maintenance programs in Bangkok, Thailand	Thailand, Bangkok	Exposure to air pollution
Liu et al. (2012)	Projected health impact and cost-effectiveness of rotavirus vaccination among children < 5 years of age in China	China	Vaccination
Mahendra and Rajagopalan (2015)	Evaluating Health Impacts from a Bus Rapid Transit System Implementation in India: Case Study of Indore, Madhya Pradesh	India, Indore City	Urban and Transport Planning
Marseille et al. (2013)	The cost-effectiveness of gestational diabetes screening including prevention of type 2 diabetes: air pollution: application of a new model in India and Israel	India-Israel	Gestational diabetes mellitus
Marzouni et al. (2017)	Health benefits of PM10 reduction in Iran	Iran, Ahvaz, Isfahan, Shiraz, Tehran	Exposure to air pollution
Mestl et al. (2007)	Health benefits from reducing indoor air pollution from household solid fuel	China	Exposure to air pollution: Indoor air pollution (gas, coal, biomass):

	use in China — Three abatement scenarios		
Molnar et al. (2012)	Health impact assessment of Roma housing policies in Central and Eastern Europe: A comparative analysis	Lituania, Slovakia, Hungary, Bulgaria	Housing
Ongel and Sezgin (2016)	Assessing the effects of noise abatement measures on health risks: A case study in Istanbul	Turkey, Istanbul	Urban and Transport Planning
Ren et al. (2016)	Inter-city passenger transport in larger urban agglomeration area: emissions and health impacts	China, Shenyang	Urban and Transport Planning
Renshaw et al. (1998)	A rair pollutionid health impact assessment of the Turkwel Gorge hydroelectric dam and proposed irrigation project	Kenya, Northwest	Development project: Dam Hydroelectric
Riojas-Rodriguez et al. (2014)	Health impact assessment of decreases in PM10 and ozone concentrations in the Mexico City Metropolitan Area. A basis for a new air quality management program	Mexico, Mexico city	Exposure to air pollution
Sa et al. (2017)	Health impact modelling of different travel patterns on physical activity, air pollution and road injuries for São Paulo, Brazil	Brazil, Sao Paolo	Urban and Transport Planning
Sabel et al. (2016)	Public health impacts of city policies to reduce climate change: findings from the URGENCHE EU-China project	China (+European countries)	Urban and Transport Planning

Scovronick et al. (2016)	Air Quality and Health Impacts of Future Ethanol Production and Use in São Paulo State, Brazil	Brazil, Sao Paolo	Exposure to air pollution: due to ethanol use
Semugoma et al. (2012)	Assessing the effects of anti-homosexuality legislation in Uganda on HIV prevention, treatment, and care services	Uganda	Homosexuality
Sharma and Patil (2016)	Emission Scenarios and Health Impacts of Air Pollutants in Goa	India, Goa	Exposure to air pollution: due to fuel use and mining industry
Sheffield et al. (2014)	Health Impact Assessments for Environmental Restoration: The Case of Caño Martín Peña	Puerto Rico, San Juan,	Development project: Water & sewage infrastructure
Srivastava et al. (2010)	Health impact assessment of development project: IOmpact of sardar sarovar narmada project on mosquito-borne diseases	India, Gujarat	Development project: Mosquito-borne program
Sun et al. (2018)	Health-related benefits of air quality improvement from coal control in China: Evidence from the Jing-Jin-Ji region	China, Jing-Jin-Ji	Exposure to air pollution: due to coal energy
Szklo et al. (2017)	Update and extension of the brazil simsmoke model to estimate the health impact of cigarette smoking by pregnant women in brazil	Brazil	Cigarette Smoking
Tashayo et al. (2017)	A Hybrid Fuzzy Inference System Based on Dispersion Model for Quantitative	Iran, Isfahan	Urban and Transport Planning

	Environmental Health Impact Assessment of Urban Transportation Planning		
Thanh and Lefevre (2001)	Assessing health benefits of controlling air pollution from power generation: the case of a lignite-fired power plant in Thailand	Thailand, Mae Moh	Exposure to air pollution: Electricity power generation
Ulzinger et al. (2005)	Assessing health impacts of the Chad–Cameroon petroleum development and pipeline project: challenges and a way forward	Chad-Cameroon	Development project: Mining
Vu et al. (2013)	air pollution application of GIS and modelling in health risk assessment for urban road mobility	China, Haiphong city	Exposure to air pollution: due to transport
Wallet et al. (2016)	Health impact of Dams: lessons from a case study	Laos, Nam Theun	Development project: Dam
Wang and Mauzerall (2006)	Evaluating Impacts of Air Pollution in China on Public Health: Implications for Future Air Pollution and Energy Policies	China, Zaozhuang	Exposure to air pollution
Wang and Smith (1999)	Secondary benefits of greenhouse gas control: health impacts in China	China	Exposure to air pollution: due to energy efficiency solutions
Winkler et al. (2010)	Assessing health impacts in complex eco-epidemiological settings in the humid tropics: Advancing tools and methods	Democratic Republic of Congo	Development project: Mining
Yorifuji et al. (2015)	Health Impact Assessment of PM10 and PM2.5 in	Korea, Singapore, Vietnam	Exposure to air pollution

	27 Southeast and East Asian Cities		
Zhang et al. (2010)	The assessment of health damage caused by air pollution and its implication for policy making in Taiyuan, Shanxi, China	China, Taiyuan, Shanxi	Exposure to air pollution: due to energy use
Zhang et al. (2016)	Modeling energy efficiency to improve air quality and health effects of China's cement industry	China	Construction
Zimmermann and Qaim (2004)	Projecting the Benefits of Golden Rice in the Philippines	Philippines	Nutrition

Chapter 5: HIA POLICY AND SUSTAINABLE DEVELOPMENT

5. Health Impact Assessment Policy And Sustainable Development

The sixth Global Environment Outlook argues that the planet is becoming seriously polluted, with huge consequences for the health and wellbeing of people. Legal instruments for assessing and reporting environmental impacts of projects have focused on environment impact assessments (EIAs). However, increasingly health impact assessment (HIA) is being used to emphasize the health dimensions of the environment and sustainable development. This chapter addresses the question: How can HIA legislation help developing countries to achieve the Sustainable Development Goals (SDGs)? It first sketches the relationship between EIAs and HIAs and provides an overview of the global distribution of HIA legislation. Second, it discusses the benefits and challenges of HIA legislation oriented towards sustainable development agendas by gathering lessons learned across the globe and highlighting those relevant to developing countries. The chapter concludes that HIA policy can be catalysed and operationalized in order to achieve the SDGs.

5.1 Introduction

Developing countries face higher risks of environmental damage and human health loss from unprecedented urbanization. By 2030, Africa and Asia will have 90 percent of 2.5 billion new urbanites worldwide(1),with increased risk of disease and death(2).Annually, 12.6 million deaths are attributable to environmental challenges(3).With urbanization, there are urgent reasons to link environment to public health(4).Urbanized areas concentrate people with higher degrees of vulnerability and exacerbate modern environmental hazards(5),such as air and noise pollution, greenhouse gas emissions and other forms of environmental degradation. There is an inequitable distribution of environment-related deaths per capita by region and countries. Low- and middle-income countries (LMICs) currently have 80 percent of global non-communicable deaths (6),92 percent of pollution-related deaths (7) and 90 percent of traffic-related deaths(8),most of which affect the urban poor.

Hence, it is urgent to address environmental exposures leading to adverse effects in countries suffering unequal health burdens. For this, health arguments could be used to support environmental protection(9).International environmental law supporting the link between health and the environment can be traced back to the 1972 United Nations (UN) Declaration on the Human Environment, which recognized the health dimension of environmental issues(10).The International Court of Justice also recognized that ‘the environment is not an abstraction but represents the living space, the quality of life and the very health of human beings, including generations unborn’(11).

In the developing world, however, the domestic implementation of environmental treaties has failed to reinforce the synergies between health and environmental objectives (12).

Traditional legal approaches to air pollution, for instance, fail to respond to health threats because of data scarcity and weak mechanisms for ensuring compliance with international norms (13). International law has also been unable to address the cumulative ecological challenges from the local to the global level, or address those who cause transboundary harm and provide reparation to those who suffer from such harm(14).

Health impact assessments (HIAs) are increasingly being used as a tool to quantify and assess the impact of ecological damage on human health (15). HIAs provide a framework to estimate and mitigate health risks through effective measures (16). Despite the promising potential of HIA (17), the coverage of HIA legislation across the world remains scarce and scattered(18). Furthermore, inadequate research on HIAs in developing countries is a barrier to the advancement of policy and practice(19). Moreover, the role HIA legislation can play in solving environmental health complexities and its influence on sustainable development, more specifically on the Sustainable Development Goals (SDGs)(20), remains largely unexplored.

Therefore, this article addresses the following question: How can HIA legislation help developing countries to achieve the Sustainable Development Goals (SDGs)? To this end, the article sketches the relationship between EIAs and health; provides an overview of the global distribution of HIA legislation in the world; discusses how legislation can advance HIA practice especially in developing countries; and argues how HIA policy can be catalysed and operationalized to achieve the SDGs.

5.2 HIA And The Sustainable Development Goals

There is increasing interest in how HIA could support the 2030 Agenda for Sustainable Development (21). This global agenda includes 17 Sustainable Development Goals and 169 targets to be achieved by 2030. SDG3 addresses health: 'Ensure healthy lives and promote well-being for all at all ages.' (22) Health is a cross-cutting concern across 10 out of the remaining 16 goals with 28 health-related targets and 47 health-related indicators (23).

A key aspect of the SDGs is to minimize trade-offs and enhance synergies between economic, social and environmental challenges. This could be to some extent operationalized by HIAs through enhancing synergies between the health and non-health sectors and reducing trade-offs between addressing health risks and environmental change. The concept of sustainable development plays an important role in considering and promoting change (structural, environmental, etc.) that will not affect future generations. HIAs can help assess and mitigate impacts triggered by policies that are unsustainable. In fact, the Gothenburg consensus paper on HIA states that sustainable development is one of the four ground values that links HIA to the policy environment (24).

In addition to affecting the health of populations, the exposure pathways addressed by HIA are crucial indicators of Agenda 2030, as health itself is a determinant, outcome and indicator of sustainable development (25).

Hence, HIA is important in addressing all health-related goals, including those addressing social and environmental determinants of ill health.

5.3 Environment Impact Assessments And Health

Environment impact assessments (EIAs) are the most developed, recognized, legally binding and institutionalized impact assessment tools affecting environment-related decision making in different countries(26).Initiated in the 1970s by the National Environmental Policy Act (NEPA) (27) in the United States, the EIA process was an ‘action forcing device’ (28) requiring project developers to report in writing to decision makers on the expected consequences of a project on the environment. In the Rio Declaration on Environment and Development(29),the UN Convention on Environmental Impact Assessment (30) and the Draft Articles on Prevention of Transboundary Harm from Hazardous Activities (31), EIA is recognized as a national instrument assessing activities which can be subject to the decision of the national authority. EIA is also an instrument used in the context of international law based on the International Court of Justice’s 2010 judgment in the *Pulp Mills* case(32).As of 2012, 191 out of 193 UN member countries have a law requiring EIAs(33).

In promoting ‘the widest range of beneficial uses of the environment without degradation, risk to health or safety’(34),EIAs explicitly include the possibility of examining health effects(35).Various case studies show that EIAs have been used to address the complex health-environment equation(36).In developing countries, they were particularly intended to estimate the health impacts of the design, construction and operation of large development projects(37).Yet, increasing concerns have been raised about their adequacy in responding to health issues(38).Evidence shows that EIAs inadequately cover health risks and rarely consider health impacts generated by social and economic determinants inducing changes in the built environment(39). They rarely incorporate the assessment of pathways between environmental exposures and health pathways, do not adopt a systematic approach to health and do not provide information on impacts on different population groups (40). A review of 42 federal HIAs in the US show that 62 percent of EIAs do not mention health impacts while the remaining inadequately support health-related analysis(41).Similarly, a study from the Republic of Korea reports that across 74 EIA unit projects, health was not properly considered or ignored(42).

These shortcomings are also reflected in other impact assessments initially designed to anticipate the implications of policies on the environment and health (43). For instance, the strategic environmental assessment (SEA) has also been reported to insufficiently consider health impacts (44).In contrast to EIAs, SEAs are legally formalized in very few countries. The development of SEAs was influenced by the EU Directive 2001/42 (45) and the Espoo Convention’s Protocol on SEA (46), which entered into force in 2010. While SEAs also address explicit environmental issues, they focus on a higher policy or planning level rather than on infrastructural or individual projects.

This may be one of the factors complicating the ability of SEAs to address health explicitly and thoroughly; thereby providing space for the emergence of HIA as a solution to environmental health challenges.

5.4 State Of The Art Of HIA

HIA: A brief description

An HIA is defined as an assessment process combining mixed methods to judge the potential health effects a proposed policy, programme, or intervention might have on different sections of a population(47).HIAs are elaborated on in several toolkits and guidance documents(48).HIA processes may differ in type, methodology and form(49),but following the World Health Organization (WHO), the HIA procedure consists of at least five basic steps: screening, scoping, appraisal, reporting and monitoring(50).The screening process establishes whether HIA is relevant and needed in a particular policy context or project. The scoping process identifies the key health-related concerns and sets the limits and focus of the assessment. The appraisal process relies on evidence (data on the affected population, prediction, exposure levels and baseline situation) to assess the health impacts. The reporting phase is used to disseminate findings and recommendations for mitigating the negative effects on health. The monitoring phase consists of following existing evidence and patterns and to monitor actual impacts where feasible and appropriate. The process leading to the decision to practice HIA is currently non-standardized and varies based on the actor, the project and level at which one undertakes a HIA.

In LMICs, the main topics covered by HIAs are diverse and include air pollution, construction, development projects, diabetes, excreta management, nutrition, public and green space, urban transport planning, vaccination, infectious diseases, clinical waste, housing and economic investment programmes(51).Different pathways affecting exposure to environment pollutants(environmental exposure pathways) and social factors have been examined, for instance access to: social services, economic opportunities, adequate housing, healthy nutrition and strong social cohesion(52).

The rise of HIA

The intergovernmental conference of Alma-Ata in 1978, which established that a wide range of non-health determinants should be considered in health policy, provided a strong foundation for the rise of HIA(53).The conference drove the formal recognition of HIA by the international and scientific community as a valid way of tackling environmental health challenges. HIAs were further promoted in the 1980s with the Ottawa Charter of Health Promotion (54) and were officially defined and framed in the Gothenburg Consensus Paper in 1999(55).In 2010, Krieger and colleagues published an informative figure featuring the major landmarks of HIA on a 30-year timeline and across regions and sectors (56).The landmarks were distinguished following HIA development in the public versus the private sector. Public-led initiatives were primarily spurred by the WHO, with the adoption of the Bangkok Charter on Health Promotion (2005), the establishment of the WHO Commission on the Social Determinants of Health (2008) and the release of the WHO Guide for Development Lending and

Community Health (2010). By contrast, HIA evolution in the private sector has been led by the World Bank and the International Finance Corporation.

A closer look at these landmarks leads to three important observations on the rise of HIAs. First, the development of HIA policy was driven by public initiatives in high-income countries. Indeed, one of the first formal commitments to HIAs was strengthened by the EU, with the conclusion of the Amsterdam Treaty (57), which led several countries (including Finland, the Netherlands and Sweden; see Table 12) to develop formal HIA policies(58). In parallel, non-EU countries such as Australia, Canada, New Zealand(59), Switzerland and the United States, were also practising HIA within formal frameworks.

Second, the advocacy of HIA in developing countries was driven by private industrial corporations and major financial institutions and influenced by the scramble for access to natural resources. Indeed, most HIAs conducted in developing countries focus on large development projects led by the private sector rather than on public initiatives led by local governments(60). However, HIA has been institutionalized in the Thai constitution (61) and is being incorporated in the Vietnamese Health Action Plan(62). No standalone HIA policy exists in Laos, Cambodia and Malaysia, but HIA legislation forms part of their EIA processes(63). In Latin America, only Mexico and Brazil have published national-level guidelines on HIA(64), but no country in Africa actively promotes or regulates HIAs(65). HIA activity has been identified in Middle Eastern countries (66) but HIA policy has only been reported in Iran, which has expressed an interest in integrating HIA into its Fifth Economic, Social and Cultural Development Plan(67).

Third, it is possible that the tension between private and public approaches to HIAs has blurred the leadership components needed for governments to decide on how to introduce HIA via public policies and environmental legislation and how to make companies accountable.

Developing country	L/G/F	SA/I	N/SN	Name of legislation/guideline/framework
Brazil	G	-	N	Avaliacao de impacto a saude AIS: metodologia adaptada para aplicacao no Brasil (2014)
Cambodia	L	I	N	Law on Environmental Protection and Natural Resources Management(1996)
China	F	-	N	National environment and health action plan (2005–2015)
India	G	-	N	Draft National Health Bill (2009)
Iran	L	SA	N	Law on the FourthFive-YearEconomic,Social and Cultural Development Planof the Islamic Republic ofIran (2004–2009)
Laos	L	I	N	National Environmental Action Plan (1993)
Malaysia	L	I	N	Environmental Quality Act(1974)
Mexico	G	-	N	Analysis de impacto en salud (2012)
Mongolia	L	I	N	Law on Environmental Impact Assessment(1998)
Philippines	L	I	N	Code on Sanitation of the Philippines and the Inter-Agency Committee on Environmental Health (1991)
South Africa	G	I	N	Environmental health impact assessment in South Africa (2010)
Thailand	L	SA	N	Thai Constitution (2007) and the National Health Act and the Enhancement and Conservation of National Environmental Quality Act (1992)
Vietnam	L	I	N	Law on Environmental Protection (2014)
Developed Country	L/G/F	SA/I	N/SN	Name of Legislation/Guideline/Framework
Australia	L	I	N	National Framework for Environmental and Health Impact Assessment in the National Environmental Health Strategy (1999)
Canada	L	I	N	Impact Assessment Act (2019)
Denmark	L	I	N	EIA Directive (2014) and SEA Directive (2011)
Estonia	F	-	SN	Healthy Cities network (2012)
Finland	L	SA	N	Constitution Act of Finland (1999)
France	L	SA	N	Law2004-806 on Public health reform (2004)
Germany	L	SA	SN	Public Health Service Act (1997)
Ireland	G	-	N	Health Impact Assessment Guidance (2009)
Italy	L	I	N	ComitatoInterministeriale per la ProgrammazioneEconomica CIPE (2011)
Lithuania	L	SA	N	Law on Public Health Care of the Republic ofLithuania (2002)
Netherlands	L	SA	N	Public Health Decree (2008)
New Zealand	L	I	N	Resource Management Act (1991)
Norway	L	SA	N	Norwegian Public Health Act (2011)
Slovakia	L	SA	N	Public Health Act (2007) and the Ministry of Health Ordinance(2014)
South Korea	L	I	N	Impact Assessment Act (2005)
Spain	L	SA	N	National Law 33on Public Health (2011)

Sweden	L	I	N	Public Health Objectives (2002)
Switzerland	L	SA	SN	National Health Service Act (2006)
United Kingdom	G	-	N	HealthImpact Assessment: Evidence on health (2010)
United States	L	I	N	National Environmental Policy Act (1970)

L: Legislation; G: Guideline; F: Framework; SA: Stand alone; I:

Table 12: Countries with HIA legislations.

HIA legislation in the world

The global distribution of HIA is uneven. In several countries, HIAs are now required by law, either as stand-alone processes, or as part of the EIA process (see Table 12). Some countries considered as pioneers in the field of HIA do not have formal HIA legislation but have published national guidelines and frameworks to facilitate the practice of HIA. Table 1 shows that while many high-income countries have adopted some form of HIA legislation (17 countries), very few LMICs have done so (eight countries). The table is adapted from previous studies (68).

There has been some reasoning on the contextual and administrative factors that may hinder the introduction of legal provisions for HIA. Some of them include the lack of knowledge and low training capacity in HIA practitioners, limited technical guides and frameworks for best practice, lack of operational tools, data limitations, and blurriness on HIA utility and use (69). As mentioned in Section 2.1, although the WHO has suggested a five-step process for a basic HIA, referred to as common HIA standards, there is still variation in the modalities to conduct a HIA. This inconsistency in practice is commonly reported in EIAs, but unlike HIAs, the lack of uniformity in EIA practice is not complemented by weak policy coverage.

The core issue for HIAs hence remains that developing countries, claiming the highest fraction of death and disease avoidable by environmental improvement (70) – i.e. countries who are most in need of HIAs – are not conducting them.

The implications of the HIA policy vacuum in developing countries

The lack of HIA legislation in developing countries is a major barrier to the advancement of the field. About 94 percent of all HIAs are conducted in high-income countries (71). In an increasingly globalized world, where poor countries are often the factories of the rich countries or where they are at the receiving end of ecological damage caused for example by climate change, the lack of HIA legislation may exacerbate their vulnerability. If HIAs are not conducted, countries may build infrastructure that increasingly threatens health. Additionally, resource-constrained countries cannot benefit from crucial HIA outcomes that can avert negative economic and social consequences.

The presence of national legislation can boost HIA practice and lead to successful regulation of HIA implementation (72). Because HIAs can predict the health impact of public policies before they are framed and implemented, it is crucial for emerging economies to step up HIA implementation and increase their ability to cope with environmental disasters faster and more efficiently.

The premature deaths caused by exposure to air pollution have been estimated at 9 million global premature deaths per year (73), but the health burden and impacts of other exposures such as climate change, especially in developing countries are still difficult to predict and estimate (74).

Further, HIAs enable the assessment of health effects across different sectors and policies (75). Therefore, the establishment of legislation can allow for HIAs to be integrated in key processes that inform both public policies and private projects. There is growing evidence that developing countries are in need of anticipating and proactively managing project-related health impacts, particularly in the extractive sector (76). Without HIA legislation, developing countries will continue to conduct large private projects without the regulatory capacity to tackle a broad range of adverse health effects, such as high incidence rates of sexually transmitted infections, pollution of drinking water or elevated transmission of vector-borne diseases.

Last but not least, HIAs legislation can support developing countries in achieving health across different population groups (health equity) and within larger operational frameworks such as the 'Health in All Policies' (HiAP) approach (77). HiAP is one of the most widely recognized approaches in public health.

The WHO defines HiAP as an approach to increase accountability of policymakers for health impacts at all levels of policy-making. It underlines that public policies have consequences on health systems and on determinants of health; HIAP also contributes to sustainable development (78).

At the international level, the adoption of the HiAP approach (79) underlined a general consensus that policymakers, project leaders, stakeholders, practitioners and regulators should consider all risks and benefits of interventions likely to affect health and its determinants (80). It facilitates synergies across non-health sectors in order to improve population health and health equity (81). In Switzerland, (82) for instance, HiAP was recognized as a paradigm that could help advance the productive feedback loop between HiAP and HIA applications (83).

Similarly, HiAP approaches operationalized by HIA can ensure far-reaching effects of environmental protection in developing countries.

5.5 HIA Legislation: An Opportunity For Developing Countries To Achieve The Sustainable Development Goals?

Literature supports HIA as an effective tool to help achieve SDGs. In Burkina Faso, Ghana, Mozambique and Tanzania, Winkler and colleagues show that HIA can contribute to mitigating the health impacts of natural resource extraction projects in relation to eight different SDGs: SDG1 (No poverty), SDG2 (Zero hunger), SDG3(Good health and well-being), SDG4 (Quality education), SDG5(Gender equality), SDG6(Clean water and sanitation), SDG10 (Reduced inequalities) and SDG16

(Peace, justice and strong institutions) (84). Authors examining the Latin American region also promote HIAs for sustainable development projects; they provide examples from Mexico, Brazil and Peru, where HIAs address SDG-related targets such as air contamination, infectious disease, human migration, wastewater reuse and mining (85). Finally, Ramirez and colleagues describe HIAs conducted in Mozambique, Bolivia, Mauritius and Morocco within the context of 15 SDGs directly (SDGs 2 and 11) and indirectly related to urban health (SDGs1–2, 4–10, 12–13 and 16–17)(86). These case studies highlight the importance of HIA practice in the context of SDGs. They mandate further reflection on the benefits that HIA legislation would have for developing countries aiming to achieve them by 2030.

Benefits of HIA legislation for developing countries in the context of SDG achievement

There are various benefits of HIA legislation for developing countries. First, HIA legislation encourages an integrative approach necessary to achieve the SDGs. Developing countries can benefit greatly from HIA's ability to gear decisions towards cross-cutting health issues and social sensitivities in non-health sectors. HIA legislation can also address the root causes of health and environmental disparities while accounting for sustainability-driven agendas (87). Evidence shows that HIA legislation can address obstacles to development by fostering partnerships and inter-sectoral collaboration crucial for capacity building and strengthening of technical skills. Studies from the United States show that HIAs lead to evidence-based decision making and improve collaboration among stakeholders from different sectors and from different backgrounds (88). HIA is promoted for its capacity to address multiple exposures and diverse health effects to influence policies and actions (89). HIAs can also be applied at different levels (project, local, national and regional) and in various policy sectors (90).

In China, HIA has been recommended to address the inadequacies of weak health protection and promotion in the face of the escalating emergence of environmental pollutants (SDG11) and health inequality (SDG10)(91). In India, HIA has been promoted to decrease negative impacts of urban transportation on health (92), but also to increase the impacts of community health practices (93). In different countries in Africa, HIAs have been used for addressing the health and socio-economic effects of the e-waste crisis (94) and expansion of the extractive industry(95).

Second, developing countries can benefit from HIA legislation promoting regulatory HIAs. Such HIAs involve regulatory (as opposed to voluntary) approaches integrating HIA into existing EIA processes. Existing EIA statutes provide procedural rules and legal levers for HIA practice. Countries such as Australia, Canada and the United States have developed official guidance for regulatory HIAs (see Table 1)(96). Evidence shows that regulatory HIAs facilitate community engagement in government decision making and provide a firm base for the involvement of a range of institutions and the engagement of various sectors in the protection of health (97). Decision makers have access to information on the health, environmental and economic impacts of a project through one process and at one point in time to better inform project approval. (98) Studies from Australia (99) and Canada (100) report that regulatory HIAs promote interdisciplinary work and successfully bring health determinants into non-health policy

agendas. When considering the SDGs, it is worth considering HIA/EIA integrated practice as it would involve stronger collaboration between agencies responsible for EIAs and public health as well as technical staff engaged in examining potential health effects of sustainability-related projects and policies.

Third, HIA legislation can lead to economic savings for initiatives connected to the SDGs. HIAs estimate health costs attributable to changes in built environments or systems by undertaking cost analysis and providing financial estimates (101). When well-conducted, HIAs facilitate the uptake of cost evaluation outcomes by policymakers. This is of particular relevance in developing countries, where pollution-related diseases drain nearly 7 percent of the proportion of GDP attributed to health compared to only 1.7 percent in high-income countries (102). A HIA in São Paulo showed that if the city could diminish air pollution from particulate matter (PM_{2.5}) by 5g/m³, this could lead to a cost saving of US\$ 4.96 billion annually in health costs. (103) HIAs reveal that air pollution abatement to meet WHO standards would save up to approximately US\$ 114 billion in 13 Chinese cities (104). Increasingly, HIAs of urban planning and transport (SDG11) are mandated by cities and governments in developing countries (105). One study reports that the economic development of transport will cause an additional 51,000 extra hospital admissions and more than 850,000 restricted activity days in India (106). These studies show that by attributing economic values to health effects, HIAs are practical and helpful to estimate advances made in different indicators relevant to sustainable development.

Challenges of HIA legislation for developing countries in the context of SDG achievement

There are various challenges of HIA legislation for developing countries. First, countries with HIA legislation promoting stand-alone HIAs (voluntary HIAs) face challenges caused by the lack of uniformity in HIA practice. Reviews from the United States show that voluntary HIAs vary significantly in purpose, scope and focus (107). Similarly, a case study evaluation across five European countries (France, Hungary, Italy, Spain and the United Kingdom) highlights that the most recurrent problem in the practice of HIA is related to its unclear voluntary status; this creates reluctance to apply, unfamiliarity with the methodology, and the perception that HIA is an added burden (108). HIAs are often conducted without clear elaboration of the theoretical framework(s) guiding their implementation, the set of analytic methods chosen, and without interdisciplinary expertise. It is also challenging to assess HIA influence on policymaking and concrete opportunities for stakeholder participation (109). Finally, the conditions and prerequisites for ensuring HIA effectiveness in differing situations have been difficult to define (110). If developing countries are to develop national legislation in the context of the SDGs, they will need to consider the limitations triggered by high variability in HIA practice. Lessons learned from European countries such as Finland and Sweden can be helpful, as they have applied stand-alone HIAs from the start despite having strong EIA histories (see Table 1) (111). The experiences in these countries have been helpful in establishing the requirements defining whether HIA should be conducted and how to ensure their effectiveness in particular situations.

Second, appropriate HIA legislation requires a solid understanding of the distribution of power within systems. An effective legislative framework in developing countries needs to tackle the issue of power: health integration depends on the unequal distribution of power between governments, project proponents, civil society and special interest groups. Health is more or less likely to be considered depending at which hierarchical level decisions are made and who bears the cost. For instance, integration of health considerations may differ if decisions are taken at the programme or at the policy level. The implications and possibility for communities to be looped in on the activities of public health and environmental authorities (see SDG16, Participatory decision making) are also important to consider by HIA practitioners or stakeholders mandating HIAs. In sum, the way that responsibilities and tasks are distributed at national, regional and local administration levels can complicate how and who should handle health issues (112). A study from Australia and New Zealand shows that HIAs are not being conducted because stakeholders have a misconception that HIA costs a lot more than what it actually achieves (113) and that there is lack of clarity about who bears the costs and who benefits. In general, the company or stakeholder may bear the costs and the public may benefit; alternatively, if the company or stakeholder does not bear the costs, the public may suffer.

Third, if HIA legislation is established in developing countries, institutional capacity as well as the technical ability of the system need to be adapted. The capacity of a system to deal with cross-cutting determinants of health (social, environmental, economic, etc.) is critical.

Factors such as tradition, administration and existing standard operation procedures may hinder such integration. Moreover, the lack of technical capacity, especially when addressing SDGs, can cause an important mismatch between policy frameworks and policy objectives, which in the long-term can hinder health objectives. It is crucial to keep in mind that a key aspect of the SDGs is to minimize trade-offs and enhance synergies.

This could be to some extent operationalized by HIAs through enhancing synergies between health and non-health institutions and reducing trade-offs between health risks and the resources needed to increase technical capacities. For instance, these trade-offs can be minimized across different goals and targets. With the use of HIA, it is possible to level population health parameters (such as the number of hospitalizations per disease) with environmental exposure parameters (such as air pollution levels). This underlines the importance of HIA monitoring, which enables following up on previous impacts and factors that may change business-as-usual scenarios. If the SDGs are operationalized by HIAs, it may become possible to increase and monitor knowledge and data on interventions that directly or indirectly affect health and sustainability.

Design issues in HIA legislation

When considering the future of HIA legislation in developing countries, several issues emerge on the design of such law: should HIA be mandatory or voluntary; for what types of projects, policies, or interventions; led by whom; and who should pay?

The HIA legislation in Thailand provides an interesting example on how a comprehensive HIA legal framework has been framed and institutionalized in a developing country seeking to implement HIAs favouring sustainable and citizen-oriented goals.

In Thailand, HIA legislation was incorporated in the National Health Act (114), one of the few Thai laws resulting from a large citizen participation process (more than 400,000 people joining general and specific public hearings and provincial assemblies) (115). In the draft law submitted to the National Health System Reform committee, HIA was addressed as follows: ‘guidelines and measures to establish the healthy public policy and the process of HIA from the public policy, aimed at joint learning of all sectors in the society, through the sufficient academic utilization, with the transparent and accountable mechanism’ (116). The draft also asserts that ‘the right of Thai people to participate in accessing the information, suggesting, performing, using the assessment outputs and making decision on the approval and permission of the policy implementation and crucial projects that may have an impact on health’ (117).

There are three sections addressing HIA in the Health Act (118) with the intention of shaping HIA as a social learning framework, i.e. available for all stakeholders in the society to examine the health impacts of policy, project or activity that may affect people. There are four ways HIA applications can be submitted and supported by law. First, actors from different health assemblies and social movements can apply HIA for policy formulation even for issues not required by law. Second, the use of HIA can be supported by the health commission office to be submitted to the cabinet. Third, individuals from civil society can demand HIAs through public policy monitoring platforms.

Finally, the National Health Commission has the authority and function, according to Section 25 (see box 1), to set up the policy monitoring system for health impacts, and support the application of HIA before any decision is made.

By grounding legislation into citizen rights and public participation as core values of HIA, the Thai case shows a potential way forward. Some procedural challenges are bypassed by formalizing the process of data distribution and information availability to the public. Also, by providing the right to individuals and groups to request an assessment and to participate herein, the law is less subject to tensions between public and private approaches. Furthermore, concentrating the law on HIA makes it possible for stakeholders to tap into the benefits of voluntary HIAs, such as bypassing the high levels of procedural rigidity dominating the EIA process. Because there are different entry points for requesting HIAs, the Thai legislation is supportive of feedback loops that are sensitive to contexts where policy and governance systems are quickly changing. Additionally, by involving the National Health Commission centrally, the law provides a consistent level of political support to HIA practice – a crucial factor to successful implementation (119).

The Thai HIA legislation affords the opportunity to discuss contested issues and implications for HIA policy and practice in different developing countries.

The first issue relates to health impact thresholds that would make a HIA mandatory under all circumstances. The emergence of transboundary threats to health such as climate change and air pollution requires that countries adopt environmental policies addressing health risks within, but also beyond their territories. HIAs provide not only the tool but also the platform to address risks such as air pollution that can no longer be perceived as a purely local or regional issue (120). The globalizing nature of health risks will only grow as distant sources from different continents contribute to local deaths and disease. The 2020 COVID-19 outbreak is an illustrative example of the complexities and far-reaching impacts of health at national and global levels.

The second issue is related to HIA costs. Even if adequate HIA legislation is in place, who will pay for the HIA? So far, most HIAs in developing countries have been undertaken by experts that have found the necessary resources through their own organization. Legislation can extend the practice to public bodies, but this would mean that they would need to commission their own HIA and use their own staff to conduct them. To make HIA practice sustainable, it would be favourable that proposers of commercial or development projects pay for their own assessment, as it is currently done in EIA, but this funding mechanism would need to be clarified for statutory HIAs.

The final non-addressed issue lies in the question of monitoring HIA outcomes. So far, no concrete steps have been taken to monitor the advancement of HIA across nations. It may be effective to introduce an SDG-related indicator on whether countries legislate and use HIA so as to best monitor and evaluate the local, regional and international benefits of HIA. Establishing an SDG indicator would not make HIA mandatory for all nations, but could formalize national and international intentions towards safeguarding the health of people and the planet.

5.6 Conclusion

The crossroads between health and environmental law presents a valuable opportunity to address the limitations of environmental policies. As global urbanization progresses, countries without HIA legislative frameworks face an acute risk of morbidity and mortality while getting locked into unsustainable systems. Countries show important variation in the coverage, timing and form characterizing HIA policy. This article exposes the urgent need for HIA legislation in developing countries, and displays how the process can be catalysed and operationalized in order to achieve the SDGs.

SDG-driven HIA legislation in developing countries can mitigate trade-offs between health and environmental change and enhance synergies between different goals and sectors. HIAs provide opportunities to make economic savings while also using existing frameworks such as EIAs to advance public health. The challenges of establishing HIA legislation lie in a lack of uniformity in HIA practice, the complexity of power distribution when addressing health, and the implications of weak institutional capacity. The design of future HIA legislation in developing countries needs to address core issues triggered by transboundary health threats and funding gaps.

With adequate legislative frameworks, HIAs may enable developing countries to sprint towards achieving Agenda 2030 while safeguarding the health of people and the planet.

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'Section 10: In the case where there exists an incident affecting health of the public, a State agency having information related to such incident shall expeditiously provide and disclose such information and the protection thereof to the public.
Section 11: An individual or a group of people has the right to request for an assessment and participating in the assessment of health impact resulting from a

public policy. An individual or a group of people shall have the right to acquire information, explanation and underlying reasons from state agency prior to a permission or performance of a programme or activity which may affect his or her health or the health of a community, and shall have the right to express his or her opinion on such matter.

Section 25: (5) National Health Commission (NHC) shall have powers and duties to prescribe rules and procedure on monitoring and evaluation in respect of national health system and the impact on health resulting from public policies, both in the level of policy making and implementation.'

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Chapter 6: URBAN TRANSPORT POLICY AND CITIZEN NEEDS IN PORT LOUIS

6. Urban Transport Policy and Citizen Needs In Port Louis

Cities in developing countries face acute pressures due to increased motorization, urbanization and growing population. Urban transport planning systems can fuel healthy cities, yet research examining the interface between policies and needs in Africa remains scarce. This chapter presents a mixed-methods approach to assess the alignment between urban transport policies and self-reported citizens' needs in Port Louis city (Mauritius). It describes logistic regression models run to detect associations between needs and demographic indicators (age, gender, income). Three policy measures were assessed: light metro rail system, bus modernization scheme and road decongestion program. The chapter also reports on six citizen needs and six mode of transit preferences extracted from 1523 surveys. The chapter concludes that citizen-centred approaches provide a unique opportunity to reform urban transport planning policies towards more healthy and equitable cities in developing countries.

Keywords

Citizen-centred policy, urban and transport planning, health

6.1 Introduction

Urban transport planning systems play a critical role in fostering healthy and sustainable cities. By 2050, 66% of the world's population will live in cities requiring a serious consideration of the role of transport and its impact on the liveability of people and planet (Stoett et al., 2019). From a public health perspective, drastic increase of motorization leads to more traffic deaths and injuries, more exposure to air pollution and noise and less physical activity (Kheis et al., 2016). The case of developing countries, also referred to as low- and middle- income countries (LMICs) for the purpose of this paper is particularly alarming. Pressure is rising with 90% of growing urban populations predicted to settle in Asia and Africa by 2050 (Nations, 2014). Already, LMICs disproportionately claim 92% of the 7 million global deaths related to air pollution exposure (World Health Organization, 2016). They absorb 90% of 1.25 million traffic-related deaths despite owning only 47% of the world's registered vehicles (Adeloye et al., 2016; Organization, 2015).

Increased motorization also triggers sedentary lifestyles contributing to the rise of non-communicable diseases in urban areas. This phenomena is also inequitably affecting the globe with 80% of 56.9 million NCD-related deaths per year occurring in LMICs (Alwan, 2011).

Scientific literature from high income countries show that citizen-centred approaches in the sector of urban and transport planning is a potential solution to achieving more liveable cities, and spaces that respond to citizen needs and aspirations (Mandeli, 2019; Lusk et al., 2018; Dierwechter and Coffey, 2010; Verlinghieri, 2019; Smith, 2017).

For instance, practicing citizen participation in urban transport planning policy is crucial to boost governance processes, increase cost-efficiency and creative problem solving (Le Pira et al., 2016). Collecting citizen preferences is also useful to identify and design infrastructure most likely to support and encourage healthy active travel modes such as walking and cycling (Lusk et al., 2018). Yet, studies on citizen-centred urban transport planning and health impact of transport policies in developing countries is lacking (Jones et al., 2016; Bartels et al., 2016).

Some evidence shows that cities in sub-Saharan Africa are struggling to deploy transport strategies that comply with global trend standards; i.e. encouraging more sustainable and compact cities, healthy living practices and environmental awareness (Sietchiping et al., 2012). Rather, cities such as Lagos, Douala and Nairobi are promoting motorization and growing to be more car-dependent in contradiction with, and at the expense of, urban populations that primarily walk and cycle for social and economic reasons (Sietchiping et al., 2012). This phenomenon is contextual to cities of the developing world and represents a real paradox in the use of urban space. Indeed, studies from Cameroun to India show that urban transport policy and planning are not responding to growing citizen needs demand for transport modes other than the car (Ouongo, 2010; Conti and Mahendra, 2014). The fact that commercial and industrial activities remain concentrated in central area where traffic congestion has become the norm and that large-scale road infrastructure projects are deployed to address congestion in countries like Kenya (Kinney et al., 2011), may be one of many reasons car-centric measures overpower policies that may be directed at other transport modes. Hence, the resulting clash between policy measures and citizen needs trigger complex issues such as alarming levels of congestion, increased air and noise pollution, and traffic danger; all of which threaten human health and social equity.

It is crucial to explore urban transport policy measures in cities already facing high burden of mortality, morbidity and inequity. This paper assesses the alignment, if any, of three government policy measures with citizen needs in an African setting, Port Louis the capital city of Mauritius. The main objective is to examine the extent to which policy measures address citizen needs. The specific objectives are to (Stoett et al., 2019): assess selected policy measures (Khreis et al., 2016), assess self-reported needs of citizens in a nationwide survey (Nations, 2014), examine the alignment of existing policy measures with citizen needs and (World Health Organization, 2016) identify what population groups are most likely to be affected possible misalignments.

The paper concludes on the health and social benefits that can result from applying citizen-centred lens to the assessment and design of urban transport planning policy in cities of low and middle-income countries.

Theoretical arguments from literature

The role of transport in developing urban areas has become an ever more important part of city life. Economic growth has resulted in a rapid increase in vehicular traffic (Runji, 2015). As urbanization grows, urban lifestyles combine with urban layouts and build environments to create ever-growing travel needs, both in frequency and travelled distances (Thynell et al., 2010).

As LMIC's concentrate some of the higher rates of urbanization and motorization growth in the world, they are in dire need of rapid transportation planning if they want to provide the necessary transport infrastructure to meet the growing demands (Godard, 2013). The process of planning transport in the midst of a motorization and urban demographic growth is a challenging proposition, and one that affluent and well-planned cities around the world have struggled with. While LMIC transportation policies tend to mirror those developed by developed countries, several important differences exist among their respective paths towards modern and sustainable transportation systems. In most cases, LMIC transport policies face the need to tackle both the increase in demand and the need to provide sustainable transportation services. Most transport systems in the developed world were built in an age where no criteria of sustainability other than the economic dimension existed. It has been only recently that they have been charged with the responsibility to convert those systems into social and environmental sustainability. Current LMIC's transportation policies aim at not only meeting demand, but doing so in a sustainable way. As pointed by Thynell et al. (2010) this endeavour in LMIC can be even more challenging when compared with high income countries. The population of LMIC's is often more socioeconomically diverse than that of developed countries, creating a much more complex map of needs, preferences and possibilities than more homogenised societies. The local transport situation is often also more complex, with an important role of paratransit transport. Having a multiplicity of vehicle ownership arrangement, wider diversity of vehicle types, speeds and street-uses increases policy complexity.

The different local cultures of planning can also impact both the planning process and the expected outcome. The political regime its openness and tradition can result in planners having more or less freedom to exercise their skills, whether for good or ill, more accountability towards local citizens or larger degrees of participation (Friedmann, 2005). Similarly, the fact that planners usually are part of a professional middle class, tend to skew transport policies toward the needs of their class, which tend to be different from the lower classes (Sietchiping et al., 2012). This often results in increased investment in road schemes, and large infrastructure plans that often neglect the smaller and more detailed oriented needs of lay citizens. While urban and spatial planning development is increasing in most LMIC cities, in terms of transportation planning, consideration for transport options other than the car are seldom given attention (Sietchiping et al., 2012).

This situation often leads to the paradox of large investments on road and rail infrastructure under a modernizing master plan in a society where the large majority of people would have benefit from cheaper investments oriented towards walking and cycling.

A common issue in both LMIC and high income countries regarding transportation planning is the salient disconnection between land use planning and transportation planning (Hickman et al., 2013). It is often that transportation solutions have to wrestle with non-existent urban development limits or sprawl inducing land use practices. One could argue that in rapidly urbanising societies, land use planning has a bigger impact on transportation options than transportation planning itself.

The examples of Lagos, Johannesburg or Cairo show how difficult it is to manage mobility and transport once sprawl has already occurred (Sietchiping et al., 2012). On the other hand, containing sprawl, investing in transit-oriented development and limiting new urban expansion to compact, mixed and dense developments can facilitate transportation plans, allowing for more and better options and avoiding car-dependency.

New transportation policy developed in the LMIC can encounter struggles in each key element of effective transportation policies: setting the policy objectives, designing the strategies, and monitoring and evaluating the results. Policy objectives often revolve around using better transport and accessibility to achieve economic growth, health and poverty reduction. At this level however, planners may suffer from bias towards hard-infrastructure projects, road investment and lack of attention to small-scale needs for improvement. When designing strategies for implementation, drawbacks can concentrate either at the design or the implementation phase. The failures in the design process can arise when strategies don't align with either policy objectives or citizen's needs. On the implementation stage, the African Transport Policy Performance Review (Runji, 2015) highlights some major drawbacks that can be extended to most LMICs: inadequate human resources capacity, affordability of transport strategies, lack of information and information systems, or inadequate investment prioritizing framework. Finally, several challenges often arise on the monitoring and evaluation phase. There is a general lack of feedback after the strategies have been implemented, due to data limitations, poor data quality or low human resources to actually manage and analyse the gathered data.

Overall, the accumulation of biases and drawbacks in the planning process can end up creating transport policies that are not properly aligned with citizen's needs. Given the essential role that transport plays at contributing to citizen's capacity to participate in work opportunities as well as also to fulfil their daily domestic needs (Sietchiping et al., 2012), this misalignment can have huge consequences for everyday life and social equity (Lau, 1997). Particularly worrisome is the general direction of most LMIC transport policies towards increased motorization and car-dependency which sets a path towards perceived modernization through the building of new road infrastructure. These set of strategies however are designed with no attention to the real needs of citizens (Porter et al., 2012), often accustomed to meeting their travel needs through a complex network of active and informal modes of transport (Godard, 2013).

The misalignment between modern transport projects, though and built by and for middle-high classes clashes with the everyday mobility of a majority of population that relies on other forms of transport. This misalignment can induce further differences in accessibility, even making it harder for some population groups to access their basic needs within the city. According to Lucas (2011), social exclusion through transport poverty is an overwhelming problem in developing countries. Transport poverty can arise from a lack of provision of transport infrastructure, from having to spend too much time in transport or having to spend too much time away from home so one cannot undertake all the necessary life-supporting activities (Porter, 2002).

Hence, the main objective of this paper is to assess the alignment of transport policy measures with citizens needs in Port Louis (Mauritius) by using a mixed-methods triangulation approach.

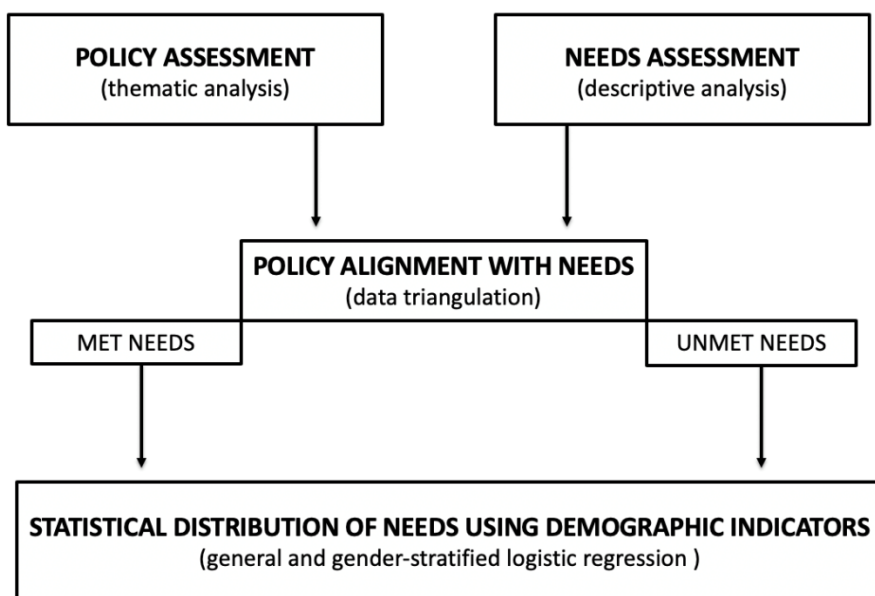


Figure 6: Study Framework

6.2 Material and Methods

A mixed-methods triangulation approach was used to examine transport policy measures and assess whether they align with citizen needs in Port Louis city (Fig. 7). The Annual Report of the Ministry of Public Infrastructure and Land Transport (Ministry of Public Infras, 2017) a key policy document on urban transport planning in Mauritius, was analysed qualitatively in order to select and examine relevant policy measures. The citizen needs assessment was conducted using an existing set of data resulting from a national survey entitled ‘Map mo Port Louis’.

The access to this data was granted by the authority and organization who conducted the survey between August and December 2016. The survey investigated citizen perceptions, needs and preferences on urban development in Port Louis. Logistic regression models were run for each need to detect associations between demographic indicators and citizen needs.

Study setting and relevance

Mauritius is a small island developing state (SID) located in sub-Saharan East Africa and is the continent’s most densely populated country (653 persons per square kilometre) (World Bank, 2013; Government of Mauritius, 2015).

The prevalence of non-communicable diseases has been rising dramatically over the last decade with a current 15% prevalence of diabetes and 30% prevalence of hypertension in adult population aged between 20 and 74 years old (31). Similar to other developing nations, urban population rates in Mauritius have practically doubled in the last fifty years. Because people have moved closer to urban areas for better economic and social opportunities, it is estimated that 60% of the population is stacked on only 8% of the available land. This trend creates a number of urban and transport planning challenges which are particular to fast developing countries, such as urban sprawl, traffic congestion, inadequate planning, increase in vehicle ownership and deteriorating transport infrastructure and services (16).

Although 98% of roads are paved in Mauritius, road accidents and traffic congestion are a rising issue, costing the nation approximately MUR 4 billion (\$119.6 million) per year (Ministry of Public Infras, 2017). The motorization rate has grown rapidly over the last decades with a national vehicle fleet estimated to have increased by 625% between 1972 and 2000 (OECD, 2014). In 2018, there was 4% increase in road traffic accidents per year with an average fatality index of 4.9 per 100 casualties (Table 13). Yet, there are no policies to restrict traffic growth in Mauritius and fiscal policy related to private motorization does not exist (33). Even though UNEP has established that 90% of urban air pollution in rapidly growing cities in developing countries is attributable to motor vehicle emissions (34), there are no urban transport planning policies aiming at fuel economy and reduction of greenhouse gas emissions specifically on the island (Ministry of Social Security, 2014).

In terms of infrastructural development, the National Development Strategy (NDS) is the most relevant policy addressing traffic congestion and transport planning Ministry of Housing and Lands G of M, 2014 (Ministry of Housing and Lands G of M, 2014). It aims to optimize the use of transport infrastructure towards a more compact pattern of development, with high concentration of people (36). Transport policies designed under the objectives of the NDS aim to (Stoett et al., 2019) promote strategic growth clusters in places with higher accessibility, and in proximity of major highway and public transport network (Threis et al., 2016) develop mix-uses in all growth centres by raising densities, reducing travel time and offering more options by public transport and reducing reliance on car and (Nations, 2014) support the use of urban public transport facilities and network along a linear urban corridor and optimize most sustainable transport options by encouraging the use of economic, residential and leisure clusters. Although the government shows concerns about the island's ecosystem (a nation-wide program aiming for sustainability was proposed in 2008 but has been on hold (Baguant-Moonshiram et al., 2013)), the concepts of sustainability and health are not mentioned as part of the NDS. Currently Mauritius monitors closely different health, urban and transport targets to stay on track for the Sustainable Development Goals (Ministry of Foreign Affairs Regional Integration and International Trade, 2019), but very little is known as to whether transport policy measures derived from the principles of the NDS respond to citizen needs.

Characteristics of Mauritius Island	
Population (million)	1273
Area (km ²)	2040
Coastline IO (km)	177
Population density (residents/km ²)	653 (most dense in Africa)
Life expectancy at birth (m/f)	71/78
Number of vehicles	492,000
Number of two-wheelers	200,000
Length of main roads	2356 km
Annual fleet vehicle increase	2.3% (estimated to 4.2% for next 5 years)
Road Accidents rate (per 100,000 population in 2016)	2397
Annual road accidents increase	4%
Casualty accidents increase	7.4%
Cars (per 100 household)	78
Motorcycle (per 100 household)	60
Public Buses (total number)	2000 (incl. 1500 private)
Bicycles (per 100 household)	No Data

Table 13: Country profile, sources (Government of Mauritius, 2015; Enoch, 2003; Ehadaroo and Seetanah, 2008).

The study was conducted in the capital city of Mauritius, Port Louis. Despite, the city being the economic and administrative engine of the country, it is considered a highly polluted and congested city. Port Louis emits 2.9 tons of net carbon dioxide per capita, costing 0.1 billion USD every year (39). It only recycles 7% of the 6308 tons of waste generated per month (Jhingut, 2016) and is highly vulnerable to deathly flash floods (41). Divided into 8 wards, it hosts approximately 119,706 residents on 46.7 km²; it is the most densely populated locality (2563 persons per square kilometre) in the country. During peak hours, the city is choked by the influx of 201,567 commuters coming from neighbouring districts mainly using motorcycles, public buses and private vehicles. The congestion is created mainly by the use of one main access motorway (M1-M2) connecting South to North, cutting through the capital city.

The motorway separates the city from the waterfront (Guttee, 2015) and complicates any possibility for integrating different transport modes on its axis (for instance bus or cycles lanes). Port Louis is a car-oriented city with poor integration of different modes of travel. The public transport system is currently being revised for improvement, pedestrian movement is limited with unsafe sidewalks and walkways, and there is a lack of green and public spaces.

Policy assessment and urban transport planning measures

The Annual Report of the Ministry of Public Infrastructure and Land Transport (Ministry of Public Infras, 2017) is an open-access document published at the end of every financial year by the Ministry of Public Infrastructure Land and Transport. We extracted it online and reviewed it using qualitative methods. The review of the document involved combining elements of content analysis and thematic analysis as described in Bowen (2009) (43), to select relevant urban transport policy measures for further assessment. To conduct the selection, we applied three criteria: time (initiation period and duration), cost (budget allocated) and implementation (objectives). In order to be included in the final assessment, the policy measure had to span over 3 years or more, cost the government more than 100 million MUR (approx. 2,8 million USD) and had to be currently under implementation. The criteria were developed by the main author based on the local policy timeframe (each government mandate lasts 3 years) and economic landscape of the country. We also identified the agencies involved in designing and responsible for implementing the policies (Table 14).

Citizen needs survey

Citizen needs were extracted from the 2016 national survey entitled ‘Map mo Port Louis’, ran online using an electronic data collection tool (<http://www.maptionnaire.com> C1600). The survey adopted a participatory approach to investigate citizens’ perceptions on urban development in Port Louis. These included residents and non-residents of the capital. The first author (MT) designed the survey jointly with different stakeholders: public officials, NGO officers and interested citizen groups. In order to ensure that hard-to-reach groups were also included, fieldworkers were deployed in different areas of the capital in order to collect data face-to-face (using the same online electronic data collection tool). The face-to-face data was automatically added to the dataset retrieved from the online process. The data was collected online and face-to-face between June and December 2016. The sample was statistically representative of the Mauritian population, consisting of proportional distribution of participants by gender, age group and main professional categories (Table 14). For the purpose of this paper, we focused on the sections of the survey addressing urban transport planning topics only (see supplementary file A). The consideration of urban transport planning questions and answers led to the identification of 6 needs and 6 preferences (Table 15) self-reported by the study sample.

Data analysis

Policy analysis

The policy assessment was conducted using the Atlas.ti software (Mandeli, 2019). The policy document was analysed to select the urban and transport policy measures satisfying the eligibility criteria set for the paper. Each selected policy measure was then examined in depth using the method of inductive thematic analysis relevant for qualitative research (Smith, 2015). The coding consisted of generating labels that identified features of policy measure responding to the research question. We then identified potential themes by looking at the codes across data extracts and subsequently analysed each theme.

Citizen survey analysis

The citizen survey data was analysed using the R Studio software (1.1.463). The 6 citizen needs were categorized into urban planning and mobility needs but the 6 mode of transit preferences were not subjected to sub-grouping. The survey results were reviewed by analysing responses to multiple answer questions. Citizens rated urban planning needs were assessed using a priority scale ranging from high priority to no priority at all.

Citizens rated mobility needs were assessed using an agreement scale ranging from ‘agree fully’ to ‘not agree at all’ to solutions for optimizing mobility in the city. Mode of transit needs was assessed by a question prompting citizens to select one mode of transit from 6 context-sensitive options (‘How would you prefer to transit through Port Louis’). The bus option was not provided as a response because inner city public bus lines do not currently exist. Logistic regression models were then applied to detect significant association between particular needs and demographic indicators. Odds ratios and confidence intervals were calculated.

Project Name	Responsible Agency	Objectives	Initiation Period	Duration	Budget
Roadsafety strategic plan	Traffic Management and Road Safety Unit	Reduce the number of fatal and serious injury crashes through infrastructural changes and road devices	Since May 2016	5 years	MUR 600 million
Bus modernization Scheme	National Transport Corporation	Bus fleet renewal, subsidy allocations to bus operators, and modernization of bus stops	Since June 2017	3 years	MUR 100 million
Metro Express	Mauritius Metro Express Company	A 26 km light rail transit system passing through five major cities. It features, 1D stations and air-conditioned trams accommodating 300–400 passengers.	Since March 2017	3 years	MUR 18.8 billion

Table 14: Summary of measures

Gender	N	%
Female	678	46.86
male	749	51.76
non-disclosed	20	1.38
N missing	133	
Age groups	N	%
12–15	138	9.52
16–18	158	10.9
19–24	172	11.87
25–29	180	12.42
30–34	162	11.18
35–39	146	10.08
40–49	178	12.28
50–59	184	12.7
60 or above	131	9.04
N missing	131	
Professional status	N	%
unemployed	242	15.32
manual workers	285	18.04
technicians	326	20.63
retired	77	4.87
seasonal visitors	11	0.7
office workers	294	18.61
student	345	21.84
Income group	N	%
5000 or less	235	14.87
5001–10000	212	13.42
10,001-15000	161	10.19
15,001-25000	196	12.41
25,001-35000	145	9.18
35,001-60000	143	9.05
above 60,000	488	30.89

Table 15: Sample profile

Urban planning needs	Percentage of sample N (%)	Road traffic safety plan	Bus Modernization Scheme	LRT system
Improve sidewalks	80.27%	✓	✗	✗
Improve public spaces	76.89%	✓	✗	✗
Increase green spaces (NM)	66.58%	✗	✗	✗
Mobility needs				
Pedestrianize strategic areas (NM)	66.28%	✗	✗	✗
Centralize hawkers at bus stations	56.62%	✗	✓	✓
Regulate private vehicles in town (NM)	39.46%	✗	✗	✗
Mode of transit needs				
On foot	33.13%	✗	✗	✗
Metro leger	26.94%	✗	✓	✓
Own private vehicle	15.31%	✓	✗	✗
Bicycle (NM)	9.05%	✗	✗	✗
Electric car and/or car-sharing (NM)	10.68%	✗	✗	✗
Taxi-boat (NM)	4.90%	✗	✗	✗

Table 16: Urban and transport policy measures alignment with needs (✗= not addressed; ✓= addressed; (NM) Not Met= needs that were not addressed by any of the policy measures)

Triangulation analysis

Finally, the method of triangulation was used to combine the findings from the policy assessment and from the citizen survey. Triangulation is the method whereby the researcher draws upon at least two sources of evidence in order to seek convergence or corroboration in data. It is used when the same phenomenon is studied by combining different methodologies and data sources(231).

6.3 Results

Policy measures

Out of 9 policy measures described in the Annual Report of the Ministry of Public Infrastructure and Land Transport (232), three policy measures were selected and assessed following the eligibility criteria. They consist of the (1) Road safety strategic plan (2) Bus modernization scheme and (3) Metro express light rail transit (LRT) system. All three measures were derived from the National Development Strategy described in Section 1.2, and they span over 3 years or more, cost the government more than 100 million MUR per year and are currently under implementation (table 2).

Road safety strategic plan

The Road Safety Strategic plan aims to reduce the number of fatal and serious injury crashes by 50% by 2025 and to bring down road crash fatality rate from 12 to 6 per 100,000 population (pg. 30). In addition to endorsing a road safety charter, setting up specialized teams and capacity building of officers, riders, examiners etc.- the plan has already achieved to construct and upgrade footpaths (over 1764), maintain speed cameras, install 3260m handrails for pedestrians, installing of road crash barriers and road safety devices. The road safety strategic plan is deployed by the Traffic Management and Road Safety Unit, which is run on a yearly budget of MUR 500.2 million.

Bus modernization scheme

The Bus Modernization Scheme has the objective of renewing an aging bus fleet by providing financial support, in the form of subsidy allocation, to bus operators. It is under review at the moment to encourage the acquisition of hybrid, electric and double-decked buses (pg. 33). The government earmarked approximately a Rs100 million to this scheme at the beginning of 2017. The bus modernization scheme is being led by the National Transport Authority, a body in charge of other projects such as the amendment of road traffic regulations, construction of smart bus services (shelters and cars).

Metro express light rail transit

The metro express light rail transit (LRT) system is considered the major transport infrastructure of the current government. It is a nation-wide mass transit system branded as a 'game changer' (pg. 53) to the wider economic development of the island. The project is depicted as a vibrant public transport system provided with a modern road infrastructural network and a rejuvenated bus fleet encouraging mode shift from private cars to public transport.

Thematic analysis

The three measures reviewed (table 2) are deployed by different agencies working within the framework of the National Development Scheme. The thematic analysis of the road decongestion program, the bus modernization scheme and the metro rail led to three main themes reflecting the objectives of the Ministry of Public infrastructure and land transport: the ease of traffic burden, concern for traffic safety and the use of public transport. There was no mention of strategies to reduce access to cars (example: pedestrianizing existing roads), to increase social co-benefits of transport (example: exposure to and interactions in public and green spaces) and to address environmental health risks and benefits (example: increase of active travel, reduction of transport-related air pollution) (Figure 7).

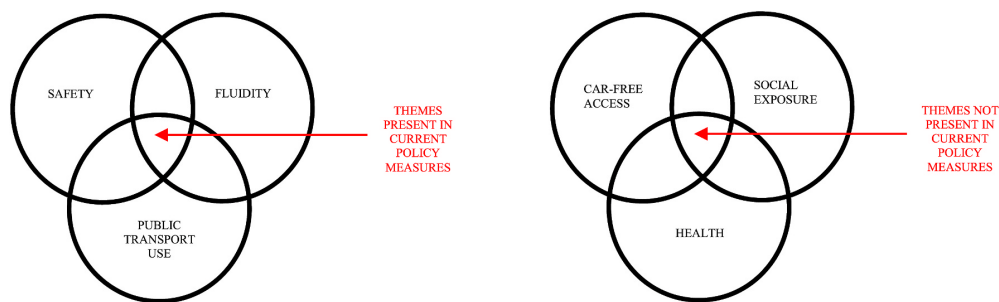


Figure 7: Themes extracted from current policy measures

Citizen needs

The six citizen needs and six mode of transit preferences (table 4) were extracted from 1523 citizen surveys. The six citizen needs consisted of three high priority urban planning needs: a) need to improve sidewalks, b) need for more public spaces and c) need for more green spaces. The three remaining needs consisted of mobility needs: a) need to pedestrianize strategic areas b) centralize hawkers (street vendors) at main bus stations and c) regulate the entry of vehicles into the city. The six mode of transit preferences included: walking, cycling, car-sharing/electric car rental, LRT, private vehicle and taxi boat.

Urban planning needs

In terms of urban planning needs, the majority of the sample (80.3%) reported that improving the state of sidewalks is of high priority, followed by the need to improve public spaces (76.9%), and the need to increase green spaces (66.68%). A descriptive analysis of the sample showed that more men reported these three needs simultaneously than women. This was also the case for students compared to other professional groups (supplementary file B).

Mobility needs

In regards to mobility needs, a proportion of 65% of the sample agreed fully to regulating private vehicle entry in the city while 55% agreed fully to centralizing hawkers (street vendors) at main bus stations instead of them selling goods on sidewalks. A smaller group of citizens (40%) agreed fully to pedestrianizing strategic areas. Approximately 26% of the sample did not agree that regulating private vehicle entry was a current need, versus 10% against hawkker centralization and 6% against pedestrianizing options. A descriptive analysis of the sample showed that women reported less the need to centralise hawkers than men. Compared to other groups, professionals/technicians most reported the need to pedestrianized strategic areas in town (table 4) (supplementary file B).

Mode of transport preference

When referring to preferences of mode of transit, nearly 33% of the sample preferred to move on foot, followed by 27% who selected the prospective LRT system (metro express), while 15% preferred using their own private vehicle. Alternative options such as electric car and/or car-sharing and taxi-boat were less popular but were still considered by smaller share of participants. Cycling was selected as an option by 9% of the sample. Overall active modes of transport were preferred by 42% of the participants, public transport by 32%, and only 26% of participants preferred solutions based on private transport.

Alignment of policy measures with needs

Three policy measures were assessed for alignment with 6 citizen needs and 6 preferences. At least one (or more) of the measures addressed 3 needs: (1) improvement of sidewalks, (2) the improvement of public spaces, (3) centralization of road vendors at main bus stations and 2 mobility preferences: (1) use of own private vehicle and (2) travel by the LRT system. None of the measures addressed 3 needs: (1) increase of green spaces, (2) pedestrianizing of strategic areas, (3) regulation of private vehicle entry in town and 4 preferences: (1) move by foot, bicycle, (2) move by bicycle (3) travel by electric car rental and/or car sharing (4) travel by taxi-boat (table 4). The road traffic safety plan addressed citizens need to improve sidewalks and public spaces and travel by private vehicle. The bus modernization scheme and the LRT system addressed the need to centralize hawkers at main bus stations and for citizens to travel by the LRT system.

Logistic regression results

A closer analysis of the data revealed an uneven distribution of needs across population groups. The logistic regression models showed significant associations between demographic indicators (age, gender, income and profession) and 6 urban planning and mobility needs (sidewalk, pedestrianizing, green spaces, etc.). On the contrary, they showed no significant associations between demographic indicators and 6 preferences for mode of transit. No test for interaction was conducted.

Needs that showed statistically significant association with demographic indicators were further categorized based on whether they were unmet or met by policy measures (see supplementary file C). Further stratification was conducted by age and income, but only stratification by gender revealed statistically significant results.

Unmet needs

We found no significant relationship between demographic indicators and the unmet need for green space. However, we found similarities in the population groups reporting the need for pedestrianizing strategic areas and regulating entry of private vehicles in town. They consisted of middle-aged groups (40 to 60 years old) and silver generation (over 60) (see supplementary file C for odd ratios and 95% CI). There was a difference however in gender and professional group indicators. Men and technician groups were more likely to report the need for pedestrianizing than women and other professional groups.

In contrast, retired and student populations were more likely to be concerned about the regulation of private cars in town than other groups. The results from male gender stratification show that males from high-income groups, i.e. earning more than Rs. 60000 were most likely to demand for both pedestrianizing and regulation of car entry (see supplementary file D). The results from female gender stratification show that females from younger age groups (16-18), from both middle and high-income backgrounds and retired women were most likely to report the need for regulating car entry in town (see supplementary file D).

Met needs

We found significant relationship between age, professional and gender indicators and the three needs addressed by policy measures (improvement of sidewalks, more public spaces, and centralization of hawkers at main bus stations). The need for more sidewalks was more likely to be expressed by low-income earners (Rs. 5000-10000) and younger citizens (16-18). In addition to technicians and service workers, seasonal visitors were also more likely to report the need for more sidewalks. The results from female gender stratification show that females from a young but wider age group (16-24), from low-income and service level professions were more likely to report for an increase in sidewalk. There was no significant relationship between age group and need for public spaces. Yet, there were higher odds for technicians and service workers to report the need for more public spaces. Finally, we found that younger population groups (19-24), men, manual workers and citizens from both middle- and high-income backgrounds were more likely to report the need for centralizing hawkers at the main bus stations. The results from male gender stratification show that men from two different age groups (young 16-18 and older 40-50) and retired men were more likely to report this particular need. In contrast, results from female gender stratification show that only young women (19-24) and women manual workers are more likely to report the need for moving hawkers from the street and centralizing them at the bus stations.

6.4 Discussion

Summary of Findings

Three policy measures extracted from the MPI annual report were selected for assessment: (1) a light metro rail system, (2) a bus modernization scheme and (3) a road decongestion program. A total of 6 citizen needs and 6 mobility preferences were extracted from 1523 surveys. (N). Findings show that the three measures are aligned with only 3 of the 6 citizen needs and 2 of their 6 mobility preferences (table 4). From a thematic point of view, policy measures did not cater for reduction in car access (pedestrianizing existing roads), did not contribute to enhancing social co-benefits of transport (exposure to and interactions in public and green spaces) and did not encourage health benefits (increase of active travel, reduction of exposure to transport-related air pollution).

The policy measures satisfied citizen needs for improving sidewalks (80%), for facilitating mobility by centralizing hawkers at bus stations (77%) and for increasing public spaces (57%).

The policies also responded to citizens' preference for using the light-rail system (27%) and their own private vehicle (15%) as mode of transport. We found that the needs met by policy measures were more likely to be expressed by citizens from low (Rs. 5'000-10'000) and middle (Rs. 10'000-25'000) income population groups. These needs were also more likely to be expressed by younger population groups (16-24) and by a greater diversity of professional groups (technician, service worker, seasonal visitor and manual worker).

The policy measures did not satisfy the need of citizens reporting for more green spaces (67%), pedestrianizing of strategic areas (66%), and regulating entry of private vehicles in town (39%). We found that the needs unmet by policy measures were more likely to be expressed by citizens from middle (Rs. 15'000-35'000) and high (Rs. above 60'000) income population groups. These needs were more likely to be expressed by older population groups (40-above 60) and by a lower diversity of professional groups (technician, retired and student). The policy measures did not support citizens' preference for walking as a mode of transport (33%), use of bicycle (9%, electric and/or car-sharing (11%) or taxi-boat (5%).

Mauritius: a relevant case study

More than 15 years ago, Enoch (2003) outlined the development of transport policy in Mauritius and concluded that expanding economic development would foster transport demand, which in turn, would increase vehicle ownership and trigger important congestion and air pollution issues (233). Enoch (2003) suggests that the Government should concentrate more effort on policy formulation, planning and regulation and reduce its role as a provider of transport infrastructure and services. Our study shows that the selected policies addresses citizen needs through both policy formulation (policy to take hawkers off the streets and modernising bus scheme) and policy implementation (measures to change transport infrastructure and services: building sidewalks and introducing an LRT).

However, if the unmet needs are examined, it is clear that additional policy formulation is needed for responding to citizens' concerns about decongestion: pedestrianizing strategic areas and regulating entry of private vehicles in town. Additionally, if transport infrastructure was to be mandated, it would have to address citizen's health needs. This can be translated by adoption of more active travel modes such as walking and cycling and not passive modes such as the use of private vehicles.

The Mauritian case study confirms findings from India that gaps between transport policy and citizens needs stem mainly from technological, institutional and infrastructure measures that cater for motor vehicles instead of non-motorized modes (234). In its current form, Mauritius transportation plans follow a trend that plans for transportation, rather than accessibility (235) and health.

By investing on road infrastructure, the transport policy is focusing on improving the way cars move from one place to another (and thereby encouraging motorized modes) but as demonstrated by our results, this only partly responds to citizen needs. Even with an ideal transport infrastructure in place, walking in developing settings such as Mauritius

is usually still the main mode of transport (236–238) and the one that provides better health and more equalitarian accessibility (239,240). The lack of walking infrastructure (pedestrianizing options) is made evident by unmet citizen needs that are clearly more focused on walking than improving the conditions for driving or public transport.

Our findings also suggest that the gap between policies and needs are caused by the misalignment of economic objectives of decision makers and social priorities of citizens. Our results show that citizens desire changes in infrastructure requiring substantial economic planning (example: improving sidewalks) that are integrated into a wider social framework of needs (example: meeting in green spaces) and imply the use of active travel modes (example: walking). Although we did not verify to what extent the current measures were based on participatory decision making, the qualitative analysis of transport measures showed that policy-makers focus on changes in transport infrastructure that are integrated into an economic, rather than a social framework of needs as per figure 2. For instance, the government's decision to implement the LRT system was based on the imperative to make it the game changer the island's economy. The provision of financial subsidies for bus companies and the omission of tax regulations for motorized transport are also deployed to support economic rather than social priorities. So, our study confirms a previous standpoint that in developing countries casting a balance between economic and social ventures related to transport is very challenging(241). One of the reasons being that limited public finance is limited and that improvement in sustainable transport usually comes at the expense of social investment projects. This discrepancy presents a missed opportunity in such contexts as studies from the World Bank show that investing in transport can effectively promote growth by increasing social value in cities(242).

Urban transport planning and social equity

The lack of transport surveys and weak understanding of mobility needs can hinder evidence-based policy making in the sector of urban transport planning in developing countries(47,243,244).

So far, very few countries of Africa have conducted surveys on mobility patterns, making it difficult for planners to understand exactly how citizens move around their cities. To this date the government of Mauritius does not perform a national and periodic travel survey that could serve as a reliable data source on mobility needs and transport satisfaction. Even in the fastest developing nations like China and India, national travel surveys still do not exist; travel surveys are done at city level using different methods and indicators that are not often comparable at country level (245).

We believe that the misalignments documented in this study may be explained by the lack of data which could inform urban planners about the needs of citizens. In the light of this constraint, planners may compensate lack of data with their own lived experiences. For instance, planners may assume that most people move as they do themselves (middle-age, educated males who move by car); hence they implement solutions that facilitating use of private vehicles and traffic lanes rather than pedestrian transits. These solutions contribute to maintain a car-dependant transportation system that in turn perpetuates structural inequities that hinder the full participation in society of some social groups, and that can even lead to social exclusion processes (246–249).

The significant associations we detected between several unmet needs and vulnerable groups (such as old age and lower income indicators) threaten to fuel such exclusion patterns.

Considering the needs of vulnerable populations is one way that transport policy can influence social inequity (250). In our study, we found the needs more likely to be expressed by older population groups (pedestrianizing strategic areas (66%) and regulating entry of private vehicles in town (39%) were not addressed by the measures. Indeed, the current urban layout has been shaped based on the main mode of transport available. By promoting road infrastructure (highways, bridges, etc.), policies are shaping the future urban layout and morphology based on the necessities of the car (more distances, less density, more sprawl and separation between uses). In this car-oriented city, not having access to a car is much worse and creates many more social impacts than in the compact walkable city. Therefore, such policies are incomplete or inappropriate not only because they do not address the current needs but also because they are creating a city that will deepen the problems of non-car owners; for instance, older population groups.

Hence, bringing concerns of social inequity to the table are crucial to understand how urban transport planning measures are unique to their own contexts. It enables us to evaluate co-benefits for different groups and consider populations that are normally left outside the formal planning process. At the same time, it is also helpful to identify more promising patterns such as those uncovered here. As our results indicate, the improvement of sidewalks is a need met by policy measures that is more likely to be expressed by low-income earners and young populations groups (less than 18 years). Positively, it is also a need expressed by the majority of the sample (80%). Therefore, catering for better sidewalks benefits the poorer sectors of society and also has a universal positive impact throughout groups at different socioeconomic levels.

Our findings are therefore more promising than those in Indian cities where the existing urban transport infrastructure do not meet the needs the urban poor (a large proportion of city residents), whose travels are primarily dominated by walking trips, short distances, public transport and use of non-motorized modes (251). Our study also indicates that the need for public transport is met by the government deploying the LRT system which also stands in contrast with a study in Cali showing that people from low socio-economic levels and living in disadvantaged districts have less mobility opportunities due to lack of access to the public transport system (252). Finally, we also found that the needs met by policy measures are mostly and more likely to be expressed by women – confirming a previous study in Brazil that the improvement of infrastructure and traffic conditions adjusted for gender differences is worth being advocated for (253). By attending to their needs, urban transport planning systems are not only considering segregated vulnerable groups but are making the situation better for the future too.

Implications of the study for other cities

Our findings have implication for other cities of the developing world. First, it indicates that unless policies respond more adequately to citizen needs, social and health inequities in cities may increase (see section 4.3).

Second, it shows that considering citizen insights in designing and reviewing urban transport planning policies in developing countries can be a valuable process and will benefit different population groups. It reveals that considering demographic indicators when addressing human needs is an efficient method to adapt policy making processes to the 'local situation'(254)(244). A study on the success of urban renewal projects in South Africa reports that the use of appropriate technologies and community-based approaches are more efficient means of satisfying community needs than approaches adopted in western, developed countries (255). Our study also confirms that policies need to be planned for activities (such as street vending businesses/hawkers) that are specific to developing countries (256). In other parts of the world, the increasing need to consider citizen concerns is justified by frustration toward urban congestion, concern for the natural and social environment, and desire for sound public investments (257). In Mauritius, the analysis of citizen needs shows a strong orientation towards an urban transport planning system that promotes healthy and active lifestyle through walking (improvement of sidewalks, pedestrianizing, green space) and increase in social exposure (more public spaces). Responding to these needs not only creates a more healthy system but also makes outcomes much more sustainable due to increase in citizen "ownership" (258). Hence, combining the concepts of health and citizen-centred planning in the context of urban transport is highly relevant.

Verlinghieri (2019) argues that citizen participation has a range of potential benefits for health and that appropriate urban and transport planning practices allow these benefits to occur (259). Yet, despite mounting evidence linking transport to health (260), indicators most often considered by urban transport planning technicians are restricted to road accidents, air pollution and noise pollution only (37). Therefore, complementing traditional approaches of policy making with citizen science can encourage the inclusion and consideration of wider health-related needs and impacts (261,262).

Hence, we join other studies in confirming the potential for citizen-centred approaches to reform urban transport planning policies towards more healthy, sustainable and equitable outcomes (14,51,55,257,263–265).

Limitations

To our knowledge, this is the first study focusing on citizen needs and urban transport policy in the developing world, and more specifically in Africa. It adds value to the scientific literature on urban transport planning in LMICs by profiling needs and policies using real-time data and preferences. It is estimated that by 2030, the majority of the world's urban residents will dwell cities of less than 500'000 residents(124). This study brings an important contribution to insufficient knowledge on how such cities work and evolve. For the sake of length, this study focuses on one policy document withholding the main policy measures currently deployed by the Government of Mauritius but does not review all urban transport policies that may have been relevant to this paper. The discussion examines citizen needs and preferences as general categories yet may have left out important insights if the needs were sub-grouped by industry, technicians, corporations, public officials or others.

Finally, the online survey was not created to be compared with the selected policies, although the topic is similar and the citizen needs were relevant with policy proposals.

A minor limitation also lies in the homogenous grouping of the online and face-to-face samples which may cause bias if results are considered by location of residence. Further research is necessary to explore the interface between needs and policies in LMICs, particularly regarding gender differences and social equity.

Policy recommendations with highlights on LMICs

Based on the findings of this study, we propose three general recommendations may be useful to policy makers involved in urban transport planning in LMICs.

1. Plan for citizen-centred approaches by preparing in advance the time, money and human resources to facilitate the integration of citizen needs in policy design and reforms.
2. Analyse, consider and prioritise the gaps that may exist between health, economic and social priorities when investing in large urban and transport planning interventions (figure 2).
3. Use citizen needs stratified by demographic indicators to design urban and transport planning interventions aiming for social, health, equity-driven co-benefits.

6.5 Conclusion

To fill research gaps in developing countries, this study used a mixed-method approach to assess the alignment of three urban transport planning measures with self-reported citizen needs in the city of Port Louis. The policies addressed 3 out of 6 needs but did not respond to citizen preferences for active modes of travel. They did not contribute to enhancing health and social co-benefits of transport. Rather the policy measures emphasized an economic agenda focused on transport infrastructure as opposed to reforms in line with public needs that much more strongly highlight the integration of urban transport planning in social life. For instance, the policy measures did not satisfy the need of citizens reporting for more green spaces, pedestrianizing of strategic areas and regulating entry of private vehicles in town nor did they satisfy mode of transit preference for walking or cycling. The logistic regression models showed an uneven distribution of needs across population groups. Yet, the assessment of policies showed some promising results related to needs expressed more likely to be expressed by populations with low income economic backgrounds. Those involved satisfying needs such as improving sidewalks and freeing space occupied by street vendors.

The paper concludes that considering citizen needs provides a unique opportunity to reform urban transport planning policies towards more healthy and equitable cities in the developing world.

Author contributions

The individual contributions of each authors are as follows: conceptualization, M.T., O.M., and M.J.N.; methodology, M.T., S.M.; software, M.T. S.M.; validation, M.T., O.M., and M.J.N.; formal analysis, M.T.; investigation, M.T.; resources, M.T.; data curation, M.T., S.M.; writing—original draft preparation, M.T.; writing—review and editing, M.T., O.M., and M.J.N.; visualization, M.T., O.M., and M.J.N.; supervision, M.J.N.; project administration, N.A.; funding acquisition, N.A.

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Declaration of competing interest

The authors declare no conflict of interest.

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Appendix A.

Supplementary data Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jth.2020.100D44>.

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Image at the bottom of the front page

Owner:

Start date:

End date:

Minimum zoom level for map responses (zero for no limit):

Show social media share buttons

Show map responses by others

Show map responses by others only on last page

Enable commenting of map responses

Maintain respondent session

Show page numbering

Hide front page

Hide title on the front page

Hide previously drawn markers and geometries while drawing a new one

The public address of your questionnaire is <https://mapquestionnaire.com/en/1400/> if you wish it to be private, set a password below.

Questionnaire passwords: Set branching rules:

Style settings

Font size:

Questionnaire title color:

Page name color:

Heading color:

Question color:

Color of the 'Next page' button:

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Language settings

Translate:

Additional languages:

Català

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Deutsch

Eesti

Español

Français

Italiano

Latviski

Nederlands

Norsk

Portugals

Kreeol Morisyen

Română

Svenska

Vjet ngi

Kinyavã

No-pycckî

日本語

Name and Description

Name of the questionnaire:

Welcome to "Map my Port Louis" survey!

We value your view of the capital, so please mark places that have a special meaning to you on a map!

It takes around 14 mins to finish the survey. Your responses are anonymous and are handled confidentially.

Happy Mapping!

The survey results are used for the Port Louis Urban Regeneration Program. The survey is conducted by Synthesys Mauritius in collaboration with State Land Development Company. If you would like to provide further comments on the urban regeneration of PL, please mail us at mapmypl@gmail.com

Pages

Page name:

Are you proud of your capital city?

Yes, definitely

Yes, quite

No, not really

No, not at all

I am indifferent

Why?

Is Port Louis a beautiful city?

Yes, definitely

Yes, quite

No, not really

No, not at all

Why?

[Add content with the button below.](#)

Page name:

Click the buttons with the colored marker!

Zoom to a place using +/- buttons!

Move the marker around the map and click when you want to place it!

Save your answers!

When you're ready to move on, click the arrow.

My favorite place

My most disliked place

My favorite walk

Hand-drawn map layers: China Town

Hand-drawn map layers: Aspravaasi Ghat Buffer Zone

Hand-drawn map layers: Marie Reine de La Paix

Hand-drawn map layers: Gare du Nord

Hand-drawn map layers: Le Parlement

Hand-drawn map layers: St Louis Cathedral

Hand-drawn map layers: Mauritius Commercial Bank Head Office

Hand-drawn map layers: Bank of Mauritius

Hand-drawn map layers: Line Barracks - Casernes

Hand-drawn map layers: Municipality of Port Louis

Hand-drawn map layers: Port Louis Theatre

Hand-drawn map layers: Museum / National Library

Hand-drawn map layers: CEB Office La Poudriere

Hand-drawn map layers: Supreme Court

Hand-drawn map layers: Jeeetoo Hospital

Hand-drawn map layers: Mauritius Revenue Authority

Hand-drawn map layers: Waterfront

Hand-drawn map layers: Cultural Hub

Hand-drawn map layers: Victoria Bus Station

[Add content with the button below.](#)

Page name:

My favorite building in Port Louis

My favorite place for arts, local culture & heritage

My favorite place for eating and shopping

My favorite viewpoint of Port Louis

[Add content with the button below.](#)

Page name:

Parking spaces needed here

Security and safety needed here

Green space needed here

Safety during rainfalls needed here

Add content with the button below.

Page name:

Do you think that:	Has improved more or less	Has degraded more or less	Has not changed
Life conditions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Commercial & Business	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Security	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cleanliness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cultural entertainment and nightlife	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Quality of the urban structure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Implication of the population in organising and managing the city	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The relationship between citizens of Port Louis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

What do you think are the priority needs of each of the following?	High priority	Priority	Important but not priority	Secondary	Useless
Decrease vehicles in town	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Improve public lighting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Improve waste collection & management system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Improve the state of the sidewalks and roads	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Improve public spaces	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increase green spaces	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Build new buildings	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reconvert old housing & unused space into lofts	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How many times per year would you like cultural events in PL?

Once a year
 3 times per year
 6 times per year

Add content with the button below.

Page name:

Which one needs more urgent improvement

Public transportation Private car solutions (more parking space, highways, etc.)

To increase mobility we have to:	Do not Agree	Agree a little	Agree moderately	Agree fully
Pedestrianise strategic areas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Centralise hawkers at main bus stations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Prohibit private vehicles to enter the city	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How would you prefer to transit through Port Louis?

On foot
 Bicycle
 Taxi-boat
 Metro léger
 Electric car rental
 Car-sharing
 Own private vehicle

How would you prefer to cross from Victoria Station to Caudan Waterfront?

Overhead
 Underground
 Zebra crossing

Add content with the button below.

Page name:

Do you live in Port Louis?

Yes
 No

Add content with the button below.

Page name:

In Port Louis, I live in

What do you like most about your neighbourhood?

What do you like less about your neighbourhood?

If you had the choice, what would you prefer?

Stay in your neighbourhood and not change housing
 Stay in your neighbourhood and change housing
 Change neighbourhoods
 Change cities

Why?

If you do not live in Port Louis, would you like to live there?

Yes, certainly
 Yes, probably
 No, Probably not
 No certainly not

Why?

If you moved to Port Louis your 1st choice of residence would be

New condominiums
 Reconverted lofts
 Existing housing

Will cultural events encourage you to live or visit PL more often?

Yes
 No

Add content with the button below.

Page name:

Port Louis is your...

home
 home (but I will move elsewhere within 5years)
 home & workplace
 previous home
 workplace (but I live elsewhere)
 daily transit city
 visit & entertainment spot

Gender

Male
 Female
 Other

Chapter 6: URBAN TRANSPORT POLICY AND CITIZEN NEEDS IN PORT LOUIS

How old are you?

Younger than 18
 18-40
 41-70
 Older than 70

Which professional category best describes where you work?

Your personal income bracket

Rs 5000 or less
 Rs 5001 - Rs 1000
 Rs 10001 - Rs 15000
 Rs 15001 - Rs 20000
 Rs 20001 - Rs 25000
 Rs 25001 - Rs 30000
 Rs 30001 - Rs 35000
 Rs 35001 - Rs 40000
 Rs 40001 - Rs 50000
 Rs 50001 - Rs 60000
 Above Rs 60000

Add content with the button below.

Page name

Well done on completing the survey.
We appreciate your input!

All of your responses have been saved; there is no "Submit" button.

Thank you for sharing your experience and taking the time to Map your Port Louis!

Please share this link with your friends and colleagues to help us collect even more Port Louis Experiences!
<https://mapionnaire.com/en/1400/>

Add content with the button below.

Supplementary File B

	NEEDS					PREFERENCES						
	More sidewalks	More public spaces	More pedestrianized	Centralise hawkers	Regulate private	More green spaces	Bicycle	Car-sharing & Electric car rental	Metro lighter	On foot	Own private vehicle	Taxi-boat
Gender												
males	538 (47.74%)	502 (46.61%)	473 (50.53%)	350 (44.19%)	257 (47.16%)	425 (46.45%)	58 (2.70%)	62 (4.40%)	191 (13.55%)	243 (17.23%)	88 (6.24%)	43 (2.91%)
females	575 (51.02%)	560 (52.0%)	453 (48.40%)	428 (54.04%)	277 (50.83%)	479 (52.35%)	86 (6.10%)	90 (6.38%)	185 (13.12%)	220 (15.60%)	124 (8.79%)	24 (1.70%)
non-disclosed	14 (1.24%)	15 (1.39%)	10 (1.07)	14 (1.77)	11 (2.02)	11 (1.20)	2 (0.14%)	0 (0%)	2 (0.14%)	9 (0.64%)	4 (0.28%)	1 (0.07%)
N Missing	73	74	37	38	26	71	5	5	16	14	8	6
Age group												
Dec-15	120 (10.67%)	109 (10.14%)	88 (9.39%)	85 (10.73%)	47 (8.61%)	95 (10.35%)	9 (0.64%)	18 (1.28%)	35 (2.48%)	35 (2.48%)	30 (2.13%)	10 (0.71%)
16-18	121 (10.76%)	127 (11.81%)	94 (10.03%)	94 (11.87%)	64 (11.72%)	95 (10.35%)	11 (0.78%)	14 (0.99%)	37 (2.62%)	60 (4.25%)	26 (1.84%)	6 (0.43%)
19-24	132 (11.79%)	122 (11.35%)	89 (9.50%)	72 (9.09%)	56 (10.26%)	107 (11.66%)	17 (1.20%)	14 (1%)	41 (2.95%)	47 (3.35%)	45 (3.19%)	5 (0.35%)
25-29	140 (12.44%)	126 (11.7%)	113 (12.00%)	85 (10.73%)	63 (11.54%)	113 (12.31%)	24 (1.70%)	17 (1.21%)	49 (3.47%)	58 (4.11%)	24 (1.70%)	7 (0.50%)
30-34	125 (11.11%)	109 (10.14%)	97 (10.35%)	84 (10.61%)	56 (10.26%)	98 (10.68%)	16 (1.13%)	20 (1.42%)	42 (2.98%)	51 (3.61%)	21 (1.49%)	6 (0.43%)
35-39	98 (8.71%)	99 (9.21%)	100 (10.67%)	75 (9.47%)	46 (8.42%)	82 (8.93%)	20 (1.42%)	16 (1.13%)	37 (2.62%)	42 (2.98%)	15 (1.06%)	7 (0.50%)
40-49	136 (12.09%)	133 (12.37%)	120 (12.81%)	103 (13.01%)	86 (15.75%)	121 (13.18%)	8 (0.57%)	21 (1.49%)	57 (4.04%)	58 (4.11%)	20 (1.42%)	8 (0.57%)
50-59	144 (12.80%)	140 (13.02%)	135 (14.41%)	114 (14.39%)	73 (13.37%)	126 (13.73%)	9 (0.64%)	19 (1.34%)	47 (3.33%)	70 (4.96%)	25 (1.77%)	8 (0.57%)
60 or above	109 (9.69%)	110 (10.23%)	101 (10.78%)	80 (10.10%)	55 (10.07%)	81 (8.82%)	13 (0.92%)	12 (0.85%)	32 (2.27%)	53 (3.76%)	12 (0.85%)	7 (0.50%)
N Missing	75	76	36	38	25	68	6	6	17	12	6	8
Professional status												
unemployed	166 (13.83%)	161 (13.99%)	101 (10.38%)	90 (10.84%)	60 (10.51%)	127 (12.88%)	12 (0.82%)	17 (1.16%)	47 (3.21%)	60 (4.10%)	16 (1.09%)	9 (0.61%)
manual workers	249 (20.75%)	230 (19.98%)	180 (18.50%)	180 (21.69%)	119 (20.84%)	185 (18.76%)	18 (1.23%)	14 (0.96%)	68 (4.64%)	116 (7.92%)	55 (3.76%)	11 (0.75%)
technicians/pros	232 (19.33%)	221 (19.20%)	235 (24.15%)	173 (20.84%)	122 (21.37%)	219 (22.21%)	33 (2.25%)	45 (3.07%)	90 (6.15%)	94 (6.62%)	35 (2.39%)	16 (1.09%)
retired	64 (5.33%)	65 (6.05%)	56 (5.76%)	46 (5.54%)	37 (6.48%)	42 (4.56%)	4 (0.27%)	6 (0.54)	14 (0.96%)	39 (2.66%)	5 (0.34%)	4 (0.27%)
seasonal visitor	6 (0.50%)	9 (0.78%)	5 (0.51%)	1 (0.36%)	6 (1.05%)	7 (0.71%)	1 (0.07%)	1 (0.07%)	4 (0.27%)	2 (0.14%)	2 (0.14%)	1 (0.07%)
service off workers	204 (17%)	196 (17.03%)	187 (19.22%)	143 (17.23%)	94 (16.46%)	183 (18.56%)	33 (2.25%)	36 (2.46%)	88 (6.10%)	69 (4.71%)	45 (3.07%)	13 (0.89%)
student	279 (23.25%)	269 (23.37%)	209 (21.48%)	195 (23.49%)	133 (23.29%)	223 (22.62%)	30 (2.05%)	36 (2.45%)	83 (5.67%)	106 (7.24%)	66 (4.51%)	18 (1.23%)
Income group												
5000 or less	188 (16.67%)	188 (16.33%)	137 (12.02%)	114 (13.73%)	74 (12.96%)	147 (14.91%)	25 (1.71%)	25 (1.71%)	74 (5.05%)	60 (4.10%)	17 (1.23%)	11 (0.75%)
5001-10000	187 (15.88%)	165 (14.34%)	133 (13.46%)	119 (14.34%)	78 (12.66%)	133 (13.49%)	14 (0.96%)	17 (1.16%)	54 (3.69%)	80 (5.46%)	38 (2.60%)	9 (0.61%)
10001-15000	120 (10.75%)	121 (10.51%)	99 (10.17%)	87 (10.48%)	61 (10.68%)	101 (10.24%)	11 (0.75%)	13 (0.89%)	43 (2.94%)	66 (4.51%)	22 (1.50%)	5 (0.34%)
15001-25000	151 (12.58%)	144 (12.51%)	133 (13.67%)	106 (12.77%)	89 (15.59%)	131 (13.29%)	21 (1.43%)	24 (1.64%)	42 (2.87%)	66 (4.51%)	24 (1.64%)	13 (0.89%)
25001-35000	112 (9.33%)	98 (8.51%)	101 (10.38%)	83 (10.00%)	60 (10.51%)	90 (9.13%)	16 (1.09%)	14 (0.95%)	38 (2.60%)	47 (3.21%)	20 (1.37%)	13 (0.20%)
35001-40000	95 (7.92%)	97 (8.43%)	85 (8.74%)	65 (7.83%)	38 (6.65%)	90 (9.13%)	17 (1.16%)	22 (1.50%)	44 (3.01%)	34 (2.32%)	13 (0.89%)	5 (0.34%)
above 60000	338 (28.17%)	338 (29.37%)	307 (31.55%)	256 (30.84%)	171 (29.95%)	294 (29.82%)	27 (1.84%)	42 (2.87%)	99 (6.76%)	133 (9.08%)	70 (4.78%)	26 (1.78%)

Supplementary File C

	GENERAL LOGISTIC REGRESSION RESULTS					
	Met needs			Unmet needs		
	Improve sidewalks	Improve public spaces	Centralize hawkers at bus stations	Increase green spaces	Pedestrianize strategic areas	Regulate private vehicles in town
Age (vs.12-15)						
16-18	2.15 (1.14 to 4.04)**	1.00 (0.56 to 1.80)	1.01 (0.62 to 1.65)	1.44 (0.88 to 2.36)	1.03 (0.62 to 1.71)	0.66 (0.40 to 1.09)
19-24	2.09 (0.99 to 4.39)	1.60 (0.83 to 3.1)	1.82 (1.03 to 3.22)**	1.30 (0.73 to 2.33)	1.04 (0.58 to 1.87)	0.64 (0.36 to 1.16)
25-29	1.43 (0.62 to 3.33)	1.39 (0.65 to 2.96)	1.42 (0.74 to 2.74)	1.24 (0.63 to 2.41)	0.76 (0.39 to 1.48)	0.54 (0.27 to 1.06)
30-34	1.35 (0.57 to 3.21)	1.48 (0.68 to 3.23)	1.17 (0.59 to 2.32)	1.38 (0.69 to 2.77)	0.77 (0.38 to 1.55)	0.50 (0.25 to 1.02)
35-39	2.17 (0.93 to 5.07)	1.49 (0.69 to 3.23)	1.33 (0.67 to 2.62)	1.66 (0.83 to 3.31)	0.65 (0.32 to 1.32)	0.64 (0.31 to 1.30)
40-49	1.36 (0.58 to 3.19)	1.05 (0.49 to 2.28)	0.93 (0.48 to 1.81)	0.96 (0.49 to 1.90)	0.60 (0.30 to 1.19)	0.29 (0.14 to 0.57)**
50-59	1.26 (0.54 to 2.96)	1.02 (0.47 to 2.21)	0.86 (0.44 to 1.67)	0.94 (0.48 to 1.85)	0.45 (0.22 to 0.89)**	0.44 (0.22 to 0.87)**
60 years and above	0.98 (0.36 to 2.69)	0.66 (0.26 to 1.70)	0.84 (0.39 to 1.82)	0.90 (0.40 to 1.99)	0.25 (0.11 to 0.59) **	0.49 (0.22 to 1.09)
Income (vs. less than 5001)						
5001-10000	0.52 (0.28 to 0.97)**	1.28 (0.74 to 2.24)	0.98 (0.61 to 1.55)	0.99 (0.62 to 1.57)	0.87 (0.54 to 1.39)	0.89 (0.55 to 1.43)
10001-15000	0.74 (0.41 to 1.34)	1.04 (0.59 to 1.83)	0.78 (0.48 to 1.26)	0.97 (0.60 to 1.58)	0.75 (0.46 to 1.24)	0.62 (0.38 to 1.02)
15001-25000	0.71 (0.4 to 1.26)	0.96 (0.56 to 1.66)	0.68 (0.43 to 1.09)	0.86 (0.53 to 1.38)	0.58 (0.35 to 0.94)**	0.41 (0.26 to 0.67) *
25001-35000	0.66 (0.36 to 1.23)	1.18 (0.66 to 2.1)	0.58 (0.35 to 0.97)**	1.19 (0.70 to 1.99)	0.63 (0.36 to 1.08)**	0.45 (0.27 to 0.77)**
35001-60000	1.07 (0.59 to 1.94)	1.14 (0.63 to 2.06)	0.92 (0.55 to 1.55)	1.19 (0.70 to 2.02)	0.99 (0.57 to 1.70)	0.96 (0.55 to 1.68)
above 60000	1.13 (0.72 to 1.78)	1.17 (0.75 to 1.82)	0.56 (0.39 to 0.81)**	1.04 (0.72 to 1.51)	0.38 (0.26 to 0.56) *	0.56 (0.38 to 0.82)**
Profession (vs. unemployed)						
manual workers	1.25 (0.64 to 2.45)	1.2 (0.62 to 2.04)	0.53 (0.33 to 0.86)**	0.80 (0.49 to 1.30)	0.64 (0.39 to 1.06)	0.60 (0.36 to 1.00)
technicians/pros	2.66 (1.43 to 4.92)**	2.22 (1.26 to 3.91)**	1.05 (0.65 to 1.7)	0.61 (0.38 to 1.00)	0.55 (0.33 to 0.92)**	0.88 (0.53 to 1.45)
retired	2.41 (0.87 to 6.65)	1.43 (0.54 to 3.79)	0.71 (0.33 to 1.54)	1.51 (0.70 to 3.25)	0.90 (0.38 to 2.14)	0.38 (0.17 to 0.82)**
seasonal visitor	5.46 (1.47 to 20.34)	1.07 (0.21 to 5.35)	2.98 (0.74 to 12.07)	0.79 (0.22 to 2.88)	1.52 (0.42 to 5.55)	0.40 (0.11 to 1.46)
service off workers	3.13 (1.7 to 5.76) *	2.23 (1.27 to 3.91)**	1.12 (0.7 to 1.8)	0.78 (0.49 to 1.26)	0.75 (0.46 to 1.24)	1.17 (0.71 to 1.94)
student	1.21 (0.59 to 2.46)	1.42 (0.73 to 2.77)	0.83 (0.47 to 1.44)	0.71 (0.41 to 1.24)	0.68 (0.38 to 1.20)	0.44 (0.24 to 0.80)**
Gender (vs. female)						
male	1.1 (0.84 to 1.44)	0.91 (0.71 to 1.17)	0.79 (0.64 to 0.99)**	0.98 (0.78 to 1.23)	1.68 (1.33 to 2.13) *	1.05 (0.84 to 1.32)
non-disclosed	1.82 (0.67 to 4.97)	0.99 (0.35 to 2.82)	0.43 (0.16 to 1.16)	1.27 (0.51 to 3.13)	2.13 (0.85 to 5.35)	0.47 (0.18 to 1.18)
* p-value <0.001						
** p-value <0.005						
All models adjusted by group age, income group, professional status and gender						

Supplementary File D

	MALES					
	Met needs			Unmet needs		
	Improve sidewalks	Improve public spaces	Centralize hawkers at bus stations	Increase green spaces	Pedestrianize strategic areas	Regulate private vehicles in town
Age (vs.12-15)						
16-18	1.79 (0.76 to 4.22)	0.96 (0.40 to 2.31)	0.99 (0.48 to 1.38)	1.38 (0.71 to 2.69)	1.45 (0.69 to 3.04)	1.20 (0.54 to 2.64)
19-24	1.18 (0.42 to 3.32)	2.33 (0.92 to 5.93)	1.33 (0.58 to 1.14)	1.14 (0.50 to 2.61)	1.13 (0.49 to 2.59)	0.64 (0.27 to 1.54)
25-29	0.93 (0.29 to 3.04)	2.69 (0.89 to 8.11)	0.77 (0.30 to 1.31)	1.31 (0.51 to 3.37)	0.63 (0.24 to 1.65)	0.38 (0.14 to 1.06)
30-34	1.03 (0.31 to 3.35)	3.43 (1.12 to 10.55)**	1.06 (0.40 to 1.03)	1.03 (0.37 to 2.83)	0.76 (0.29 to 2.05)	0.41 (0.14 to 1.16)
35-39	1.53 (0.47 to 4.94)	3.54 (1.15 to 10.93)**	0.92 (0.35 to 1.08)	1.08 (0.40 to 2.92)	0.61 (0.22 to 1.66)	0.50 (0.17 to 1.44)
40-49	1.15 (0.36 to 3.64)	2.48 (0.82 to 7.54)	0.62 (0.24 to 0.67)	0.67 (0.25 to 1.79)	0.56 (0.21 to 1.48)	0.30 (0.11 to 0.82)**
50-59	0.72 (0.23 to 2.28)	2.11 (0.71 to 6.29)	0.73 (0.29 to 0.73)	0.73 (0.26 to 1.99)	0.38 (0.14 to 0.98)**	0.33 (0.12 to 0.88)**
60 years and above	0.60 (0.16 to 2.28)	1.74 (0.50 to 6.12)	0.70 (0.25 to 0.57)	0.57 (0.16 to 2.09)	0.19 (0.06 to 0.60)**	0.44 (0.14 to 1.33)
Income (vs. less than 5001)						
5001-10000	0.77 (0.32 to 1.88)	2.28 (0.97 to 5.35)	0.72 (0.36 to 0.59)	0.93 (0.48 to 1.80)	0.74 (0.36 to 1.49)	1.02 (0.49 to 2.15)
10001-15000	0.71 (0.29 to 1.74)	1.36 (0.58 to 3.20)	0.59 (0.29 to 0.95)	0.95 (0.46 to 1.95)	0.63 (0.31 to 1.28)	0.73 (0.35 to 1.54)
15001-25000	0.89 (0.40 to 1.96)	1.26 (0.57 to 2.78)	0.52 (0.27 to 1.01)	1.01 (0.48 to 2.14)	0.52 (0.27 to 1.03)	0.35 (0.18 to 0.69)**
25001-35000	0.48 (0.20 to 1.18)	1.20 (0.52 to 2.77)	0.33 (0.16 to 1.95)	0.87 (0.42 to 4.42)	0.46 (0.22 to 0.97)**	0.27 (0.13 to 0.57)*
35001-60000	1.25 (0.56 to 2.81)	1.82 (0.81 to 4.12)	0.65 (0.32 to 1.00)	1.00 (0.41 to 2.42)	0.78 (0.38 to 1.62)	0.74 (0.35 to 1.58)
above 60000	1.59 (0.83 to 3.08)	1.63 (0.84 to 3.17)	0.49 (0.28 to 1.20)	0.70 (0.20 to 2.04)	0.39 (0.22 to 0.69)**	0.53 (0.29 to 0.94)**
Profession (vs. unemployed)						
manual workers	2.34 (0.70 to 7.85)	1.37 (0.50 to 3.76)	0.70 (0.33 to 1.12)	1.33 (0.67 to 2.63)	0.74 (0.35 to 1.58)	0.73 (0.33 to 1.60)
technicians/pros	4.83 (1.53 to 15.19)**	2.50 (0.94 to 6.63)	1.12 (0.54 to 0.72)	0.89 (0.43 to 1.84)	0.55 (0.26 to 1.17)	1.20 (0.56 to 2.59)
retired	5.58 (1.22 to 25.49)**	1.51 (0.39 to 5.90)	0.72 (0.26 to 0.75)	3.19 (0.89 to 11.47)	1.21 (0.39 to 3.73)	0.53 (0.18 to 1.55)
seasonal visitor	7.78 (1.20 to 50.47)**	2.82 (0.42 to 18.77)	7.55 (0.81 to 0.52)	0.05 (0.05 to 5.42)	2.35 (0.38 to 14.42)	0.70 (0.13 to 3.93)
service off workers	4.97 (1.57 to 15.74)	2.22 (0.83 to 5.94)	0.87 (0.42 to 1.03)	0.52 (0.2 to 2.04)	0.56 (0.26 to 1.21)	1.38 (0.63 to 3.02)
student	2.16 (0.61 to 7.63)	4.88 (1.55 to 15.34)**	0.77 (0.33 to 0.78)	0.36 (0.36 to 1.71)	0.50 (0.21 to 1.22)	0.40 (0.15 to 1.04)

* p-value < 0.001

** p-value < 0.005

All models adjusted by group age, income group and professional status

	FEMALES					
	Met needs			Unmet needs		
	Improve sidewalks	Improve public spaces	Centralize hawkers at bus stations	Increase green spaces	Pedestrianize strategic areas	Regulate private vehicles in town
Age (vs.12-15)						
16-18	3.35 (1.16 to 9.67)**	1.13 (0.50 to 2.52)	1.09 (0.56 to 1.38)	1.38 (0.71 to 2.69)	0.78 (0.38 to 1.59)	0.44 (0.22 to 0.85)**
19-24	4.49 (1.37 to 14.72)**	1.12 (0.43 to 2.96)	2.33 (1.04 to 2.37)	1.14 (0.50 to 2.61)	0.91 (0.39 to 2.12)	0.61 (0.26 to 1.39)
25-29	2.63 (0.69 to 9.97)	0.84 (0.28 to 2.49)	2.37 (0.92 to 1.31)	1.31 (0.51 to 3.37)	0.80 (0.30 to 2.12)	0.59 (0.22 to 1.55)
30-34	1.76 (0.43 to 7.25)	0.69 (0.22 to 2.19)	1.14 (0.42 to 1.03)	1.03 (0.37 to 2.83)	0.72 (0.25 to 2.06)	0.44 (0.16 to 1.23)
35-39	3.38 (0.87 to 13.19)	0.78 (0.25 to 2.43)	1.95 (0.73 to 1.48)	1.08 (0.40 to 2.92)	0.71 (0.25 to 2.00)	0.71 (0.25 to 1.98)
40-49	1.99 (0.5 to 7.88)	0.49 (0.16 to 1.53)	1.48 (0.57 to 0.67)	0.67 (0.25 to 1.79)	0.59 (0.21 to 1.61)	0.23 (0.09 to 0.60)**
50-59	3.39 (0.85 to 13.52)	0.63 (0.20 to 2.00)	1.01 (0.37 to 0.73)	0.73 (0.26 to 1.99)	0.52 (0.18 to 1.50)	0.59 (0.21 to 1.64)
60 years and above	2.31 (0.43 to 12.55)	0.21 (0.04 to 1.12)	0.95 (0.27 to 0.57)	0.16 (0.16 to 2.09)	0.39 (0.10 to 1.62)	0.56 (0.16 to 1.98)
Income (vs. less than 5001)						
5001-10000	0.35 (0.14 to 0.89)**	0.88 (0.40 to 1.93)	1.26 (0.65 to 0.97)	0.93 (0.48 to 1.80)	1.04 (0.52 to 2.07)	0.89 (0.45 to 1.74)
10001-15000	0.75 (0.32 to 1.77)	0.76 (0.33 to 1.73)	0.97 (0.47 to 0.77)	0.95 (0.46 to 1.95)	0.94 (0.45 to 1.99)	0.48 (0.23 to 0.99)**
15001-25000	0.48 (0.2 to 1.2)	0.66 (0.29 to 1.53)	0.77 (0.37 to 1.49)	1.01 (0.48 to 2.14)	0.59 (0.26 to 1.34)	0.45 (0.21 to 0.96)**
25001-35000	1.15 (0.46 to 2.91)	1.51 (0.62 to 3.68)	1.49 (0.65 to 1.95)	0.87 (0.42 to 4.42)	1.16 (0.49 to 2.79)	1.15 (0.47 to 2.81)
35001-60000	0.96 (0.36 to 2.56)	0.62 (0.23 to 1.63)	1.56 (0.64 to 1.00)	0.41 (0.41 to 2.42)	1.67 (0.66 to 4.22)	1.40 (0.54 to 3.64)
above 60000	0.81 (0.42 to 1.58)	0.95 (0.51 to 1.78)	0.67 (0.40 to 1.20)	0.70 (0.20 to 2.04)	0.38 (0.22 to 0.66)*	0.57 (0.33 to 0.98)**
Profession (vs. unemployed)						
manual workers	0.95 (0.39 to 2.32)	1.36 (0.61 to 3.06)	0.48 (0.24 to 0.92)	1.33 (0.67 to 2.63)	0.60 (0.29 to 1.23)	0.56 (0.28 to 1.14)
technicians/pros	1.94 (0.82 to 4.59)	2.74 (1.21 to 6.17)**	0.92 (0.45 to 0.67)	0.89 (0.43 to 1.84)	0.47 (0.21 to 1.09)	0.71 (0.33 to 1.52)
retired	0.63 (0.1 to 4.13)	1.37 (0.25 to 7.65)	0.67 (0.19 to 0.93)	3.19 (0.89 to 11.47)	0.37 (0.08 to 1.79)	0.18 (0.05 to 0.64)**
seasonal visitor	4.58 (0.52 to 40.08)	-	0.93 (0.12 to 0.52)	0.05 (0.05 to 5.42)	0.63 (0.06 to 6.70)	0.13 (0.01 to 1.47)
service off workers	2.96 (1.31 to 6.69)**	3.23 (1.49 to 6.99)**	1.65 (0.83 to 1.65)	0.52 (0.2 to 2.04)	0.98 (0.47 to 2.05)	1.33 (0.64 to 2.76)
student	0.97 (0.38 to 2.52)	0.68 (0.27 to 1.68)	0.90 (0.42 to 0.78)	0.36 (0.36 to 1.71)	0.88 (0.40 to 1.97)	0.48 (0.22 to 1.08)

* p-value < 0.001

** p-value < 0.005

All models adjusted by group age, income group and professional status

Chapter 7: PQHIA OF URBAN TRANSPORT PLANNING IN PORT LOUIS

7. PQHIA Of Urban Transport Planning in Port Louis

High rates of motorization in urban areas of Africa have adverse effects on public health. Transport-related mortality will increase as a result of inadequate transport infrastructure, air pollution and sedentary lifestyles. Health Impact Assessments (HIAs) have proven to be a successful tool to predict and mitigate negative health impact of urban transport planning policies, programmes or projects. Yet, there is a gap of evidence on transport and health in African countries. The aim of chapter is to assess the health impacts of transport scenarios in Port Louis using a full chain participatory quantitative HIA (PQHIA) model. It assesses health and economic impacts associated to transport scenarios with qualitative data and quantitative comparative risk assessment methods. The chapter concludes that implementing transport policies aiming for less than an ideal situation may not be adequate or sufficient to avoid negative transport-related mortality in Mauritius. Transport policies should aim to restrict all forms of private motorized vehicles and promote active and public transport to support public health. The chapter recommends the use of participatory approaches in quantitative HIA to ensure context specificity and policy relevance.

Keywords

Health impact assessment, Premature mortality, Africa, Mauritius, Urban transport planning

7.1 Introduction

It is urgent to estimate and mitigate environmental health impacts of transport in cities of low- and middle-income countries (LMICs). Increased motorization and cumulative poor transport planning and infrastructure have irreversible health implications for urban populations. LMICs currently absorb 80% of global non-communicable disease (NCD) deaths, 92% of pollution-related deaths and 90% of traffic-related deaths (Alwan, 2011; UNEP, 2011; Landrigan et al., 2017; World Health Organization, 2016). And health risks will grow as more people move to cities. By 2050; 90% of 2.5 billion new urbanites will have migrated from rural to urban areas in LMICs of Africa and Asia. In sub-Saharan Africa, megacities rose from 10 in 1990 to 28 in 2014 (Nations U, 2014). This trend will continue as the number of African cities with more than half a million people will increase by 80% by 2030 (Nations U, 2014). Along with the surge of new cities, annual urban population growth rates in Africa will continue to be the highest in the world for at least until 2040 (Schwela, 2012). This rate is 3.09% for the 2011–2030 period, compared to 1.87% in Asia, 1.13% in Latin America, 0.98% in North America and 0.33% in Europe (Schwela, 2012).

Like elsewhere, African cities drive innovation, economic growth, increased access to health care and social advancement (Bettencourt et al., 2007; Cohen, 2006), yet claim high proportions of disease burden and deaths related to urban transport (World Health Organization, 2016).

In sub Saharan Africa (SSA), air pollution (AP) is the fourth leading cause of DALYs (disability-adjusted life years) (Collaborators GBD 2015 RF, 2016), killing 176,000 people prematurely, inducing 626,000 DALYs (Amegah and Agyei-Mensah, 2017) and causing cardio-vascular and cerebrovascular diseases and lung and respiratory infections (Cesaroni et al., 2014; Beelen et al., 2014; Stafoggia et al., 2014; Stewart-wilson, 2018). Besides adverse health effects, air pollution in African cities carry economic implications and costs 2.7% of GDP per year (Akumu). It is estimated that about 90% of urban air pollution in rapidly growing cities of LMICs (UNEP, 2011) and in SSA (Haq and Schwela, 2012) is attributable to motor vehicle emissions. In Africa only, CO₂ emissions from transport have increased 53.7% between 1990 and 2010 (Haq and Schwela, 2012).

Increased motorization can lead to sedentary lifestyles and decrease in physical activity (PA) (Nieuwenhuijsen and Khreis, 2016). Globally, more than 2 million premature deaths per year are caused by insufficient PA (Collaborators GBD 2013 RF, 2015). The lack of data and the complexity involved in measuring PA levels has limited the study of physical activity in Africa (Assah et al., 2011). Across 22 African countries urbanization has led to decreasing physical activity (Guthold et al., 2008) inducing lifestyle related diseases such as diabetes (Mbanya et al., 2010; Christensen et al., 2009), high blood pressure (Luke et al., 2005) and obesity (Sobngwi et al., 2002).

In addition to adverse health effects due to less PA, commuting populations in Africa are exposed to unsafe roads (Adeloye et al., 2016). Road injuries have increased by 33% between 1990 and 2015 (Murray et al., 2015).

Africa has the highest rate of fatalities from road traffic injuries worldwide at 26.6 per 100 000 population (Organization, 2015).

Road traffic accidents are the major cause of mortality among people aged 15–29 years (Bonnet et al., 2017). While car ownership may rise to 2 billion motor vehicles worldwide by 2030 (Sperling and Gordon, 2008), it remains low in African settings (0.06–0.16 cars per household) (Rwebangira, 2001). In contrast, motorcycle ownership has increased drastically, with motorcyclists exposed to 16 times more risks of dying in a road accident than car occupants (Kudebong et al., 2011).

There is growing interest on the use of Health Impact Assessments (HIAs) to estimate the risks and benefits of traffic-related policies on health in high (De Nazelle et al., 2011; Mueller et al., 2015) and low income settings (Pereira et al., 2017; Winkler et al., 2013). HIAs combine mixed-methods to systematically assess the potential health effects of a proposed policy, programme, or project (European Centre for Health Policy WHO, 1999), also in terms of distributive effects within a population (social and equity effects). HIAs enable identification of the most healthy, feasible and acceptable transport policy measures in cities facing environmental and health hazards and high levels of social inequity (Nieuwenhuijsen, 2016). Transport-related HIAs in LMICs have assessed the impacts of air pollution only (Chang-Hong et al., 2009; He et al., 2016; Vu et al., 2013; Tashayo et al., 2017; Aggarwal and Jain, 2015; Mahendra and Rajagopalan, 2015; Dhondt et al., 2011; Ongel and Sezgin, 2016; Guo et al., 2010; Permadi et al., 2017); of air pollution, road traffic and physical activity combined (Mahendra and Rajagopalan, 2015; de Sá et al., 2017); air pollution and greenhouse gas emissions combined (Ren et al.,

2016); and finally, noise, air pollution and greenhouse gas emissions combined (Ongel and Sezgin, 2016).

There is an urgent need to conduct and report on more HIAs in LMICs (Winkler et al., 2013; Erlanger et al., 2008). Particularly, there is little scholarship on HIAs of urban transport in Africa (Thondoo et al., 2019). Data scarcity and poor technical support impeded the completion of a transport-related HIA in Mozambique for this study (Rojas- Rueda et al., 2016). One paper collected primary data on air pollution in Kenya but did not estimate the health outcomes of exposures (Kinney et al., 2011). Some studies have covered HIAs in mining and industry (Utzinger et al., 2005; Winkler et al., 2011; Winkler and Utzinger, 2014; Knoblauch et al., 2017); waste management (Gulis and Mochungong, 2013), and international development projects (O’Keefe and Scott-Samuel, 2010). To bridge scholarly and empirical gaps, we address the question: What are the major risk exposures and health impacts derived from urban transport planning policies in an African city? This study aims to conduct and present an HIA of urban transport planning in Port Louis, Mauritius, based on a full-chain participatory HIA model for quantitatively estimating health and economic out- comes.

The model builds on previous work to account for ‘the full-chain from source through pathways to health effects and impacts to substantiate and effectively target actions’ (Nieuwenhuijsen et al., 2017). It aims to estimate the health impacts of urban transport on the basis of a transport mode shift using a combination of participatory approaches and quantitative modelling.

7.2 Material And Methods

The participatory quantitative HIA includes baseline data collection co-validation of transport policy scenarios with stakeholders and quantitative modelling of health impacts (see Fig. 1). The study was approved by the National Ethics Committee of the Ministry of Health and Quality of Life in Mauritius (project protocol MHC/CT/NETH/THONM) and by the Ethical Advisory Board of the Amsterdam Institute for Social Science Research (AISSR). Information and consent sheets were signed by all participants.

Study conceptual model

We conducted a full-chain participatory HIA to assess health im- pacts on the basis of a transport mode shift in Port Louis, Mauritius. By applying mixed-methods, we estimated averted deaths per year and economic outcomes by assessing the health determinants of air pollu- tion, traffic deaths and physical activity (Fig. 1). As done elsewhere (Mueller et al., 2017), we follow the WHO ’s standard process of HIA (see left margin): screening, scoping, appraisal and reporting phases. We excluded the monitoring phase due to restricted duration of study.

In the screening and scoping phase, we applied a participatory process to examine the context of urban transport planning in Mauritius. It included (a) open-ended individual interviews (IDIs) with 14 stakeholders (b) closed-ended survey questions to 600 citizens and (c) 2 focus group discussions (FGDs) with the same 14 stakeholders from (a). The IDIs and FGDs were used to select health indicators and co-validate HIA scenarios. The survey was used to collect baseline data to establish current exposure levels to selected indicators.

The appraisal phase consisted of the quantitative assessment of health risks. Risk estimation was conducted by calculating the exposure difference between baseline and predicted exposure levels under the different scenarios studied. The scenarios represented the changes in status quo. We used the exposure Response Function (ERF) and Relative Risk (RR) to calculate the Population Attributable Fraction (PAF). We applied mortality rates to PAF to obtain scenario attributable deaths and economic outcome estimation. The reporting phase consisted of a knowledge translation process on the HIA results and joint discussion on way forward with stakeholders.

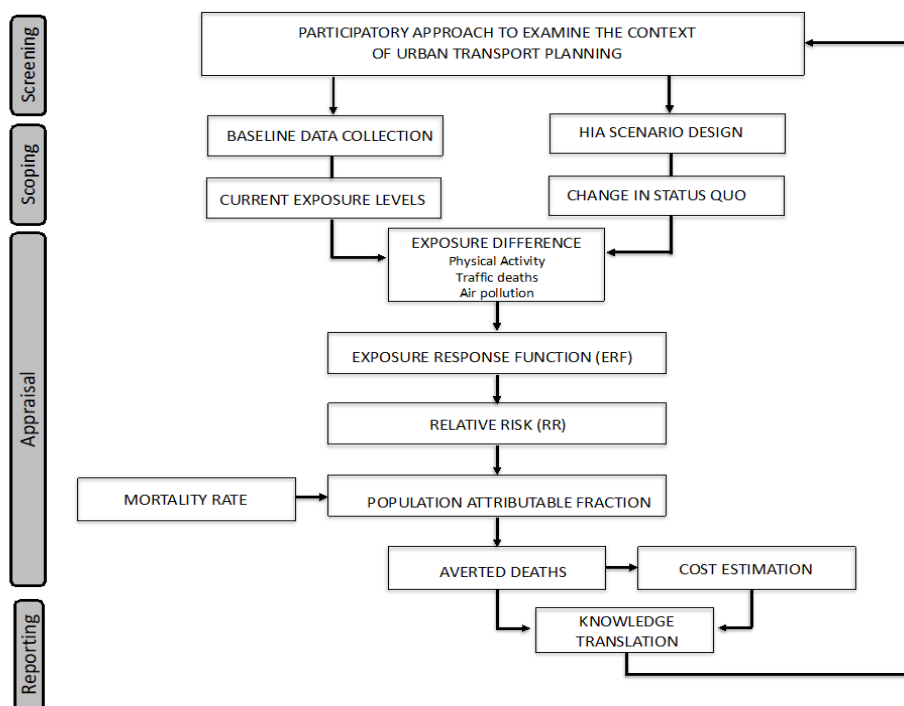


Figure 8: Conceptual Framework for Participatory HIA

Study setting

With 1.2 million people (Government of Mauritius, 2015), Mauritius (2040 km²) had the highest population density in Africa in 2013 (World Bank. Countries by Population Density, 2015). Mauritian urban population rates have doubled since 1980 with 60% living on 8% of the territory (one city and four main towns). Like elsewhere in Africa (Stewart-Wilson 2018), non-communicable diseases in Mauritius have been rising rapidly since 2010 with a current 15% prevalence of diabetes and 30% prevalence of hypertension in the adult population between 20 and 74 years old (Government of Mauritius, 2015). The national fleet increased by 625% between 1972 and 2000 (OECD, 2014) and road traffic accidents have increased by 4% annually (OECD, 2014). Traffic congestion costs Mauritius approximately USD 119.6 million per year (Ministry of Public Infrastructure and Land Transport, 2017).

The capital city Port Louis is comparable to many other African cities (Adeloye et al., 2016; Kudebong et al., 2011; Sietchiping et al., 2012). It is densely populated (2,563 persons per square km) with 119, 018 people residing on 46.7 km (Mauritius and Digest of Demographic, 2017). It is highly polluted, emitting 9 tons of carbon dioxide per capita, costing USD 0.1 billion every year (Fowdur and Rughooputh, 2012).

During a 3-month stand-alone road-side test, the level of air pollution (PM 2.5) on the outskirts of Port Louis was about 68ug/m³ (Organization, 2016), six times higher than the WHO standards of 10 µg/m³ annual mean. Like other African cities (Sietchiping et al., 2012), Port Louis' transport planning fails to respond to population and spatial growth with heterogeneous vehicles using limited and non-adapted road infrastructure. It is a car-oriented city with very little green space and pedestrian movement is limited to unsafe sidewalks. There is a poor integration of different modes of travel and limited possibility to introduce bus or cycle lanes. The city suffers from major traffic congestion caused by the daily influx of 201,567 people coming from 9 neighbouring districts, creating bottlenecks at the city entrance and exit. Traffic flow is further hampered by narrow roads, street vendors and side-street parking spaces.

Methods for the IDIs and FGDs**Sampling.**

We selected 14 individuals using purposive sampling methods across different communities of interest and following their role in current urban transport initiatives and policy-making processes (Table 17). The same informants were used for the IDIs and FGDs.

IDIs.

We conducted face-to-face interviews using a semi-structured topic guide and open-ended questions in August 2019 (annex 1). We recorded, transcribed and anonymized IDIs using number identifiers. Interviewees were asked about the urban transport policies they are most familiar with, the linkages between urban transport planning and health, the current challenges in the transport sector, and (World Health Organization, 2016) their idea of a healthy, feasible and sustainable urban transport planning system and what is needed to achieve that.

FGDs.

From the IDIs, we isolated the factors stakeholders described as linking urban transport planning to health and the main challenges faced by the sector. We presented these results at subsequent focus group discussions (FGDs), during which stakeholders contrasted their views, needs and priorities. They discussed different transport-related health indicators and shared their opinions on potential scenarios. They also debated if, where, and how their individual visions differ and clash with the proposed scenarios and discussed if they can reach similar endpoints (annex 2).

Communities of interest	Expertise (information held)	Reason to for inclusion
Community-based organization	Expert (Ecosystems)	Active role in liaising between communities and developers of private urban project
Service provider/ industry	Consultant (Sustainable development)	Consults for public and multilateral organizations on the environmental impacts of land and sea infrastructure projects
Elected official	Adviser (Land Transport)	Provides expert advice and strategies to the high level politicians on transport related policies
Elected official	Permanent secretary (Medicine and health)	Reviews environmental impact assessment reports on national projects in order to identify health risks
Industry	Planner (Urban planning)	Leads on private and public transport urban planning projects such as main bus terminal
Public agency	Statistician (Land transport)	Updates and monitors data on land transport such as traffic incidents and deaths
International multilateral organization	Head of department (Sustainable development)	Reports on the advancement of sustainable development targets on the island including SDG 11
Public agency	Head of department (Traffic Planning)	In charge of deploying public transport strategies and involved in the new light-rail public transit system
Public agency at parastatal level	Technician (Sustainable economic development)	Works on establishing urban standard guidelines for economic development focusing on investments in transport, social housing and real estate projects
Public Agency at municipal level	Municipal agent (Town planning & services)	Works at municipal level on housing and transport initiatives and municipal policies
Industry	Executive and board director (Economic investments, Food services and Sustainable development)	Directs decisions for different companies focused on services and investments in the city of Port Louis
Resident	Journalist (urban development)	Critically analyses and reports on urban development projects across the island
Resident	Politician (Social & economic development)	Leads a stand-alone political party with expertise in sustainable economies
Resident	Social worker (Health and social justice)	Provides support and leads initiatives supporting the urban poor in the capital

Table 17: Stakeholder Profile

Methods for the survey

Sampling.

We conducted randomized sampling of 600 individuals residing in Port Louis (n =600). We considered an initial conservative sample of 384 participants to account for the key parameters surveyed and increased sample to 600 to account for statistical representation of population subgroups by gender, age group, and socio-economic status.

Survey

We used electronic mobile surveys to collect baseline data on demographics, PA and travel patterns (annex 3) from September to November 2019. PA data was collected using IPAQ (International Physical Activity Questionnaire) short questionnaire (Craig et al., 2003) that assesses the frequency (days) and duration (minutes/hours) of a person's activity over the preceding seven days, and group activity levels into vigorous-, moderate-, and low-intensity levels. Travel patterns were collected using one full week-day diary and all trips completed between wake-up and bed-time. Each trip was documented in terms of travel mode, duration and distance (annex 4).

Methods and data inputs for the quantitative HIA

We modelled all-cause mortality effects using (Alwan, 2011) three health indicators: AP, traffic deaths and PA, three future transport scenarios, survey travel data, survey PA data, existing AP data, existing traffic death data, and natural all-cause mortality rate for the adult population (18–65 years old). Exposure–response functions were derived from existing studies and calibrated for current exposure and health conditions in Port Louis. We used RR functions and PAF for PA and AP and calculated the change in mortality (Fig. 17).

Selecting health indicators

Three health indicators were selected from different factors stakeholders identified as linking health to transport (see Section 2.3). The list of factors was drafted and assembled from the IDIs and discussed during the FGDs. Three final health indicators were selected by both consensus and elimination (Table 18): PA, traffic deaths and AP.

Three future transport scenarios

We co-designed the scenarios based on shifts in transport modes that created a change in the challenges reported in the IDIs (see Section 2.3). The challenges were coded and extracted as follows: overuse of cars, road congestion, bad road infrastructure, bad urban transport planning, government over spending, no smoke emission control, no regulation about private vehicle purchase, no entry regulations in the city, lack of green space, no walkable areas, lack of traffic safety, no bus lanes, no cycle infrastructure, high car social pressure, no legal framework for more sustainable and energy-sensitive mobility, lack of parking spaces, bad pavement and side-walk conditions, lack of hygiene and bad public transport conditions. During the FGDs, the challenges were discussed and placed within the context of a mode-shift possible scenario.

Included or not	List of indicators	Reason for inclusion / exclusion
Included	Physical activity	Ability to collect data within given timeframe
Included	Traffic deaths and air pollution	Availability of data
Not included	Congestion, stress, noise, mental distress, vibration, hygiene	Unavailability of data
	Consumption patterns, nutrition, nature exposure	Complexity to collect data within given timeframe
	Temperature, traffic injuries	Stakeholders found the indicator less relevant
	Violence, road rage, access to public transport	Selected but there is no current methodology to consider them in quantitative HIA

Table 18: List of indicators and reasons for exclusion

The process for generating and validating the scenarios included (1) discussing hypothetical baseline modes shares (2) proposing changes in car mode share and predicting how this change may impact other mode shares, (3) discussing which mode share splits would most benefit experts, citizens or public officials. Additional suggestions such as the inclusion of motorcycles as a standalone mode in the scenarios was proposed by several informants and were validated by consensus during the FGDs.

In the worse-case scenario, current challenges are exacerbated; car trips are doubled (10% to 20%) as people shift from walking, public transport and motorcycle trips. The overuse of motorized vehicles causes congestion, puts more pressure on road infrastructure, generates more emissions, encourages vehicle purchase, increases traffic accidents and deaths, decreases walking patterns and discourages use of public transport.

In the good case scenario, current challenges are reduced, car trips are halved (10% to 5%) and people use more public transport, motorcycle and walking trips. Less cars on the road applies less pressure on infrastructure, decreases congestion, while increasing walking patterns and use of public transport. This scenario has the highest proportion of motorcycle trips (18% mode share).

In the ideal-case scenario, current challenges are addressed, with car trips practically eliminated (10% to 1%), motorcycle trips reduced and walking and public transport trips are increased. The decrease of both forms of private motorization (cars and motorcycles) relieves pressure on traffic congestion and infrastructure, significantly decreases emissions, increases traffic safety, increases the possibility of regulating vehicle and motorcycle purchase, increases walking patterns and encourages use of public transport.

In order to calculate the health impacts of a shift in transport mode, several assumptions were applied. We assumed mode shifts scenarios by percentage and in proportion to the business as usual scenario (BAU) established from the survey results. Stakeholders took the lead in proposing different proportions for the car mode share (20%, 5%, and 1%) (Table 19). To maintain consistency in modelling, consensus was achieved that percentage switches from other modes of transports (bus, motorcycle, walking) would remain constant for each transport mode and across different scenarios (40% shift to/from public transport, 20% shift to/from walking, 40% shift to/from motorcycle trips) (see annex 4). The percentages for the switching trips were agreed upon given the current Mauritian context. For example, 40% switch from car to public transport trips was realistic given the new metro light rail project established by the government. We considered that cycling and informal transport modes remained constant to the BAU scenario due to data constraint issues and limited consensus on how peoples' choice in adopting these two modes could evolve. When cars were replaced by motorcycles or public transportation, we assumed the average length of car trips would remain constant. When cars were replaced by walking trips, we assumed the average length of walking trips would remain constant. During the modelling the following variables were assumed to remain constant: BAU mode share, trip length, per capita trip rate. We assumed a fixed value to the average speed of modes of transport as proposed elsewhere (Goel et al., 2015) (annex 4).

Mode share (%)	Worse-case scenario 1	Good-case scenario 2	Ideal-case Scenario 3	BAU
Car	20%	5%	1%	10%
On foot	52%	55%	60%	54%
Public transport	10%	16%	23%	14%
Motorcycle	12%	18%	10%	16%
Cycle	1%	1%	1%	1%
Informal transport	5%	5%	5%	5%

Table 19: Mode share shifts and scenarios

Baseline PA ^a		Transport shift-related PA ^b	
Activity	METs*	Transport mode	METs
walking	3.3	walking	3.5
cycling	6.8	cycling	6.8
moderate activity	4.0	sitting in public transport	1.3
vigorous activity	8.0	car	1.3
		motorcycle	2.8
		sitting in public transport	1.3
		walking 10 minutes to public transport	3.5

*METs: *Metabolic Equivalent Task*; Sources a (266); b (267)

Table 20: METs attributed to activity and transport mode

Travel data

We extracted baseline travel patterns from 600 individual surveys and 514 travel diaries (see Table 19). The data covered 1520 trips per day. Each person completed an average of 3 trips per day. Walking was the most popular transport mode in the city. The mode share was walking (54%), motorcycle (16%), public transport (14%), car (10%), informal transport (5%) and cycling (1%). The average distance and time of different modes were as follows: walking (1.04 km, 12.6 min), public transport (10.29 km, 29.4 min), car (10.11 km, 2 min) and motorcycle (7.12 km, 17 min) (annex 4).

Physical activity data

We translated the survey participants' IPAQ physical activity data into a metabolic equivalent of tasks per week (MET/hr/week) based on the type of activity practiced (baseline) and mode of transport used (Table 4). The survey participants' PA data was assumed to represent the overall PA behaviour of the Port Louis adult population. For baseline PA, MET score were assigned per activity (Committee, 2005). These values were summed up to calculate the individual overall baseline PA MET/hr for a week. For transport shift-related PA, MET score were assigned per mode (Ainsworth et al., 2011). After assigning MET scores, we calculated the difference between baseline PA and PA lost or gained due to modal shift scenarios studied. We estimated reduced mortality risk by using a curvilinear ERF, applying a 0.25 power transformation to PA, and using the relative risk of 0.81 for 660 MET minutes (Woodcock et al., 2013). The median baseline PA was 3.85 (MET/hr/week) with the following IQR values [0.508; 3.85; 3.85; 10.20; 36.13] (MET-hr/week) (see Table 20).

Air pollution data

We considered particulate matter with a diameter of $\leq 2.5 \mu\text{m}$ (PM_{2.5}) as an indicator of AP and proxy for exposure to all fossil fuel combustion sources. We only modelled the exposure to PM_{2.5} emissions; all other emissions were assumed to be constant. We used the background PM_{2.5} annual mean of 14.95 (microgram/m³) extracted from the WHO database for Port Louis for 2015 (Organization, 2016).

Local data was available but not considered because the monitoring station for Port Louis is located on the top of a mountain surrounded by green space and does not provide valid measures for road-level exposure. The background level of PM 2.5 was calibrated to different microenvironments (background, sleep and rest in addition to micro- environments of each transport mode) using set ratios (De Nazelle et al., 2011) and was adapted for ventilation rates of each transport activity type (Buekers et al., 2015) (see annex 4). We used a linear ERF with a relative risk (RR) of 1.09 (1.04–1.09) per 10 µg/m³ increment of PM_{2.5} to quantify the association between PM_{2.5} and mortality (Organization, 2014; Kahlmeier et al., 2017).

	Worse-case scenario		Good- case scenario		Ideal-case scenario	
	Annual premature deaths*	(95% CI)	Annual premature deaths*	(95% CI)	Annual premature deaths*	(95% CI)
Air pollution (PM _{2.5})	-4.06	(-5.08, -2.63)	0.98	(1.26, -2.63)	-2.65	(-3.40, -1.52)
Road traffic fatalities	0.00		1.52		-0.66	
Physical activity	7.34	(5.54, 9.84)	-1.71	(0.29, -2.32)	-10.41	(-7.69, -22.98)
Total	3.28	(-0.09, 5.98)	0.79	(3.76, 0.36)	-13.72	(-4, -21)
Annual economic estimates (USD)	6 million		1 million		- 23 million	

* *negative value: reduction in premature deaths*

Table 21: Health Impact Outcomes

Traffic death data

To estimate the reduction in fatalities, the fatality rate for alternative scenarios was assumed to be the average of traffic fatality values over six years (2013–2018) adjusted to the risk per billion km travelled for each mode of transport (National Transport Authority, 2017). The data was retrieved from official government reports and police stations with jurisdiction over the North and South of Port Louis. We calculated new risk ratios based on the shift between transport modes, using the average value and given difference in the kilometres travelled by mode for each scenario (Watkiss et al., 2000). We assumed that the proportion by age group remained constant. Traffic fatality impact was quantified on the basis of kilometres covered per mode and did not account for other risk reductions due to infrastructure improvement. No traffic fatalities were reported for public transport (annex 4).

Mortality rate

We estimated the health impacts for natural all-cause mortality for residents of Port Louis aged between 18 and 64 years old (n =77'271) (Mauritius and Digest of Demographic, 2017). We assumed that this age group conducts most trips for work or study based on studies elsewhere (Rojas-Rueda et al., 2011) and also corresponded to the same age group as the survey respondents. The 2017 natural all-cause mortality rate after excluding external causes of death was 1031/100'000persons.

Data Analysis and sensitivity

Qualitative results from the interviews and focus groups were analysed using Atlas.ti 8. Quantitative modelling and results were analysed using Microsoft Excel 16.16.21 (2018) and R Studio 1.1.463. Confidence intervals for PA and AP were calculated by modifying the RR value (annex 4). We also conducted a sensitivity analysis on the input measures for PA and background AP (annex 4). Self-reported PA has been reported to underestimate the prevalence of PA because of the different interpretations of questions and recall difficulty. Therefore, we conducted sensitivity analysis by changing the average value of light Pain Mauritius (79%) by the average value of light PA in Malaysia (89.31%), a country with comparable urbanization rates, HDI and GDP (Poh et al., 2010). For background AP we used the average between the current measure (14 ug/m³) and the reported road-traffic level data officially reported on the outskirts of Port Louis during a 3-month monitoring exercise in 2011 (67 µg/m³) (Organization, 2016). We used the Value of Statistical Life (VSL) approach to estimate the economic value of deaths. Due to the lack reliable individual data, we used a population-average VSL for Mauritius using a base U.S. VSL calculated using U.S labour market estimates and adjusting VSL for differences in income elasticity from Mauritius (1.08) (Viscusi and Masterman, 2017).

7.3 Results

Results show health gains in the ideal-case scenario and health losses in both the worse- and good- case scenario (Table 19).

In the worse-case scenario, a doubling of car trips and a reduction in walking, motorcycle, and public transport trips resulted in a total increment of 3.28 premature deaths per year [95% confidence interval (CI) 0.09, 5.98]. We estimated an increment of 7.34 premature deaths per year [5.54, 9.84] due to decrease in physical activity. Air pollution exposure led to a reduction in 4.06 premature deaths [5.08, 2.63], with no additional changes in estimated premature deaths related to traffic fatalities.

In the good-case scenario, reducing car trips by half and increasing walking, motorcycle, and public transport trips resulted in a total increment of 0.79 additional premature deaths [3.76, 0.36]. We estimated a reduction of 1.71 premature deaths per year due to additional physical activity [0.29, -2.32].

Air pollution exposure led to an increment of 0.98 premature deaths [1.26, -2.63] and traffic fatality led to an increment of 1.52 premature deaths.

In the ideal case-scenario, a reduction in car and motorcycle trips and an increase in walking and public transport trips resulted in a total reduction of 13.72 premature deaths [-4, -21]. In this scenario, increase in physical activity led to a reduction of 10.41 premature deaths [-7.69, -22.98], decreased exposure to AP to a reduction of 2.65 premature deaths [-3.40, -1.52], and traffic fatality led to a reduction of 0.66 premature deaths.

The economic value associated to premature deaths was estimated to a societal economic impact of USD 6 million annually in the worst- case scenario and USD 1 million for the good-case scenario. In the ideal- case scenario, the economic value estimated due to the reduction of premature deaths resulted in USD 23 million reductions in terms of economic impact.

7.4 Discussion

This study supports current evidence that the flexibility and scientific validity afforded in quantitative HIAs are crucial to estimate health risks that can inform policy-making in LMICs (Benaïssa et al., 2016; Chilaka and Ndioho, 2015; Burke and Ambasa-Shisanya, 2014). The lack of data in Africa hampers the generation of long-term robust environmental and epidemiological measurements for transport-related risk assessments. Yet, HIAs provide methodological flexibility with a risk assessment approach that can be contextually adapted and applied in places like Mauritius where there are weaker epidemiological surveillance systems. Particularly, our study reflects well the value of participatory approaches in quantitative modelling. Three crucial components of the proposed model were brought forth by local stakeholders: the integration of motorcycles in the scenarios the creation of scenarios based on context-sensitive realities and the type of policies needed to address current challenges.

Our results show that in order to obtain health benefits, strong action and policies are needed to decrease at least these two forms of motorization: an extreme reduction of car trips from 10% to 1% and motorcycle trips from 16% to 10%. This ideal case scenario would lead to a combination of increase in physical activity decrease in traffic fatality and decrease in air pollution exposure. A similar combination of exposures leading to health benefits were reported in HIAs of transport mode shifts in São Paulo (Brazil) and Barcelona (Spain) (de Sá et al., 2017; Mueller et al., 2017). While it is hard to imagine a city without cars (or with 1% car mode share), the advent of Covid-19 has shown us that extreme motorization can become a reality (even if policies may apply only temporarily depending on settings). Several cities including Ghent, Hamburg, Helsinki, Madrid, Bogota, Brussels, Chengdu, Copenhagen, Dublin, Hyderabad, and Milan are however, showing that partially or drastically reducing motorization is possible on a long-term basis by implementing car free days, investing in cycling infrastructure and pedestrianization, restricting parking spaces and considerable increases in public transport provision (Nieuwenhuijsen and Khreis, 2016).

The application of such measures may be facilitated given the smaller size of Port Louis (42 km²) yet may be hindered by the complexities of a developing African city. For instance, the health risks caused by increased motorcycle use and ownership in developing countries like Mauritius are worth discussing (Adeloye et al., 2016; Jones et al., 2016). Scarce evidence indicates that motorcycle accidents in northern Ghana account for 4% of all crashes per year but related mortality is not provided (Kudebong et al., 2011). In Mauritius, motorcycles account for 38.5% of road accidents, ten-fold the northern Ghanaian value.

In Port Louis, motorcycles account for 43% of traffic-related deaths versus 20% for car users (see annex 4). This may be the reason why more cars (worse-case scenario) did not increase the risk for traffic fatality. Both motorcycles and cars are passive modes of travel, therefore not the best choices for maintaining healthy physical activity levels. This explains why fewer cars coupled with more motorcycles (good-case scenario) did not result in reducing overall premature mortality even if physical activity benefits are achieved. Therefore, 'weaker' forms of policies aiming for the reduction of cars only may not be adequate or sufficient for contexts similar to Port Louis. It is highly probable that car users will shift to motorcycles which is a scenario that should be avoided at all cost (this will significantly increase their exposure to air pollution and they will face higher risk of traffic fatality). It is also crucial to avoid motorcycle users to shift to cars which are an increasing trend in developing countries due to large investments in road infrastructure such as highways.

HIAs from high income countries (HICs) show that replacing car trips by walking, public transport and cycling trips (i.e. active travel modes) can increase health benefits (De Nazelle et al., 2011; Mueller et al., 2015; Rojas-Rueda et al., 2016b; Lindsay et al., 2011; Götschi et al., 2015). Like in other African cities (Rwebangira, 2001), safe cycling is not a current option in Port Louis. However, 36% of motorcyclists and 20% of car users cover 5 kms or less per trip, which are distances that could be covered on foot. Motorcyclists would maintain physical activity while being less exposed to air pollution (lower ventilation rates as pedestrians). Car users would increase physical activity. Yet, walking mode share is already high (54%), with increased traffic fatality rate (331 fatalities/billion kms). Walking distances are short (12:45 min compared to 33 min in Switzerland for instance (Götschi et al., 2015), therefore the levels of PA achievable on foot is limited. Therefore, a strong policy aiming at reducing both cars and motorcycles may be effective by targeting the 64% of motorcyclists and 80% of car users covering more than 5kms to use public transport or electric bicycles if safe cycling infrastructure is provided.

The importance of scaling up

Our study shows that even on a small sample ($n = 77'271$), urban transport planning affects mortality. The bulk of urban population growth in the near future will not occur in big cities (Nations U, 2014). In LMICs particularly, more than half of urban populations live in settlements with fewer than 500'000 residents (Rojas-Rueda et al., 2011). However, scaling up studies similar to ours is important because many cities do not yet exist.

Two-thirds of the investments in urban infrastructure to 2050 have yet to be made in African cities and towns (Migration IO for. World migration report, 2015). In African cities with over 15 million people such as Cairo, Lagos, and Kinshasa, the levels of air pollution, physical activity and road traffic accidents are likely to be very different, causing higher mortality and morbidity.

In line with previous studies (Rojas-Rueda et al., 2011, 2016b), we found that physical activity in Port Louis is the most important driver of health impacts (Table 1) and is the most efficient way to increasing transport-related health benefits.

The reverse correlation between urbanization and physical activity (Guthold et al., 2008) is bound to be a challenge given the annual urban population growth rate in Africa is and will continue to be, the highest in the world for at least the next two decades (Schwela, 2012). In HICs, more physical activity in urban settings can be achieved by active travel (walking and cycling) (De Nazelle et al., 2011; Woodcock et al., 2013; Rojas-Rueda et al., 2011; Macmillan et al., 2014; Xia et al., 2015). Much of current Africa's urbanization has been rapid and unplanned, making it difficult to change the way infrastructure has already been laid out (ex: integrating cycle lanes). In India, the introduction of a Bus Rapid Transit (BRT) increased walkers and cyclists in urban corridors, saving up to 14 lives per year (Mahendra and Rajagopalan, 2015). This suggests that in developing settings, large public transport projects rather than stand-alone infrastructural changes, may be more efficient for increasing active travel and benefitting LMIC urbanites who are often the most socio-economically deprived (walkers and cyclists).

The health impacts of air pollution in our study were modelled using ambient emission data because no data exists at road-traffic level. This may have caused underestimation of mortality outcomes related to transport in Port Louis. Scaling quantitative HIA may be challenging given the lack of viable data on air pollution in many African countries (Laid et al., 2006). So far, existing air quality information shows that if and when data is available, it exists in an unsystematic form and at different degrees of quality, depth and completeness (Schwela, 2012). Currently Mauritius and no other African country restrict the use of cars based on emission standards. Twenty-five African countries including Mauritius, however, impose age restriction on imported vehicles. These policies encourage the purchase of vehicles emitting lower emissions, but do not decrease motor-vehicle use as a general rule. Such policies disregard scientific findings that increasing active travel and decreasing general motor-vehicle use has higher health benefits than increasing the use of motor-vehicles with lower emissions (Woodcock et al., 2009).

Our study estimates the economic value of averted deaths in the ideal scenario (60% increase in public transport trips and extreme decrease in private motorization) to 23 million USD. This corresponds to 20% of the total amount (119.6 million USD) spent by the Mauritian government every year on road accidents and traffic congestion (Ministry of Public Infrastructure and Land Transport, 2017). It is estimated that road traffic crashes in LMICs cost between 65 and 100 billion USD per year, more than the total annual amount received in development aid (Kudebong et al., 2011).

In SSA countries, the economic burden of road traffic deaths and injuries can account for 1–3% of the Gross National Product (GNP).

Our study highlights that in economic terms, health impacts provide an opportunity for savings in LMICs where a motor vehicle is over a hundred times more likely to be involved in a fatal crash than in HICs (Haq and Schwela, 2012).

Strengths and limitations

This is the first participatory quantitative HIA of urban transport planning in Africa. It contributes to the few participatory quantitative HIAs in the world (Chang-Hong et al., 2009; Benaissa et al., 2016; Nieuwenhuijsen et al., 2016) and confirms that even conservative measures of health impacts can reduce transport-related mortality in LMICs (Conti and Mahendra, 2014). Quantitative HIAs of transport have previously assessed modal shift impacts through physical activity, air pollution and traffic deaths (de Sá et al., 2017; Mueller et al., 2017; Woodcock et al., 2009), but none employed participatory approaches. Indeed, despite consensus on the need for participation in HIA (European Centre for Health Policy WHO, 1999; Jones et al., 2014; Tamburrini et al., 2011), participatory approaches in HIA remains an exception rather than rule (Iroz-Elardo and McSharry, 2016) particularly in quantitative models (Nieuwenhuijsen et al., 2017; Veerman et al., 2005).

We estimated health impacts on a small scale ($n = 77,271$), but the scientific approach is robust and supported by high quality data collected in the local context. The validity of the input data for quantitative modelling is based on data triangulation from a survey ($n = 600$), national government emission reports (Mauritius and Digest of Demographic, 2017) and police records. We used traffic fatality data from 6 different years to avoid single year trends. By conducting primary data collection, we have limited exposure-outcome mis-classification by using exposure, health and population data from the same time span (2017–2018). Although the scenarios were hypothetical, they were built based on direct feedback from local stakeholders to provide more realistic projections. We conducted a sensitivity analysis to address uncertainties related to PA and background AP data (see Section 3.5). We did not identify significant variations in sensitivity analysis results (see annex 4).

HIA estimates must be interpreted with care given the multiple assumptions and uncertainties entailed in quantitative modelling. There is systematic evidence on causal inferences relating the three exposure factors (PA, AP, traffic fatality) to all-natural cause mortality (Watkiss et al., 2000; Prabhu and Pai, 2012; Organization, 2006; Kahlmeier et al., 2011). However, none of them were based on studies conducted in LMICs or tropical zones. The application of risk assessment methodology adds uncertainties due to the extrapolation of risk estimates to other settings. It also disregards the challenge that actual ERF may vary across populations. Although we used risk estimates established on valid epidemiological evidence, it should be noted that such estimates were not estimated based on Mauritian populations.

Similarly, PAF values indicating the proportion of disease preventable due the variation in a specific factor must be interpreted cautiously. The main assumptions in estimating PAF imply that the risk factors should be independent from other factors that influence disease and death- meaning that there should be a causal relationship between factor and outcome (death or disease). In this study, we examine motorized traffic as one common source of exposure for the three risk factors.

This makes it difficult to ensure that the effects of the risk factors are independent and that we have not double-counted the deaths estimated by each environmental exposure.

7.5 Conclusion and Recommendations

This study reported a full-chain participatory quantitative HIA model estimating the health and economic value of transport mode shift in an African capital, Port Louis (Mauritius). Participatory approaches were crucial to involve stakeholders and design a context-specific HIA model adapted to local needs. This study estimated that 13.72 premature deaths, representing an economic benefit of 23 million USD, would be averted if the ideal-case scenario is implemented in the city. This scenario involved a mode shift reduction for cars (10% to 1%) and motorcycles (16% to 12%) and a mode shift increase for walking (54% to 60%) and public transport (14% to 23%).

Building on our findings and previous LMIC-based studies (40,96,104), we propose the following policy recommendation for urban transport planning policies for Port Louis and cities with similar features. Urban transport must be tackled as an opportunity to encourage physical activity in rapidly urbanizing settings of Africa. Transport policies should aim to restrict all forms of private motorized vehicles and promote active and public transport to support public health. This can be done with policies including specific restrictions for motorcycle traffic. Policies promoting the benefits of physical activity should be accompanied by interventions to increase pedestrian and cyclists' safety. Policies to increase public transport use should provide incentive for users of private motorized modes.

More environmental health studies are needed to encourage the estimation and mitigation of health risks in rapidly urbanizing developing countries (Nieuwenhuijsen, 2020). We recommend that morbidity impacts be considered especially in terms of cardiovascular diseases which are on the rise in Africa. And if data availability permits, further analysis should be stratified by population groups, particularly for vulnerable populations suffering from transport-related inequities and urban poverty. We highly recommend the use of participatory approaches in quantitative HIA to ensure context specificity. Further research is needed to assess to what extent stakeholder engagement in HIA models lead to evidence-based policy and protection of human and environmental health.

Author Contributions

The individual contributions of each authors are as follows: conceptualization, M.T., N.M., D.R.-R., J.G., D.H.d.V., and M.J.N.; methodology, M.T., N.M. and D.R.-R.; software, M.T.; validation, M.T., N.M., D.R.-R., J.G., D.H.d.V., and M.J.N.; formal analysis, M.T.; investigation, M.T.; resources, M.T.; data curation, M.T., N.M., and D.R.R.; writing—original draft preparation, M.T.; writing—review and editing, M.T., N.M., D.R.-R., J.G., D.H.d.V., and M.J.N.; visualization, M.T., N.M., D.R.-R., J.G., D.H.d.V., and M.J.N.; supervision, D.R.-R., J.G., D.H.d.V., and M.J.N.; project administration, N.A.; funding acquisition, N.A.

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Credit authorship contribution statement

M. Thondoo: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - original draft, Writing - review & editing, Visualization. N. Mueller: Conceptualization, Methodology, Validation, Data curation, Writing - review & editing, Visualization. D. Rojas-Rueda: Conceptualization, Methodology, Validation, Data curation, Writing - review & editing, Visualization, Supervision. D. de Vries: Writing - review & editing, Visualization, Supervision. J. Gupta: Conceptualization, Validation, Writing - review & editing, Visualization, Supervision. M.J. Nieuwenhuijsen: Conceptualization, Validation, Writing - review & editing, Visualization, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Annex 1: Individual interviews topic guide; Annex 2: Protocols for FGDs; Annex 3: Survey Questionnaire; Annex 4: HIA Input Data. Supplementary data to this article can be found online at <https://doi.org/10.1016/j.envint.2020.106027>.

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HIA Annex 1

Id of the participant:

Date of the interview:

Duration of the interview:

Name of the interviewer:

Name of the interviewee:

Date of birth:

Telephone:

Email:

Home address:

Stakeholder group	Expertise (information held)	Role in HIA	Interest or concerns about HIA	Power to influence policy/development	Opportunities to communicate (when, where)

Stakeholder Topic Guide Questions

BACKGROUND

- Describe the role of your group/institution/employer concerning urban & transport planning
- Are you active, involved in projects, measure – what are your responsibilities?
- With whom do you cooperate (Traffic, Transport, Mobility sector, Health sector)?

TOPIC 1: HEALTH MEANING

- What do you think makes you healthy in the city?
- How do you manage your health while in the city?
- Do you think that UTP is related to health -if yes, how?
- Do you think there are needs in terms of health to support transport/urban decision making?
- If yes, how can health can be used to support urban/transport decision making?

TOPIC 2: U&T POLICIES

- Can you describe 2 major U&T policies you are familiar with? (current legislation)
 - Involvement of interviewee
 - Involvement of group/institution/employer
- How do you think these policies may impact (+/-) on health in the city?
 - Policies- promoting health?
 - Do you think health was considered when shaping such policies?
 - Which importance had the arguments related to “health”?
 - How were they implemented?
- About the policy itself
 - Name of the measure
 - Which measure?
 - Where? When? (time frame: short, medium, long term)
 - What is/was the aim? Which results are/were expected?
 - Did the results happen? Has the measure been evaluated?

- Who (person or institution) had the idea to implement this measure? Who was involved (persons, city, district, public participation)? Who was mainly responsible for the project? Responsibilities?
- How did they finance the project? What lessons have been learnt? Have there been any supporting factors or barriers?
- Do you have any data available about this measure (e.g. counts of cyclists, pedestrians, accident data, etc.)? Could you provide any documents?

TOPIC 3: HIA

- Do you know about Health Impact Assessments?
 - Yes: Have you ever used it (or other experiences)?^[11]_[SEP]
 - No: Can you imagine using it? For which purpose?
- To what extent do you think HIA outcomes will be taken seriously in decision-making?
- How do you think HIA can support sustainable development?

TOPIC 4: VISION & WISHES

1. What is your idea of a healthy and sustainable UTP system in PL?
2. What is needed to achieve that? (which measures to be implemented to promote)
3. What is feasible? What framework conditions would that require?
4. Why have good ideas and measures failed so far? ^[11]_[SEP]
5. What is missing in the current situation? (is there overuse of motor-vehicles, over-isolation from car-use, no consciousness about pollution, like or dislike)
6. What would make your personal behavior change to more healthy or sustainable actions?
7. How could sectors/groups/departments cooperate better?
8. How should it happen?

HIA Annex 2

Protocol for Exchange Panels on HIA (FGDs)

Duration: 1.5hrs max

Total number: 2 panels

Number of people: 3-5 maximum at a time

Session 1: Thurs 20th of September at 16:00 at La Turbine (Moka)

Session 2: Monday 24th of September at 15:30 at UNDP (Port Louis)

Prerequisite for engagement: IDI completed

Aim of Panels:

1. Stakeholders are invited to:
2. share their individual stories and express their needs and priorities (10%).
3. share their opinions about the 3 proposed scenarios of a healthy and sustainable UTP system (10%)

4. discuss if, where and how their individual visions differ and clash with the 3 scenarios (60%)
5. discuss if they can reach similar endpoints (10%)

Rephrase aim into Questions:

Rephrase all of these in terms of questions you want to know. It will be easier to communicate to them.

Structure of the Panels:

1. Introduction of each stakeholder to one another
2. Describe how their expertise is related to Health or UTP
3. Overview of the 3 scenarios emerging from IDIs

The added value of the panels:

The major value of this process is to contrast perspectives and opinions between stakeholders. In addition, the result also assesses the dynamics of contact between experts, public officials, and citizens. In this sense, HIA is not only about influencing decisions, it is also about providing contextual info and links between different sectors.

HIA Annex3

The survey can be found at <https://doi.org/10.17632/p6xkw92rfw.1>

HIA Annex 4

Input Data

Population Port Louis city (2017)	119,018
Population 18-64	77271
Natural all-cause Mortality rate /100 000	1032
Total trips	228506
Average trips	3

Transport data input	Average distance traveled (km)	Average speed traveled (km/h)	Average time traveled (h)	Transport data input
Walking	1.037806769	5	0.207561354	Walking
Bicycle	4.125416667	15	0.275027778	Bicycle
Motocycle	7.125264831	25	0.285010593	Motocycle
Public transport	10.28615785	21	0.489817041	Public transport
Car	10.11192021	22	0.459632737	Car
Walking due to PT	0.83	5	0.166	Walking due to PT
Total number of trips	1520.00			Total number of trips
Number of people	514			Number of people
Number of trips/ day	3			Number of trips/ day
Days traveled/ week	5			Days traveled/ week
Days traveled/ year (52.14 weeks)	261			Days traveled/ year (52.14 weeks)

Physical activity	Average METs/ mode	Average MET/h/ trip
Car	1.30	0.5975
Public transport	1.30	0.6368
Walking	3.50	0.7265
Bicycle	6.80	1.8702
Walking to bus	3.50	0.5810
Motorcycle	2.80	0.7980

Baseline PA Input	Baseline PA Sensitivity Analysis
MET/h/week	MET/h/week
	5.0000
	30.0000
	50.0000
	10.19939394
	36.13003923

Air pollution			
PM2.5 concentration in each micro-environment	PM2.5	Ratios	
Background		14.95	1.00
Sleep		14.95	1.00
Rest		14.95	1.00
Walking		39.90	1.90
Bicycle		42.00	2.00
Motorcycle		42.00	2.00
Public transport		39.90	1.90
Car		52.50	2.50
Informal transit		52.50	2.50
Minute ventilation m3/h	PM2.5		
Sleep		0.27	
Rest		0.61	
Car		0.61	
Public transport		0.61	
Walking		1.14	
Bicycle		2.22	

Air pollution Sensitivity Analysis

PM2.5 concentration	PM2.5	Ratios
Background	40.98	1.00
Sleep	40.98	1.00
Rest	40.98	1.00
Walking	9.50	1.90
Bicycle	10.00	2.00
Motorcycle	10.00	2.00
Public transport	9.50	1.90
Car	12.50	2.50
Informal transit	12.50	2.50
Minute ventilation m3/h	PM2.5	
Sleep	0.27	
Rest	0.61	
Walking	1.14	
Motorcycle	2.22	
Public transport	0.61	
Car	0.61	

Traffic fatalities

Year	Car	Motorcycle	Bicycle	Walking	Other	Unknown	Total
2012	7	17	0	16			40
2013	12	7	3	9			31
2014	3	10	1	11			25
2015	2	11	1	15			29
2016	1	18	2	9			30
2017	3	11	4	9			27
2018	11	14	1	3			29
Average deaths per mode of transport per year	7	15	2	12	0	0	35

Scenarios

	On foot	Cycle	Motorbike	Bus	Private car	Informal	SUMS
BAU							
Share (%)	54%	1%	16%	14%	10%	5%	
Number of trips	123393.2	2285.059	36560.95777	31990.8	22850.59	11425.299	228506
Persons traveling	325	86		3805	86	3	
	41131	762	12187	10664	7617	3808	77271
Scenario 1 - Worst case							
Share (%)	52%	1%	12%	10%	20%	5%	
Number of trips	118823.1	2285.059	27420.71832	22850.5	45701.19	11425.299	228506
Persons traveling	127	86		986	721	3	
	39607.70	761.6866	9140.239442	7616.86	15233.73	3808.4331	77271
Difference in persons traveling	425	201		6201	24	01	
	-1523	0	-3047	-3047	7617	0	
Scenario 2 - Good Case							
Share (%)	55%	1%	18%	16%	5%	5%	
Number of trips	125678.2	2285.059	41131.07749	36560.9	11425.29	11425.299	228506
Persons traveling	923	86		5777	93	3	
	41892.76	761.6866	13710.35916	12186.9	3808.433	3808.4331	77271
Difference in persons traveling	411	201		8592	101	01	
	762	0	1523	1523	-3808	0	
Scenario 3 - Ideal Case							
Share (%)	60%	1%	10%	23%	1%	5%	
Number of trips	137103.5	2285.059	22850.5986	52556.3	2285.059	11425.299	228506
Persons traveling	916	86		7679	86	3	
	45701.19	761.6866	7616.866201	17518.7	761.6866	3808.4331	77271
Difference in persons traveling	721	201		9226	201	01	
	4570	0	-4570	6855	-6855	0	

Traveler switch	Bus to car	Walk to car	Moto to car	Car to bus	Car to walk	Car to moto
Scenario 1	-3047	-1523	-3047			
Scenario 2				1523	762	1523
Scenario 3				6855	4570	-4570

Mode shift Assumptions

TRANSPORTATION SCENARIOS	Description	Assumption 1	Assumption 2	Assumption 3	Assumption 4	Assumption 5

A	Worst case scenario	2x car trips	40% of trips from PT trips	20% from walk trips	40% from motorcycle trips	0% from cycling	0% from informal transport
B	Good case scenario	0.5 car trips	40% of trips go to PT trips	20% go to walk trips	40% go to motorcycle trips	0% go to cycling	0% from informal transport
C	Ideal case scenario	0.01 car trips	40% of trips go to PT trips	20% go to walk trips	40% go to motorcycle trips	0% go to cycling	0% from informal transport

Chapter 8: FRAMEWORK FOR PQHIA IN LMICs

8. FRAMEWORK FOR PQHIA IN LMICs

Conducting Health Impact Assessments (HIA) is a growing practice in various organisations and countries, yet scholarly interest in HIA has primarily focused on the synergies between exposures and health outcomes. This limits our understanding of what factors influence HIAs and the uptake of their outcomes. This chapter presents a framework for conducting Participatory Quantitative HIA (PQHIA) in low- and middle-income countries (LMICs), including integrating the outcomes back into society after an HIA is conducted. The chapter examines the question: What are the different components of a participatory quantitative model that can influence HIA implementation in LMICs? The chapter identifies key factors influencing PQHIA practice and uptake of HIA outcomes. It concludes that the integration of HIA in LMICs can be facilitated by investing in opportunities that fuel good governance and evidence-based policy-making.

Keywords:

Health Impact Assessment, participatory approaches, evidence-base policy making, developing countries, governance

8.1 Introduction

Health impact assessments (HIAs) aim to enable policymakers and other stakeholders to assess the impacts of their decisions primarily before but also after enforcing policies, projects or programs. HIA is defined as a mixed-method process to systematically judge the potential effects that a proposed intervention might have on health and the distribution of those health effects within a population [1]. HIAs are more likely to influence decision-making when the process encourages participation of decision-makers [2], local communities [3,4] and vulnerable groups [5]. There has been a growing interest in using participatory approaches in impact assessments for improving health in local communities and cities. The use of participation in health care policy was underlined in the 1978 Alma-Ata Declaration IV of the World Health Organization (WHO) [6]: ‘The people have the right and the duty to participate individually and collectively in the planning and implementation of their health care’. However, participatory HIAs are still more an exception rather than a rule [7], even in countries with more experience in HIA practice, such as Australia [8,9], Italy [10], the USA [7] and the Netherlands [11].

There is consensus that participation needs to be inherent to the HIA process [1,9,12], even though it has both benefits and challenges [13,14]. Participatory HIAs can contribute to scoping and prioritizing impacts, ensuring the objectivity and suitability of findings, and reducing costs triggered by potential public objections, providing an opportunity to value local knowledge, and improving relations between local communities and agencies [15–17]. Additionally, participation is generally more necessary in moderately and unstructured problems where there is less consensus on

science and values [18]. Participatory processes move the costs of addressing trade-offs to the ex-ante stage rather than the ex-post stage.

Participatory methods can be applied in both qualitative and quantitative HIAs. Participation is more commonly applied in qualitative HIAs [19]. Few quantitative HIAs are participatory [20], even though quantitative HIAs are primarily designed to provide estimates that stakeholders can use for evidence-based policy making [21,22]. Hereafter, we refer to such HIAs as participatory quantitative HIAs (PQHIA). In addition to the lack of PQHIAs, very little is known on ‘how’ participatory HIAs are currently conducted [15] and what resources are needed to do so. Few studies focus on the costs of participation, what is counted, who pays, and whether projects adequately budget for participation [23].

This study aims to fill these gaps by focusing specifically on participation in quantitative HIAs, in the sector of urban transport planning and in the context of low- and middle-income countries (LMICs). It builds on previous work addressing the lack of participatory quantitative HIA models to assess the overall burden of mortality and morbidity related to urban transport planning and the implication of HIA practice for stakeholders to establish policies in favor of healthy and environmentally sustainable cities [19,20,24–26]. It addresses the research question: what are the different components of a participatory quantitative model and how can these influence HIA implementation? Two sub-questions are addressed: (1) what resources are needed to conduct PQHIA in an LMIC setting? (2) What factors are likely to influence PQHIAs and the uptake of their outcomes? Our starting point is that PQHIA can be applied to different urban contexts to assess the health consequences of different environmental and lifestyle determinants within policy scenarios. Our PQHIA framework was developed based on fieldwork in Mauritius and then discussed for applicability in cities of LMICs.

We use the terms ‘participatory approaches’, ‘participation’ and ‘stakeholder engagement’ interchangeably. Such interactions can go from one-way collaboration in decision-making to empowered action triggered by individuals, informal groups or within formal partnerships [2]. This definition is wider than ‘citizen participation’ [27]. WHO states that: ‘participatory HIA consists of the ‘identification of a large number of relevant people, groups and organizations [...] and the implication of stakeholders in a meaningful way, allowing their messages to be heard’ [28]. We operationalize this definition by considering (1) stakeholders as laypersons, health practitioners and policymakers most likely to use HIA in their fields, (2) sampling of participants based on their ability to act on HIA outcomes and (3) organizing recurrent meetings between the researcher and the stakeholders (see section 2.1).

8.2 Methods

To build the framework, we used an existing PQHIA fieldwork model (see Figure 1) as a baseline and tested it in a HIA case study (Annex A) on urban transport planning in Port Louis in Mauritius [24]. We have modified the model based on data extracted

from ethnographic fieldnotes, individual interviews (IDIs), focus group discussions (FGDs) and feedback exercises with 14 stakeholders. We followed qualitative thematic analysis methods to analyze the data and structure study findings [29]. We confirmed the validity of the ethnographic data using five quality criteria: credibility, transferability, dependability, confirmability, and authenticity. All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the National Ethics Committee of the Ministry of Health and Quality of Life in Mauritius (project protocol MHC/CT/NETH/THONM) and by the Ethical Advisory Board of the Amsterdam Institute for Social Science Research (AISSR).

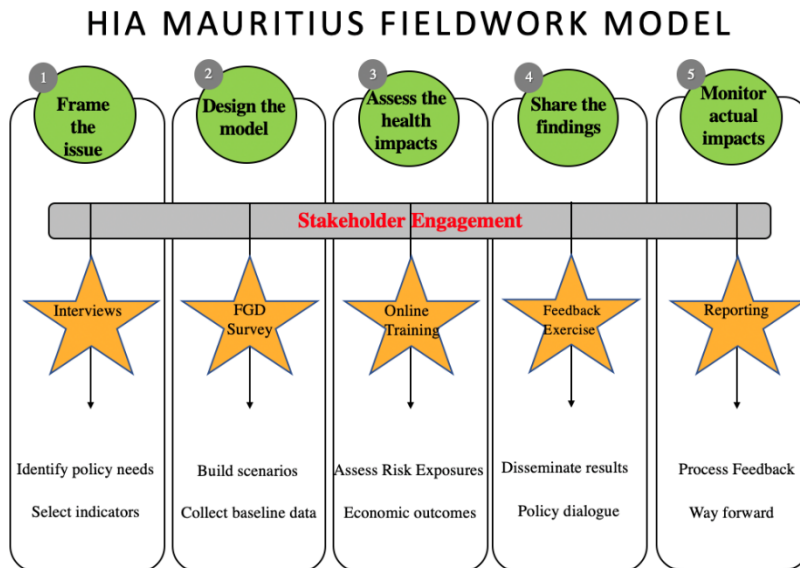


Figure 1. Baseline case-study fieldwork model

Case Study

Mauritius is a small island developing state (SID) with the highest population density in Africa [30]. Exposure to adverse health risks is rising with high rates of motorization and increasing levels of air pollution. In Port Louis, transport planning is reactive to the autonomous changes including population and spatial growth, with heterogeneous vehicles using limited and non-adapted road infrastructure. The central business district is car-oriented with very little green space and pedestrian movement limited to unsafe sidewalks.

The first author conducted an HIA aimed to estimate the health impacts of shifting transport modes by designing a PQHIA. This idea was proposed by the first author to different local stakeholders during previous research in 2016, which focused on the impact of urban and transport planning on citizens and their needs in Port Louis [25]. This HIA had, in addition to being policy relevant, a scholarly intention aiming at piloting a feasible model accounting for restricted resources and limited data. The quantitative component of the HIA consisted of estimating averted deaths per year and the economic value of health loss by assessing the health determinants of air pollution, traffic deaths, and physical activity for the adult population in Port Louis. The methods for the quantitative process have been published elsewhere [24]. The qualitative component of the HIA consisted of participatory methods to scope context, select health indicators, co-design HIA scenarios which are used as projections for the quantitative assessment, report results, and obtain feedback, as described below.

Sampling and Participant Profiles

The study participants ($n = 14$) were recruited using purposive and snowball sampling. The sample consisted of stakeholders including laypersons, health practitioners and policymakers from different communities (see Table 1). We settled on the sample of 14 individuals based on their interest in HIA, their commitment to participate in the iterative process, and positions to potentially act on the outcomes of the HIA, as it is commonly practiced in qualitative methods for HIA [31] and also reported elsewhere [32]. The purpose of the sampling was not aimed primarily at representation, or at meeting the WHO requirement of a “large” number of stakeholders, but nonetheless special care was applied to ensure balance across communities of interest. An initial contact list was drafted with leaders and head of projects in both public and private sectors and involved in implementing different urban transport interventions and policies. Additional stakeholders were added based on recommendation from initial contacts. The government officials were chosen based on their affiliation to ministries of health or transport planning and following their availability. The citizens were contacted following events (during the sampling period) where they publicly expressed (in radio interviews or in newspaper articles) their concerns on the effects of urban transport planning on citizens. The same individuals participated in the interviews ($n = 14$), FGDs ($n = 2$) and feedback exercises ($n = 6$). All activities were conducted using semi-structured topic guides (see Annex A).

Communities of Interest	Expertise (Information Held)	Reason to for Inclusion
Community-based organization	Expert (Ecosystems)	Active role in liaising between communities and developers of private urban project
Service provider/industry	Consultant (Sustainable development)	Consults for public and multilateral organizations on the environmental impacts of land and sea infrastructure projects
Elected official	Adviser (Land Transport)	Provides expert advice and strategies to the high-level politicians on transport related policies
Elected official	Permanent secretary (Medicine and health)	Reviews environmental impact assessment reports on national projects in order to identify health risks
Industry	Planner (Urban planning)	Leads on private and public transport urban planning projects such as main bus terminal
Public agency	Statistician (Land transport)	Updates and monitors data on land transport such as traffic incidents and deaths
International multilateral organization	Head of department (Sustainable development)	Reports on the advancement of sustainable development targets on the island including SDG 11
Public agency	Head of department (Traffic Planning)	In charge of deploying public transport strategies and involved in the new light-rail public transit system
Public agency at parastatal level	Technician (Sustainable economic development)	Works on establishing urban standard guidelines for economic development focusing on investments in transport, social housing and real estate projects
Public Agency at municipal level	Municipal agent (Town planning and services)	Works at municipal level on housing and transport initiatives and municipal policies
Industry	Executive and board director (Economic investments, Food services and Sustainable development)	Directs decisions for different companies focused on services and investments in the city of Port Louis
Resident	Journalist (Urban development)	Critically analyses and reports on urban development projects across the island

Resident	Politician (Social and economic development)	Leads a stand-alone political party with expertise in sustainable economies
Resident	Social worker (Health and social justice)	Provides support and leads initiatives supporting the urban poor in the capital

Table 1. Participant profiles. Source: [24].

Individual Interviews

A semi-structured guide (see annex A) was used to elicit opinions on priority needs and challenges related to health and urban transport planning. The questions covered during the individual interviews addressed the following points:

- Urban transport planning (UTP) measures that stakeholders are most familiar with;
- Different factors stakeholders consider to lie in the interface between urban transport planning and health;
- Factors missing in the current situation and challenges face by the UTP sector; and
- Idea of a healthy, feasible and sustainable UTP system and what is needed to achieve this.

Focus Group Discussions

The focus group discussions enabled the same stakeholders to discuss, contrast and develop their views in a group setting. During the focus groups, stakeholders were invited to discuss the following points:

- Their individual experiences as citizens, their needs and their priorities;
- Their opinions on the 3 proposed scenarios;
- How their visions differ and clash with the 3 scenarios; and
- Whether they can reach similar endpoints.

Feedback Exercise

The feedback exercise was used to report the HIA results and as a debriefing session with the participants. Due to the coronavirus pandemic (2020), these sessions were conducted on virtual platforms (Zoom, Skype and Google meets). During the feedback exercises, the following points were covered:

- Reporting of baseline exposure data and final HIA results;
- Relevance of HIA outcomes to stakeholders' positions and fields;
- Re-integration of HIA results in the society;
- Feedback on participatory HIA process; and
- Review and in some cases co-drafting, of the policy brief delivered to the authorities (see annex).

Fieldnotes

Fieldnotes were taken during recorded meetings with the study participants to collect primary data for the qualitative component of the HIA (see Table 1) and also during non-recorded meetings with external participants to collect secondary data for the quantitative component of the HIA (see Section 2.1). These stakeholders worked across five public ministries, 3 parastatal bodies and 2 private companies (see Table 2).

Meeting with	Data Needed	Category	Institutional Affiliation
Health statistician	Population Census by gender and age	Demographic	National Institute of Statistics
Land transport agent	Mode and time of travel by gender and age	Transport	National Transport Agency Ministry of public infrastructure and land transport Private transport provider
Environmental expert	Air pollution emissions inventory and database	Air pollution	National Environmental Laboratory Ministry of Environment
Public Health statistician NCD expert Permanent secretary	Health and Physical activity survey data by gender and age	Physical activity	Ministry of Health
Police officers Hospital staff Transport expert	Records of traffic collisions Vital registration statistics Hospital records	Road deaths	Police headquarters and traffic offices Transport agency National institute of statistics Hospitals
Health researcher Health statistician	Vital registration statistics Burden of disease data	Burden of disease	National institute of statistics Health agency University of Mauritius
Climatologist Weather expert	Daily mean temperature	Heat	Mauritius Meteorological station
Urban planner GIS expert Permanent secretary Architect	Map of land use Topography layers Public transport route maps	Land use	Ministry of Housing and Lands Economic Development Board Ministry of Local Government and disaster risk management

Table 2. Non-recorded meetings for secondary data.

Quality Criteria Assessment

We used Lincoln et al.'s system of criteria for assessing and validating the qualitative participatory approach used to build the framework [33]. The five quality criteria include: credibility, transferability, dependability, confirmability, and authenticity. We used different proxies (questions developed by consensus with co-authors using field notes and field experience) for each quality criteria (see Table 3).

Criteria	Description of Criteria	Proxy
Credibility	<i>Internal validity of participation:</i> Do participants feel that the findings represent their experience?	Was there a prolonged engagement with participants? Was there a debriefing session with the participants?
Transferability	<i>External validity of participation:</i> are the findings applicable to other contexts?	Are participants' responses in harmony with researcher's experience? Is there scope to provide a detailed description from both sending and receiving ends?
Dependability	<i>Reliability in participation:</i> are the findings consistent?	Can the researcher use documents and methods to check if research strategies have effect?
Confirmability	Can we confirm the findings using data analysis?	Can the findings be confirmed if data are recollected and analyzed?
Authenticity	<i>Integrity of participation:</i> are all the different views fairly represented? Did the process stimulate action from participants?	Were viewpoints from different participants considered? Did the participatory process lead to participants acting on HIA outcomes?

Table 3. Description of quality criteria.

The *internal validity of participation* (credibility) was ensured by a prolonged and consecutive engagement with the 14 participants using different methods and in different locations. The attendance rate of the stakeholders to all activities was 100%. The stakeholders were able to express feedback and debrief on the process during the feedback exercises.

External validity of participation (transferability) was ensured by practicing knowledge exchange between the participants' responses and researchers' knowledge. For instance, stakeholders voiced concerns about the use of electric public transport, walkability and car overuse. These issues echoed the researchers' knowledge of similar challenges faced in comparable LMIC settings. Stakeholders also identified health risks that are well reported in the scientific literature on HIA modelling. The subsequent meetings focused on the co-validation of scenarios and provided the opportunity for stakeholders to exchange views. The research also used articles about similar experiences to triangulate with findings from exercises with participants.

The *reliability of the approach* and *consistency in findings* (dependability) was ensured by using a collaborative process, structured topic guides (see Annex A) and recordings of sessions. The fieldwork materials were documented and indexed to ensure reliability.

Confirmability was ensured by gathering data at different stages of the framework and ensuring that stakeholders could be contacted for data clarification. Contact details were collected on informed consent sheets and used to confirm availability for participating in subsequent research stages.

Finally, the *integrity of participation* (authenticity) was ensured by ensuring that different views were fairly represented. Purposive sampling was used to recruit stakeholders from diverse economic backgrounds and sectors. Stakeholders were given the opportunity to add and modify their views and comments during different sessions. During the FGDs, there were different rounds of reviews after each topic to ensure that the viewpoints from different participants were contrasted, noted and considered for modifying research design and implementation (further details in [24]).

8.3 Results

We present an exploratory framework reflecting the process of PQHIA (Figure 2). The framework enables operationalizing HIA, showing how to engage stakeholders and overcome the political, economic and cultural barriers of implementation. The qualitative analysis of interviews, FGDs and feedback exercises show that costs for participation, HIA knowledge and interest, multi-sectoral coordination and multi-level stakeholder engagement influence PHIA execution. Factors such as social responsibility, policies, citizen participation and data availability influence the uptake of PHIA outcomes to have policy relevance. In our case study, good governance, resourcefulness and evidence-based policy making culture enable PQHIA execution and policy uptake in LMICs. The framework consists of three components:

1. A three-layered circular figure depicting the five main HIA stages. For each stage, a summary of participatory activities (intermediate circle) and outcomes (outer circle) is proposed.
2. A set of eight factors that can influence the process of PQHIA are presented as grey background rectangles.
3. A dotted rectangle presents three areas of opportunities for proper integration of PQHIA process in the outside environment.

Component 1

The framework depicts the participatory approach as a central element. The initial model (Figure 1) was modified from a linear to a circular process of the five main stages (screening, scoping, appraisal, reporting and monitoring). In our study, secondary data collected from existing monitoring databases (see Section 2.1.5) and information used during informal meetings were used to define the scope of the HIA, to map the relevant stakeholders to interview, and influenced the discussion on which indicators to examine. There was no disconnect between monitoring and screening stages. A full description of

the content of the PQHIA including participatory activities and outcomes can be found in the fieldwork protocol (Annex A) and previous publications [24].

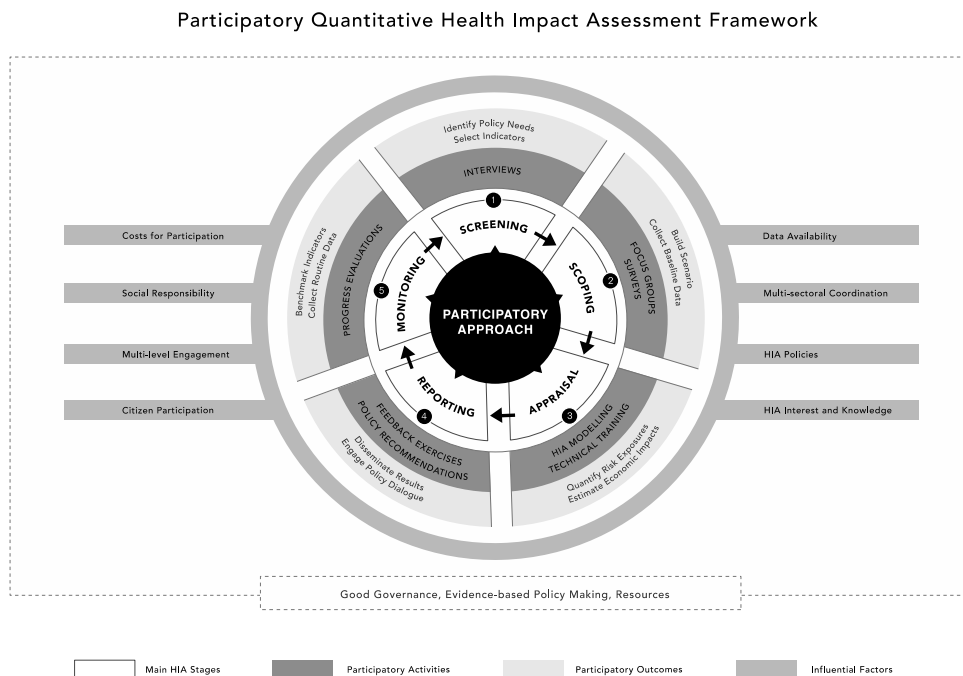


Figure 2. Participatory quantitative health impact assessment (PQHIA) framework. Note: for sake of visual clarity, the recommendation stage is presented as a sub-activity of the reporting stage, even if in practice this holds its importance as a stand-alone stage.

Component 2

Eight different factors were found to influence PHIA (influential factors) and the uptake of HIA outcomes in Port Louis, Mauritius: costs for participation, HIA interest and knowledge, social responsibility, HIA policies, data, citizen participation, multi-level stakeholder engagement and multisectoral coordination.

2.1. Cost for Participation

Preliminary information shows that a lack of resources can hamper the nature and outcome of participation, leading to the inclusion/exclusion of stakeholders in participatory processes [23]. Since there are very limited data on how much participation actually costs in the broader participation literature (*ibid*), we used our experience from the Mauritius case study to explore these costs in more detail. Initial assumptions of participatory processes were that participants would be willing to volunteer their time and resources for such activities as the outcomes would be to their interest. As can be seen from our data, we did not cover any costs for the participants to contribute—so, our 14 participants participated entirely on a voluntary basis. This may have meant that some other stakeholders are excluded because they do not have the resources to participate both in our case study, but also more generally in LMICs.

The costs of engaging these 14 participants during an 8-month period of fieldwork amounted to 299 Euros; 7% of the entire fieldwork process for conducting the PQHIA. This excludes the plane ticket fares from the researcher's work location (Spain), the salary of the researcher supervisors and the statistical team supporting the quantitative appraisal of fieldwork data. These costs were excluded because participatory activities on the field site in Mauritius would have still been possible without considering them. It is important to note, however, that if the municipality should undertake such an activity, the cost of the employees who organize and undertake the impact assessment will need to be added. The cost of PHIA (and HIA in general) has been identified as a major barrier to policy-level HIA [8,11,34], yet few studies have specifically reported on the actual costs of the process, leaving empirical uncertainty on the nature and extent of such barrier. This also creates uncertainty as to who is expected to fund the HIA and whether the decision to apply participatory approaches is based on financial affordances. With participatory activities covering 7% of all costs and lasting 44 days (see Table 4), our case study shows that participation in HIA does not need to be expensive or time consuming. Nonetheless, costs are influential in deciding the sample size of the population to be included in the research and the duration of the PHIA.

Activity	Item	No. of Items	Price Per Item	Total MUR	Total EUR	Work Days
Survey Data Collection	Fieldworker (FW) salary	8	12,000 rps/FW	96,000	2412	20
	Bus trips for FW	320	25 rps/trip	8000	201	
	Weekend bonus	8	1000 rps/wkend	8000	201	4
	Software and hosting	One-off fee	24,000 rps	24,000	603	
Intern Support	Intern support (1)	20 hrs	20 hrs	1875	47 *	4
	Intern support (2)	20 hrs	20 hrs	1500	38 *	4
FGD	Room location	2hrs	750	1500	38 *	1
	Facilitation strategy	3 hrs	1000	3000	75 *	1
Secondary data	Heat data	5	200 rps	1000	25	10
	Cartography Layers	4	4000	16,000	402	
	Transport	40 hrs	100 rps/hr	4000	101 *	
	Outline Planning Scheme	1		5000	126	
				Total	4268 EUR	44 days

Table 4. Cost and working days.

* Costs related to engaging the 14 participants only.

2.2. Stakeholder Knowledge and Interest in HIA

Stakeholder interest in HIA is a key precondition for ensuring the effectiveness of participatory HIA process and may influence the uptake of outcomes. HIA effectiveness depends on the level to which stakeholders are (1) willing to participate, (2) knowledgeable of impact assessments, and (3) interested in, and have the authority to, integrate HIA outcomes in their work. In the case study, willingness to participate was

secured by using stakeholder interest in HIA topic of HIA as a criterion for the sampling participants, following [35]. However, it was difficult to assess stakeholders' current knowledge of HIA and their understanding of the HIA process in Port Louis. In other places, it is also still unclear as to what extent HIA processes are actually understood by health practitioners and decision-makers [36]. This may be justified by the fact that HIA has received much less policy and practice attention, compared to environmental impact assessment (EIA), for which 190 over 193 United Nations member states have signed legislation [37].

Although some participants had previous knowledge of HIA, this was not stated as a condition for them to replicate a HIA themselves or use HIA outcomes in their work. Only two participants had used HIA before (ID4 and ID10), and another had vaguely heard of HIA via EIA (ID11). In hindsight, we could have asked them about their HIA experiences in terms of the substantive and procedural aspects. One participant, a local transport provider, was interested in the visibility of issues (e.g., road deaths) that can be measured by HIA. His interest, then, was not only a precondition for participation, but also a driver to subsequently consider HIA outcomes. In the following, he comments on policy makers' interest in transport issues: *'I think it's all about the visibility... of the issues [...] if you say anything that will reduce road death, they [policy makers] will definitely consider it because that's an issue (ID1 02).*

The literature confirms the importance of the 'visibility' of issues in the public domain [38]. Participatory impact assessment, in particular, has demonstrated how revealing 'hidden troubles' allows greater insights into unmet health and social needs [39]. Bringing health issues into the public domain has demonstrated that priorities for action affect physical environment, social support, and the use of epidemiological data. Participants already familiar with HIA had clear ideas on how actions should be taken and how HIA should be developed, as they were willing to use it only if it was 'adaptable' and 'easy to use' (ID01), and 'if it help[ed]' (ID03). Another participant highlighted that her interest in using HIA would increase if her work benefited from the external value of HIA—for instance, through the opportunity to calculate the welfare costs of health losses, especially as it is expressed in monetary terms. She commented: *'In Mauritius, as soon as you come with monetary values, people take you seriously (...) We carry much attention to this issue [road accidents], yet, it all comes down to money if this is to be taken seriously' (ID07).*

Thus, when an issue become visible and a quantifiable monetary value, it may have a higher policy impact. This confirms our hypothesis that to increase stakeholders' active involvement in PQHIA and successful uptake of HIA outcomes, it might benefit from evidence of the welfare costs of inaction versus the economic and social benefits of identifying issues and risks before their impacts are felt.

2.3. Social Responsibility

Several participants mentioned that the (corporate) social responsibility of decision-makers is an important factor for executing PQHIA and related policy uptake. Participants perceived social responsibility as the alignment in decision-making between words and actions. A participant explained that social responsibility was lacking when political intention to change urban and transport policies had been declared but not

implemented, but no action had been deployed: *'lately, they [policy makers] organised big consultation meetings and declared they would improve green spaces, increase pedestrianizations, plant trees on the Citadelle. All the newspapers reported this... But I see nothing, nothing, nothing...'* (ID13).

The participant's frustration with the lack of action by decision-makers reinforces our point on the need for PHIA to have outputs that can be realistically implemented. Similar tensions in the follow-up of good intentions expressed in public declarations have been reported in the field of impact assessments. Processes grounded in social responsibility have been proposed to encourage the systematic assessment of health impacts in local policies [40]. Thus, social responsibility becomes connected to the idea of 'accountability' of decision-makers towards their promises: *'If one makes a mistake, it is responsible and necessary to correct them'* (M, FGD2).

Networks such as the WHO's Health Cities network and the Milan Declaration have suggested that a way to build accountability is via 'making health and environment impact assessment part of urban planning decisions, policies and programmes' [41]. In Port Louis, stakeholders reported that social responsibility would increase if policy makers adopted gradual changes, *'retro-fitting'* (ID 03) rather than proposing new development plans at every round of decision-making. This would increase *'pre-visibility'*, *'resolution'* and *'follow-up'* of plans (K, FGD1). Without this continuous, accountable and reliable process, the planning strategy has no value: *'there needs to be follow-up in the decisions taken'* (M, FGD2). Finally, social responsibility is closely related to the ability of policy makers to go beyond political mandates and balance short-term needs with long-term benefits (IDI10). In this sense, social responsibility is evident in the *'difference between the political figure and the statesman the political figure thinks about policies for the next elections, the state figure thinks about policies for the next generations'* (IDI14).

2.4. HIA Policies

Participants reported that policies and legal frameworks are necessary to encourage the use of tools such as HIAs. One participant commented: *'The underlying issue lies in the lack of regulatory policy frameworks: a legal administrative protocol to use tools such as HIA and a framework that goes beyond government or private mandates'* (R, FGD2).

Participants also confirmed that they would use and conduct HIA only if it were regulated by law or imposed on top of their required workload (ID2, ID5). One participant says: *'If the regulations do not force or regulate us to use HIA, then we will not use it'* (ID 2). Although few LMICs have established HIA legislation and no African country regulates HIA [42,43], large multilateral organizations such as the African Union have recognized the need for developing HIA policy in developing countries [44]. Indeed, developing countries showing strong political commitment to HIA will not only raise awareness of its use, but will effectively contribute to building technical capacity for HIA [45].

Past experience with EIA shows that policy makers struggle to satisfy policy goals including political, economic and social aims, are challenged to find ways for enforcing EIA recommendations, and that governments are concerned about how to integrate different policy initiatives [46,47].

Stakeholders from Port Louis highlight similar issues. For example, even though governments have been talking of electric cars for 20 years, based on EIA reports, no progress has been made (B, FGD2).

In response, they suggest that policies for planning should be applied long term especially those that focus on the deployment of impact assessments:

'If we have policies, we need to apply them sustainably' (R, FGD2). Finally, *'having law is not enough, we need to enforce them'* (IDI4). Finally, a participant stresses that there should be continuity between policy-making and policy integration in order to translate HIA outcomes into actions. *'It should be the same policymakers who formulate [policies] and integrate [policy-driven actions and interventions] too'* (ID07).

2.5. Data Availability

Participants reported that data availability provides the opportunity to assess a larger scale of factors impacting health. One of them remarks *'how can we predict health impacts effectively if we do not have baseline data?'* (P, FGD2). Lack of data on air pollution could be compensated by data on the fuel used by public transport (ID2). Setting up epidemiological databases could address the issue of data scarcity (ID 10). Beyond a lack of data, various concerns were raised about how existing data are collected, managed and used:

'I think they do not use what they have intelligently, they do not know what they have' [...] there is a lot of data management equipment that is being under-utilized' (ID 10). Such data (e.g., that there is better air quality on Sunday because people do not travel as much) should be directly used to encourage and increase awareness of the public (ID12).

Adequate data collection and management is useful to examine how environmental factors affect population groups differentially. Specific data are needed to better assess the health impacts of transport on those most exposed, such as traffic policemen and slum dwellers; and whether people actually use green spaces in a city (ID12). Understanding who is benefitting the most, or who is most impacted by policies, is critical (S, FGD1).

Data (quantitative or scientific but qualitative or contextual) can also serve to inform policies and avoid mismatches between what people are doing and what policies are regulating. For example, data on travel mode shares and travel behaviors is needed to design car reduction strategies (R, FGD2). Lack of adequate data feeds misinformation and misconceptions, which in turn makes the adoption of novel strategies for health harder, as in the case of cycling, which is perceived to be risky: *'People are concerned about their security on bicycle, but this is a lie that protects the car [...] of course the road is dangerous, especially for the two-wheelers, but this should not be encouraging the restriction of cycling modes and favour the use of cars'* (G, FGD1).

Finally, obtaining and using data also means that policy makers can explore and use other types of evidence from similar settings and countries (particularly, in the region of Africa) when they consider designing policies (IDI02).

2.6. Multi-Sectoral Coordination

Following stakeholder opinions, multi-sectoral coordination prompted by PQHIA is essential to (1) interact with agents from other fields, (2) to use data and evidence from other sectors, and to (3) tackle different issues with the same strategy. Within our sample, multi-sectoral coordination was already happening prior to HIA and was fostered during HIA. For instance, a public service urban planner was working with the head of project of an international multilateral agency and at the same time collaborating with a consultant from the private sector (ID02). Furthermore, one participant suggested that different forms of evidence (other than travel data) are needed to regulate public transport in Port Louis (ID02). Using multi-sectorial approaches enables one to tackle different issues and how they intertwine. Transport-related health issues and national security influence each other (ID12).

Participants argued that a lack of cross-sectoral work leads to poor coordination of actions and policies. One participant suggested that an official board should be created specifically for overseeing projects that demand a cross-sectoral approach and coordination between ministries and different stakeholders (ID 11). This could build on experiences in other sectors such as on employment protocols, occupational health and immigration laws (ID 07).

Not adopting cross-sectoral approaches can lead to the design of sector-specific policies that address the wrong problems. For instance, participant (ID 09, Z FGD 1) mentions that her choice of travel mode is not based on health benefits per sé but on the level of physical safety: *'I will not choose to walk, even if it is better for my health, [...] because of rapists potentially hiding'* (Z, FGD1). Therefore, even if policies to increase walking are designed, they are not efficient if they overlook personal safety issues. Participants called for addressing health in different policies and sectors (e.g., agriculture, trade): *'sustainable transport is linked to a lot of different things, agriculture, oceans, partnerships, income trade, you name it, it is all linked'* (ID09). Additionally, such an approach enhances the link between sectors, for instance between transport and use of natural land and urgency of protecting resources (J, FGD2).

2.7. Multi-Level Stakeholder Engagement

Engaging stakeholders from different levels of decision making within one sector of interest was recommended (ID07) as it can provide contrasting perspectives and facilitate priority setting of issues. However, the gaps between different actors and levels of decision-making action in the health sector might hinder collaboration:

'Half of the doctors are very interested [in impacts of environment on health], but there are no avenues for them to actually get data [...] All the policies or everything that they produce make sense but the human reality is different...it would be better if they were aware of the meaning of their work' (IDI 10).

Multi-stakeholder collaboration intertwines with other issues considered above, such as the importance of resources, data, policies, and multi-sectoral coordination, and how all come into play in making HIA possible.

2.8. Citizen Participation

Within PQHIA, participants considered that a space should be provided for citizens to contribute to more inclusive processes of policymaking: *'I believe that citizens should be responsible and accountable enough to ask what they need and want'* (ID 12). PQHIAs reflect the willingness of HIA practitioners and stakeholder to consider citizen's views and lay knowledge alongside expert opinions and scientific data. The process of triangulation implied in combining several types of evidence and from different sources increases the value of the process. In some contexts, decision-makers may value information sourced from communities; citizen expectations can help them decide on priority issues (IDI 13). Therefore, PQHIA can provide channels for such evidence to be rapidly conveyed to them, in a clear and transparent manner. This is also valid to feedback HIA findings to the community, to strengthen equity and gather baseline information for routine impact assessment. The literature reports that citizen participation is a complex process that can be expensive [23] and requires citizen organization to have effective influence [48]. In developing countries, however, not enough evidence exists to verify such statement and our case study reports otherwise (see previous section).

Component 3

Three areas of opportunities were found to facilitate implementation for HIA: good governance (political), evidence-based policymaking (cultural) and resources (socio-economic). They are represented in a dotted rectangle delimiting PQHIA with the outside environment (see Figure 2). Without investment in these three areas of opportunities, PQHIA faces the risk of not being properly integrated, limiting the ways in which countries and institutions can use and benefit from the tool.

3.1. Good Governance

By facilitating multi-sectoral and multi-level coordination, PQHIA provides a point of focus on good governance, especially in countries with limited resources. Governance is the manner in which power is exercised in the management of a country's economic and social resources for development to be able to properly execute governance, government integration and internal collaboration is a key factor [49]. Collaboration between departments (multisectoral) and between levels of government (multi-level) can provide a more effective identification of needs and gaps, data collection, policy elaboration, evidence integration and comprehensive policy execution. In this sense, governance structures aimed to promote collaboration makes any HIA proposal and results be integrated in the system to be effective. So, how HIA demands and outcomes/outputs are integrated in real policy also depend on how these multi-sectoral/level structures are emplaced and working. HIA requires the leadership of the health sector but most of the policies require other sectors and levels of authority to be executed. The lack of good governance will diminish HIA quality and utility. Therefore, PQHIA in a context of good governance can be optimized as a tool to provide evidence, use robust data, maximize health, minimize risks, and integrate recommendations. HIA can also help to identify governance gaps and reinforce the need for good governance structures to support evidence-based interventions.

3.2. Evidence-Based Policymaking

The primary output of HIA is scientific evidence that can inform decision makers early in the process of policy development and ensure that health impacts are not overlooked. Validating evidence-based policy making as an area of opportunity for HIA practice provides scope for increasing political authority and diffusing impact of HIA outcomes. During an interview, a public servant working at the Ministry of Health reported that outcomes resulting from impact assessments are taken seriously in Port Louis (ID 04). There are environmental impact committees evaluating health components and providing recommendations. Yet, the participant reports that *‘legislation can be enough [to promote use of evidence] but enforcement is a problem.’* (ID 04).

Different public health frameworks facilitate and promote the practical application of scientific evidence derived from evaluation tools such as HIA. For instance, the Health in All Policies (HIAPs) approach is widely applied to support evidence-based public policy and benefit local decision-making processes [26,50]. However, in LMICs, such frameworks are weak, making it complicated to assess whether or not outcomes are effective for evidence-based policy making. In the case study, a policy brief was drafted and submitted to decision makers after the HIA was conducted (Annex B). Various participants agreed to co-author on the policy brief to show their interest not only to support HIA practice but also to enforce its impact. On a wider scale, however, securing evidence-base policy making practices may imply building resources and skills, planning for effective engagement strategies for key stakeholders, defining evidence-based monitoring and evaluation mechanisms for health data, etc.

3.3. Resources

The need for human and economic resources that enable decision makers to consider health impact outcomes emerged various times in the participatory study. While discussions about human resources traditionally evolve around distribution of workforce and manpower, in the context of PQHIA, human resources were expressed in terms of the ability, attitude and skills of decision makers to analyze, understand and predict the health impacts their strategies and interventions that would compel them to consider HIA outcomes and strategically plan in advance (ID 12). Yet, addressing human resources (skills and attitude) without the support of economic resources is limitative. Decision makers need both ‘intentions’ (see social responsibility) but also the means to follow these intentions (e.g., skills, economic resources). Elsewhere, this has been referred to as developing resourcefulness; i.e., ensuring access to economic, civic and intellectual resources at the same time [51].

Economic resources are necessary to address environmental and health concerns. For example, one participant commented that *‘A country focuses on health and traffic safety only if a given milestone towards development has already been reached’* (R, FGD2). His statement, which effectively mentions the level of ‘economic development’ as a precondition for implementing PQHIA, speaks directly to the academic debate on the links between GDP and environmental policies. Different studies have observed that countries tend to react to increasing levels of environmental damage only after a certain level of pollution (and health impacts) and GDP is reached, as expressed in the so-called ‘Environmental Kuznets Inverted U’ curve [52]. However, the question is whether the idea that one

needs to develop first before considering the environment and health issues is an increasingly problematic one, because inappropriate investments (or access to economic resources) cannot easily be phased out before their useful life-time without being extremely expensive (e.g., a city that has heavily invested in fossil fuel using private transport cannot easily shift into a city that has electric public transport and lots of bicycle paths without creating stranded assets).

Another participant raised the complexity in defining what this threshold of economic development may be, because, in his view, when health is considered in non-health sectors, this is often unplanned and unexpected: *'In Mauritius, the best urban and transport planning achievements, including those that benefit health, have been completed without specific strategy and clear planning. There is local pride in this approach to development, leaving very little space for critique'* (IDI08).

While it is possible to frame development through GDP levels (as in the previous paragraph), this participant shows that there may exist different ideas about urban development or progress, and how they interrelate to the possibility for HIA to bring about change. Such ideas may pertain to dimensions beyond economic resources and into human resources as mentioned previously. They can also be linked to local knowledge, institutional cultures towards both strategic (or in this case, unstrategic) planning, further supporting our point that the current framework may need to be adapted across contexts.

8.4 Conclusions

The proposed PQHIA framework is a tool for guiding participation in quantitative HIA while overcoming political and cultural barriers for implementation. It was developed based on fieldwork conducted in Mauritius and can be considered for wider applicability. The findings are valuable given the scarcity of HIAs in LMICs. In a systematic review of 57 HIAs in LMICs, only seven studies reported participatory approaches [19]. They showed how participatory HIAs assist to set assessment boundaries [53], to clarify expectations of HIA practitioners, to disaggregate different determinants of health [54] and to promote collaboration with HIA practitioners from other countries [55], but none explained in detail and with precision how the participatory process should be operationalized. The aforementioned studies were also participatory qualitative, and not quantitative, HIAs.

The framework brings additional evidence to previous models addressing process [56,57] and HIA implications for policy-makers in LMICs [58]. It stands out, however, by reporting different factors underlying PQHIA at every stage, using empirical data and recording stakeholder insights before, during, and after the appraisal stage. The framework fills existing gaps in the research and complements studies that do not adequately report the theoretical and practical process leading to specific methods for participation [15]. It also provides an insight on how to tackle the issue of the mismatch between how participation is described and perceived and the actual realities of involved [13].

By including a diversity of stakeholders in the process the framework caters for different perspectives in the participatory HIA process [59]. Finally, the engagement of stakeholders in the Mauritian case and the resulting framework is promising and contrasts with findings from a richer setting that stakeholders perceive participation as a burden and a constraint characterizing HIA [60].

The proposed framework reflects how contextual factors can influence participatory HIA. Wismar et al. 2007 showed that the effects of HIAs on decision-making processes are complex and can vary significantly: (a) they directly affect the decision being made; (b) they do not affect the decision but raise awareness of health issues; (c) they have little impact because the decision was already favorable to health; and (d) they are ignored or dismissed by the decision makers [61]. Even if this was possible, claiming that a standardized one-size-fit-all framework can encapsulate all changes attributable to the practice of participation in HIA would require a large number of empirical studies and an acute understanding of PHIA implementation in settings such as Mauritius, both of which are currently lacking. Therefore, we propose our framework as a guiding tool rather than a standardized framework for participatory HIA. In the process of building this framework, some lessons have been learnt:

1. Methods for participation (e.g., activities, sample size and study period) should be carefully planned, in advance, based on budget and time available.
2. The flexibility afforded by choosing the type, form, and duration of HIA alongside local communities is crucial for stakeholders to use and most benefit from PQHIA.
3. Focusing on the areas of opportunities highlighted in the framework can have wider benefits on governance systems, policy-making practices, and access to resources in LMICs.

Several challenges remain and should be further studied. The study presents results based on a small-scale sample (14 participants). Even if large samples are seldom used in the context of participatory impact studies of transport and there is a consensus that cost affects sample size and time of study [62], implications of how to scale methods to national level or in another context need to be examined carefully. Small sample sizes and their limitations to extrapolate findings are a common challenge in the field of impact assessments [32]. Studies reporting stakeholder involvement were all in OECD countries covering between 14 and 52 participants [63–66]. Those involving more than 100 participants were rare and conducted in rich countries with the most history and experience in HIA, such as Canada and Switzerland [67,68].

In this LMIC-based case study, the choice to work on a small scale was deliberate and adapted to satisfy scholarly objectives. The samples needed to be manageable to ensure long-term engagement from stakeholders across different meetings and events, the timeline was set, the resources and costs were limited and the HIA was led by one person (main author) who did not reside in the country of study. The selection of participants based on their interest in HIA carried the risk of sampling bias that was reduced with careful research design and transparent sampling frame.

The sample also consisted of participants who were able to participate without financial stipend. This may not be afforded in other situations or settings.

Sampling participants for qualitative and participatory research phases requires a judgement of who is irrelevant and where to draw the line, but also to consider how different views are included in the final decisions and the way in which they are implemented.

It is possible that slow institutionalization of HIA in LMICs (at national level) increases the complexity of incorporating stakeholders with environment and health backgrounds [32]. Yet, we believe that the sample satisfied the focus and limits of this study in terms of city-level approach, the intensity of their engagement (recurrence and thoroughness) and inclusion process in conducting the HIA but also disseminating its results. This study supports current evidence that stakeholder engagement is an efficient method to improve the quality and relevance of HIA [35,69,70]. Even if some concern may remain on what ‘minimum level’ of participation is required for a quantitative HIA to be defined as PQHIA, the quality criteria assessment we applied (see Section 2.2) was helpful in exposing the framework’s ability and potential to guide planning and implementation. In addition to the formal participatory activities with 14 participants, a large number of informal meetings and fieldnotes (see section 2.1.5) were collected during the PQHIA. Ensuring the robustness of qualitative data using criteria is invaluable in ensuring scientific rigor, researcher reflexivity, and ethics towards participants.

To conclude, our study recommends the use of PQHIA to bring health to non-health sector agendas such as urban transport planning. By allowing for the greater dissemination of HIA outcomes, PQHIA raises health awareness among wider members of the community. PQHIA engages stakeholders at every stage of the process, increasing their knowledge gradually and providing various points of entry for HIA to impact their individual environment and sectors. Finally, PQHIA responds to an urgent need to combine increased knowledge on deteriorating health determinants and experiences with impact assessment as a potential solution to safeguard the health of people and the planet.

Supplementary Materials: The following are available online at www.mdpi.com/xxx/s1, Annex A: Fieldwork protocol (includes topic guides, fieldwork model and description of each field activity). Annex B: Policy Brief.

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Annex A

Fieldwork Protocol Participatory Quantitative HIA 2017-2020

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Mortality Pathways for Urban and Transport Policies

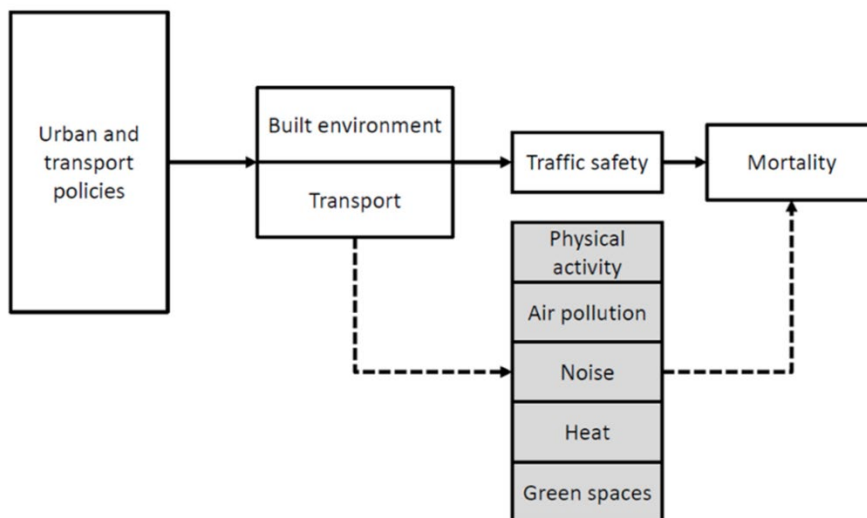
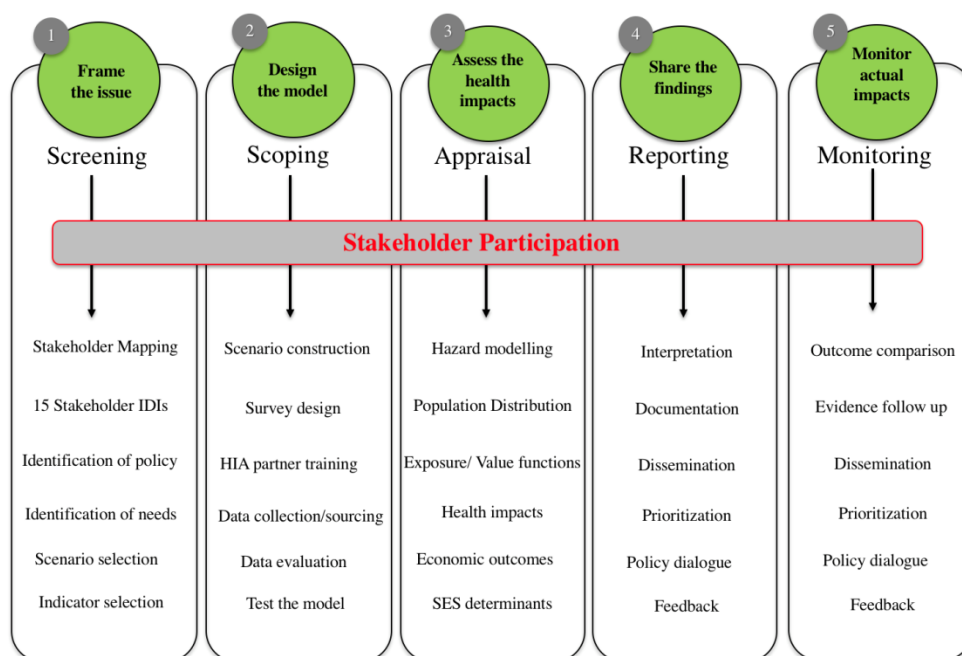


Figure 1. Mortality pathways for urban transport policies (Mueller, 2017).

Fieldwork Model

HIA MAURITIUS FIELDWORK MODEL



Phase 1

The purpose of the first phase (issue framing) is to identify and enter into dialogue with adequate political and social partners. Stakeholder consultations will be held in order to define barriers and opportunities for HIA in respective study settings. The importance of consulting stakeholders is to (1) define the current status of HIA in the study setting (2) identify the ongoing or prospective urban and transport planning policies and (3) to build realistic and context-specific scenarios overtime.

Phase 2

The aim of design stage is to deliver a specific protocol for conducting the impact evaluation. This part will focus on the execution of integrated full-chain HIAs of urban and transport planning policies in Port Louis and Manhiça City. A novel HIA model and framework will be constructed in order to estimate the health impacts of scenarios of selected urban and transport planning policies. This implies clearly defining the system and protocol that best fits for analytical procedures: exposing clear variables and relationships and presenting solid reference and alternative scenarios.

Phase 3

The execution stage will involve conducting the evaluation assessment by using modelling techniques. The HIA will include the traditional risk assessment steps of hazard identification, exposure assessment and risk characterization.

It will assess the combined effect of environmental and social factors on health with newly collected or existing national data (see the data collection section below). The models ITHIM and UTHOPIA that are proposed have been tested, used, and validated in other studies (Woodcock, 2011; Muller 2015). Sensitivity analysis will be conducted to assess uncertainties.

Phase 4

The appraisal stage is the result dissemination phase. The HIA process and outcomes from Mauritius will be compared to those of Mozambique, with the aim of discussing commonalities and differences in health determinants and impacts. This part will analyse how HIA can be integrated in local policy processes and contribute to sustainable development and achievement of SDG 2030.

Phase 5

The monitoring phase consists of establishing HIA procedures and assessing the feasibility of evaluating and monitoring estimated health impacts. This phase is illustrated here but may be out of the scope of the project given the 3-year time limit.

Category of Stakeholders for Step 1/ Screening and Step 2/Scoping

Category of Stakeholder	Opportunities	Challenges
Elected Officials	<ul style="list-style-type: none"> • Provide information on political objectives, timelines and decision-making processes • Inform on current opportunities and feasibility to apply recommendations • Provide guidance on how to address concerns of policy-makers 	<ul style="list-style-type: none"> • Hard to access and limited time availability • Need to educate on HIA process • Politically constrained • May not support the use of HIA outcomes
Experts from Public Agencies	<ul style="list-style-type: none"> • Provide data and analysis on health, land use, housing and socio-economic situation • Prepare forecasting reports and monitoring impacts • Bridge to policy-makers and potential leaders in HIA practice 	<ul style="list-style-type: none"> • May not be interested in health • Lack of technical and financial capacity • May not want to participate on a long-term basis • May be concerned about HIA outcomes
Residents	<ul style="list-style-type: none"> • Grassroots data and results • Potential to mobilize community leadership • Help to address language, knowledge and cultural barriers 	<ul style="list-style-type: none"> • Irregular or insufficient engagement due to time constraints and varying interest • Lack of trust in researchers, agencies or projects • Capacity building measures required • Potential need to provide incentives

List of communities of Interest

Communitybasedorganization
Residents
Elected officials at municipal, regional, state/provincial level
Small businesses
Industry, developers, and big business, Service providers
Public agencies
Statewide or national advocacy organisations
Academic, learning and research institutions
HIA consultant organizations

Tentative Activity Log

Date	Time	Where	Affiliation	Purpose
Tues 07Aug	11:30- 12:30	Bureau of Statistics	N/A	Access Road Transport and Road accident statistics
Tues 07Aug	14:00- 15:30	MRC	Academia1	Intro HIA
Wed 08Aug	14:00- 15:00	Bureau of Statistics	GovtOff1	IDI1
Wed 22 Aug	10:30-	Traffic planner, CNT, Vacoas, Bonne Terre	ServiceProv1	IDI2
Wed 22Aug	21:00-	Restaurant BG	Exp1UP	IDI5
Thurs 23Aug	12:00-	Restaurant PL	Industry1	IDI8
Thurs 23Aug	16:30-	PH	CBO2	IDI6
Thurs 23Aug	20:00-	Restaurant FF	Citizen1	IDI7
Lun 27Aug	11:00-	PH	Industry2	IDI12
Tue 28Aug	9:00-	S.William Newton st, Moorgate House, 9 th floor	GovtOff2	IDI9
Tue 28 Aug	13:00-	EDB 10 th floor	PubAgency1	IDI3
Fri 24 Aug	She returns	TBD	Exp1Engineer	IDI10
Fri 24 Aug	16:00-	PH	CBO1	IDI4
Thurs 23 Aug	He returns	TBD	AdvOrg1	IDI11
Mon 27 Aug	10:00	Ministry Building	GovtOff2	IDI13
Tuesday 28 Aug	11:00	TBD	CBO3	IDI14

Stakeholder Analysis Table (Worksheet)

Stakeholder group	Representative (contact info)	Expertise (information held)	Role in HIA	Interested or concerns about HIA*	Power to influence policy/development*	Opportunities to communicate (when, where)
Elected Officials						
Public Agency						
Residents						

Table adapted from Baker et al. (2011)

Using these two a prioritization assessment can be created in categories: with those A) interested in HIA and with influence, B) non-interested in HIA with influence, c) interested no influence, D) non-interested, no influence. With this an extra effort will be done to contact those in categories A, B, and secondary C.

Data Sourcing

Type	Purpose	Source	Indicators/ Target
Qualitative data	Build scenarios	15 IDIs with stakeholders	<ol style="list-style-type: none"> 1. Perceptions of health in city 2. Vision for healthy and sustainable U&T policies 3. Potential of HIA to impact on policy making
		1 FGD (narrative evaluation)	
Quantitative data	Collect baseline exposure data	<p>380 Surveys</p> <p>Local databases National statistics Census Hospital records City Council records Police records Spatial maps of land use Climate monitoring station</p> <p>International databases WHO Air Pollution database Climate monitoring station DHS Global Burden of Disease NDVI</p>	<ol style="list-style-type: none"> 1. Demographics (Age, Sex, SE status) 2. Burden of disease 3. Causes of deaths 4. Levels of Physical activity 5. Travel Patterns 6. Distance to public transport 7. Road traffic deaths 8. PM 2.5 9. Green space 10. Noise 11. Heat

Quantitative Data by Categories

	Categories	Inputs to modelling	Examples of data sources	Suggestions of places to look for
1	Demographics	Population by gender and age	Census Intercensal survey Intercensal estimate	National institute of statistics
2	Travel patterns	Mode and time of travel by gender and age, Length travelled, distance travelled.	Household travel survey (sometimes called mobility survey) Census Travel demand model Physical activity survey	Transport agencies, consultancies, academic research National institute of statistics Transport agencies, consultancies, academic research Health or sport agencies, academic research
3	Air pollution	Concentration of PM2.5, fraction due to road transport, emission by mode of transportation, and concentration of PM2.5 in the subway	On-road measurement of PM2.5 pollution EDGAR (modelled) estimates of PM2.5 Source apportionment reports Emission inventory of road transport	WHO Global Urban Ambient Air Pollution Database, environmental agencies, academic research EU Emissions Database for Global Atmospheric Research WHO Database on Source Apportionment Studies for Particulate Matter in the Air, environmental agencies, academic research Environmental agencies, academic research
4	Physical activity	Energy expenditure on non-travel	Health survey Sports and recreation survey	WHO STEPS, health or sport

		physical activity, by gender and age MET hr/week	Physical activity survey Movement sensors	agencies, academic research
5	Road injuries	'Who-hit-whom matrix' for deaths and injuries, by gender and age	Traffic collisions records	Traffic police, transport agencies
			Vital registration statistics	National institute of statistics, health agencies
			Mortuary and burial registers	Local mortuaries
			Household health and injury survey	Health and transport agencies, academic research
			Hospital records	Local hospitals, health agencies
6	Burden of disease	Deaths, years of life lost (YLL) and years lost due to disability (YLD) by cause, gender and age	Vital registration statistics	National institute of statistics, health agencies, Health statistics outcomes
			Burden of disease data	WHO Global Health Observatory data, Global Burden of Diseases, Injuries, and Risk Factors Study, other academic research
7	Heat	Daily mean temperature-1 year (average mean/day in C°) 99th versus 74th temperature percentile	Climate monitoring station	Mauritius Meteorological station World Meteorological Organization
8	Green space	Map of land use (industrial lots,	NDVI	University research Parastatal agencies: Landscape, EDB

		residences, green space) Per 10% increase in greenness Street network, topography layers, public transport layers, households layer, census track		
9	PM 2.5	Per 10 $\mu\text{g}/\text{m}^3$ increase in PM _{2.5} exposure	Air quality monitoring stations	WHO Air Pollution database National Environmental Laboratory of the Department of Environment
10	Noise	Daytime traffic noise $L_{Aeq,16hr}$	Monitoring stations	

Budget

Survey Data Collection

Item	Number of items	Price per item	Total MUR	Total EUR
Fieldworker salaries	8	12000 rps/fieldworker	96000	2412
Bus travel for FW	20 days	400 rps/day	8000	201
Wkend bonus	8	1000 rps/wkend	8000	201
Software & hosting	One-off fee	24000 rps	24000	603

Intern Support

Intern support Part 1 YR	20hrs	20hrs	1875	47*
Intern support	20hrs	20hrs	1500	38*

FGD

Room location	2hrs	750	1500	38*
Facilitation strategy	3hrs	1000	3000	75*

Data Costs

Heat data	5	200rps	1000	25
Cartography Layers	4	4000	16000	402
Transport	40hrs	100rps/hr	4000	101*
Outline Planning Scheme	1		5000	126

Total	4268
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Individual Interviews Semi-Structured Topic Guide

Objective of the IDIs:

1. What is current status in urban and transport policies?
2. What is important to them?
3. Do they think that UTP (urban & transport planning) is related to health -if yes, how?
4. What is their idea of a healthy and sustainable UTP system?
5. What is needed to achieve that?
6. What is feasible?
7. What is missing in the current situation? (is there overuse of motor-vehicles, over-isolation from car-use, no consciousness about pollution, like or dislike)
8. What would make your personal behavior change to more healthy or sustainable actions?

Recall Aim of Stakeholder consultation

Consultation= important process for decision makers to anticipate the consequences of their decisions

Inclusion of diverse stakeholders enhances HIA core values: democracy, equity, sustainable development & ethical use of evidence

Identify important stakeholder concerns

Assemble experiences, knowledge, expertise

Create support for implementation of HIA recommendations

Shape HIA communication & dissemination methods

Recall the objective of the HIA:

Assess an existing policy to (1) estimate its impact on health and (2) assess whether improving it can promote sustainable development.

Note: Maybe sustainability has positive health outcomes. Maybe health is a co-benefit of sustainability

BACKGROUND

- Describe the role of your group/institution/employer concerning urban & transport planning
- Are you active, involved in projects, measure – what are your responsibilities?
- With whom do you cooperate (Traffic, Transport, Mobility sector, Health sector)?

TOPIC 1: HEALTH MEANING

- What do you think makes you healthy in the city? (more specific)
- How do you manage your health while in the city? (health and transport more specifically)
- Do you think that UTP is related to health -if yes, how?
- Do you think there are needs in terms of health to support transport/urban decision making?
- If yes, how can health can be used to support urban/transport decision making?

TOPIC 2: UTP POLICIES

- **Can you describe 2 major U&T policies you are familiar with? (current legislation)**
 - Involvement of interviewee
 - Involvement of group/institution/employer

- **How do you think these policies may impact (+/-) on health in the city?**
 - Policies- promoting health?
 - Do you think health was considered when shaping such policies?
 - Which importance had the arguments related to “health”?
 - How were they implemented?

- **About the policy itself**
 - Name of the measure
 - Which measure?
 - Where? When? (time frame: short, medium, long term)
 - What is/was the aim? Which results are/were expected?
 - Did the results happen? Has the measure been evaluated?
 - Who (person or institution) had the idea to implement this measure? Who was involved (persons, city, district, public participation)? Who was mainly responsible for the project? Responsibilities?
 - How did they finance the project? What lessons have been learnt? Have there been any supporting factors or barriers?
 - Do you have any data available about this measure (e.g. counts of cyclists, pedestrians, accident data, etc.)? Could you provide any documents?

TOPIC 3: HIA

- Do you know about Health Impact Assessments?
 - Yes: Have you ever used it (or other experiences)?
 - No: Can you imagine using it? For which purpose?

- To what extent do you think HIA outcomes will be taken seriously in decision-making?

- How do you think HIA can support sustainable development?

TOPIC 4: VISION & WISHES

1. What is your idea of a healthy and sustainable UTP system in PL?
2. What is needed to achieve that? (which measures to be implemented to promote)
3. What is feasible? What framework conditions would that require?
4. Why have good ideas and measures failed so far?
5. What is missing in the current situation? (is there overuse of motor-vehicles, over-isolation from car-use, no consciousness about pollution, like or dislike)
6. What would make your personal behavior change to more healthy or sustainable actions?
7. How could sectors/groups/departments cooperate better?
8. How should it happen?

Note: inform about current exposure levels and shift towards indicators of interest

Focus Group Discussion Semi-Structured Topic Guide

Duration: 1.5hrs maximum

Number of people: 3-5 maximum at a time

Prerequisite for engagement: IDI completed

Main objective of the Panels:

contrast perspectives and opinions between stakeholders

engage small-scale dynamics between experts, public officials, and citizens

co-create the research agenda: finalize the three scenarios together

Stakeholders are invited to:

share their individual stories and express their needs and priorities (10%).

share their opinions about the 3 proposed scenarios of a healthy and sustainable UTP system (10%)

discuss if, where and how their individual visions differ and clash with the 3 scenarios (60%)

discuss if they can reach similar endpoints (10%)

Potential Structure of the Panels:

Introduction of each stakeholder to one another

Overview of the 3 scenarios emerging from IDIs

Contrast-facilitation session

Validation Exercise Semi-structure Topic Guide

Duration	Action	Concern
3 mins	Short welcome and updates	What has been done since our last exchange?
4 mins	Reporting of baseline exposure data and final HIA results	What data has been used and what are the health impact assessment outcomes?
4 mins	Relevance of HIA outcomes to their positions and fields	<p>What is the relevance of the findings to you?</p> <p>What were the expectations on the HIA outcomes?</p> <p>How would you prefer to see the HIA outcomes?</p> <p>How can/ will you use the HIA outcomes/outputs?</p>
4 mins	Re-integration of HIA results in the society	<p>What are the conditions necessary to integrate HIA results in your own sector/agency?</p> <p>What are the barriers and opportunities to integrate HIA results in your own sector/agency?</p> <p>Who should receive this information?</p> <p>When should this information be shared to have greater impact?</p>
5 mins	Feedback on participatory HIA process	<p>What do you think of the process and engagement in the HIA?</p> <p>Were your expectations met?</p> <p>How can we increase your attention/interest on future HIA?</p> <p>What do you need from HIA experts to support their future work?</p>
5 mins	Open floor for questions and comments	

Annex B

Policy Brief

September 2020



A new approach to Urban Transport

In a rapidly urbanising world cities must consider the health impacts of urban policies and projects. This policy brief makes a strong case for participatory quantitative Health Impact Assessments (HIAs), a promising and practical tool to ensure healthy, equity-driven and sustainable cities. In Mauritius, urban population rates have doubled in the last fifty years and vehicle ownership has increased by 625 % in only twenty years. There are five towns across the island, but 60% of the population lives on 8% available land. The concentration and multiplication of transport networks and settlements in restricted urban corridors causes overcrowded housing, increased congestion and cumulative poor transport planning.

Transport and Public Health in Port Louis

Port Louis faces major traffic congestion caused by over 200,000 people commuting to the city on working days. Most of them use private motorisation on the motorway that cuts through the city and do not use different integrated transport modes (for eg. no bus or cycle lanes) on its axis. Similar to other African coastal cities, Port Louis transport planning fails to respond to population and spatial growth with heterogenous vehicles using limited and non-adapted road infrastructure. Despite the introduction of a recent metro rail system, Port Louis remains a car-oriented city with very little green space. Pedestrian movement is also limited to unsafe sidewalks, and traffic flow is hampered by narrow roads and side-street parking spaces.

So, what happens if motorisation further increases? Health risks in cities like Port Louis are likely to grow as well – and the health status of the adult population in Mauritius is already characterised by a strong prevalence of diabetes, hypertension and cardiovascular diseases. There is a risk for physical inactivity to increase, as people choose motorised modes instead of walking and cycling. Also, levels of air pollution and traffic deaths are likely to rise.

PQHIA in Port Louis

Participatory Quantitative HIAs (PQHIA) use statistical data and risk assessment modelling to estimate health risks while engaging stakeholders. The aim was to understand and estimate how proposed transport policies would impact the health of residents.

Steps of PQHIA in Port Louis

- Several stakeholders across the public and private sector were engaged in order to design and conduct a local model of PQHIA.
- Participants were interviewed about local urban transport policies and provided their views on what health meant to them, and on the potential health impacts of urban transport.
- Information from the stakeholders were combined with policy reviews, the data on travel patterns, air pollution, traffic deaths and physical activity.
- Health impacts of different transport mode shifts in Port Louis were estimated using a risk assessment approach that compares a reference scenario (the current situation) with three alternative scenarios.
- All scenarios, types of policies and the associated challenges were built in collaboration with stakeholders during focus groups discussions.

Results

Policies to reduce car use on a large scale will not be enough to save lives. One alternative scenario included a strong reduction in both car and motorcycle use indicates health benefits through the increase in physical activity, decrease exposure to air pollution and reduce traffic fatalities. In terms of economic impact, this hypothetical scenario resulted in reductions worth 23 million US Dollars due to the number of averted traffic deaths. Car-dependent designs strongly contradict the main mean of mobility adopted by more than half of urban population in Port Louis: walking. Strong, rather than mild policies targeted at different modes of motorisation – and not only the reduction of private cars will be useful to orient transport agendas towards health and social benefits. It is important to maintain and increase the protective effects of active travel modes such as walking and cycling in Port Louis.

Policy and advocacy recommendations

- Urban transport must be tackled as an opportunity to encourage physical activity
- Transport policies should aim to restrict all forms of private motorized vehicles and promote active and public transport to support public health
- Policies must include specific restrictions for motorcycle traffic.
- Policies promoting the benefits of physical activity should be accompanied by interventions to increase pedestrian and cyclists' safety
- Policies to increase public transport use should provide incentive for users of private motorized modes.

Summary

Using a participatory approach to conduct HIAs in settings such as Mauritius is valuable, and should be conducted in other cities, too. Participatory quantitative HIAs can improve the development of healthy and sustainable transport networks while encouraging stakeholders to actively contribute to the future of their cities. HIAs can facilitate dialogue, bring local knowledge to the table, and use scientific data modelling methods to generate powerful impact estimations. Participatory approaches can help stakeholders to understand the HIA process and encourage them to use HIA outcomes in the field of urban development, climate change and, ultimately, in favour of people and planet.

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Chapter 9: DISCUSSION AND CONCLUSIONS

9. Discussion and Conclusions

This section summarizes the findings by paper (9.1). It provides the overall conclusions of the thesis (9.2), contribution to current knowledge (9.3), strengths and limitations (9.4) and implications for practice and future research (9.5). The thesis was guided by the main research question: How can Health Impact Assessments contribute to inclusive development in low- and middle- income countries?

9.1 Summary of findings

In order to respond to the thesis objectives to understand how HIAs can contribute to inclusive development in LMICs, 5 research papers were presented in chapters 4-8. Two papers examined the practice and policy landscape of HIA in the world (I/II), one paper exposed the alignments between urban transport policy and social needs in the study setting (III) and two papers reported on a full-chain participatory HIA model assessing the mortality and economic health impact of transport mode shift in sub-Saharan Africa, Port Louis (IV/V).

Paper I reviewed and audited HIA trends in LMICs using systematic PRISMA guidelines and a process evaluation assessment to define exactly where and how HIAs are being conducted, by whom, and for what purpose, in LMICs across all regions of the world. With 57 eligible case studies, the paper reports that HIAs were conducted in 26 out of 156 countries, with great variation in the way they are conducted. No study reported the time, money, and staff used to perform HIAs. Only 12% of HIAs were based on participatory approaches; 92% of HIAs considered multiple outcomes; and 61% of HIAs provided recommendations and fostered cross-national collaboration. Barrier to expand HIA practice included limited transparency in process, weak participation, and inconsistent delivery of recommendations.

Paper II addressed the question: How can HIA legislation help developing countries to achieve the Sustainable Development Goals (SDGs)? The article sketched an overview of the global distribution of HIA legislation and identified 25 countries having some form of policy, guideline or framework regulating HIA. It concluded that adequate HIA legislation provides an opportunity for LMICs to achieve SDGs. Benefits of HIA policy include the use of integrative approaches, the promotion of regulatory processes, and the uptake of cost evaluation outcomes. Challenges of HIA policy include the lack of uniformity in HIA practice, the power dynamics around health integration, and the mismatch between policy frameworks and technical objectives.

Paper III assessed the alignment of three government policy measures with citizen needs in an African setting, Port Louis, the capital city of Mauritius, and identified which population groups were most likely to be affected by possible misalignments. The study reported that policies in Port Louis emphasize an economic agenda focused on transport infrastructure rather than addressing public needs geared towards integrating urban transport planning in social life.

Results showed an uneven distribution of urban transport needs across population groups (age, gender, SES) and policies catered for needs most likely to be expressed by the poor. Policies did not cater for reduction in car access, did not contribute to enhancing social co-benefits of transport and did not promote health agendas.

Paper IV addressed the question: What are the major risk exposures and health impacts derived from urban transport planning policies in an African city? The study aimed to conduct and present an HIA of urban transport planning in Port Louis (Mauritius), based on a full-chain participatory HIA model for quantitatively estimating health and economic outcomes. The study found that policies to reduce cars are not sufficient to increase physical activity, decrease traffic fatality and decrease air pollution exposure. It also showed that to achieve health benefits in Port Louis, strong policies should aim to restrict all forms of motorization with particular measures to reduce motorcycle use and increase active travel. Out of the three scenarios, an ideal scenario can lead to 20% savings on the total government budget spent on road accidents and traffic congestion.

Paper V proposed a PQHIA framework based on a field model tested in the case study. The final framework depicted the 5-standard PHIA stages and summarized participatory activities and outcomes. The framework also reflects key factors influencing PQHIA practice and uptake of HIA results: costs for participation, HIA knowledge and interest of stakeholders, social responsibility of policymakers, existing policies, data availability, citizen participation, multi-level stakeholder engagement and multi sectoral coordination. The framework suggests that factors necessary to complete a participatory HIA are the same needed to re-integrate HIA results back into the society. There are three different areas that can provide opportunities to facilitate implementation PQHIAs: good governance, evidence-based policy making, and access to resources.

The following section provides an integrated interpretation of the present thesis by discussing the main findings. After presenting the overall conclusions (section 9.2), it covers the contributions to current knowledge (9.3), the methodological considerations (9.4), the implications for public health and development (9.5) and finally the future research needs (9.6).

9.2 Overall Conclusions

This section presents the overall conclusions of the thesis by assimilating and integrating the findings of Papers I-V. Overall, the thesis succeeded in bringing health into the agenda of urban transport planning by developing and testing a novel PQHIA model in a LMIC setting. The thesis responds to current issues by concluding that HIAs can be an effective tool to integrate health into the agenda of urban transport planning (see section 1.1). Particularly, PQHIA provides a solution to quantify health effects of urban transport policies by using participatory approaches and adapting quantitative modeling to the study context (section 1.2).

The proposed PQHIA (paper V) was designed after a comprehensive examination of HIA practice and policy in the context of LMICs (paper I and II). HIAs in LMICs are scarce and unevenly distributed (Paper I). The existing case studies were hard to identify and evaluate due to bad reporting of methods and unclarity on what resources were used to conduct HIA. These shortcomings can be partly addressed if methods and costs are reported in detail and transparently (Paper V). The thesis brings evidence that HIA practice can also increase if HIA legislation is established (Paper II). Countries having conducted several HIAs (Paper I) were also those identified to have some form of policy, guideline and framework (Paper II). HIA legislation should be grounded in local realities and should consider the important variation and low uniformity in HIA practices in LMICs (Paper I).

The thesis demonstrates that health can be integrated into the agenda of urban transport planning using PQHIA. The case study showed that PQHIA can clarify the nature of health trade-offs in policies (paper IV) and therefore can be used as an advocacy tool for evidence-based policy making (paper V). In Port Louis, the quantification of health trade-offs was completed using three counterfactual policy scenarios. The worse-case transport scenario (doubling in car trips and a reduction in walking, motorcycle, and public transport), resulted in a total increment of 3.28 premature deaths per year. The good-case scenario (reducing car trips by half and increasing walking, motorcycle, and public transport trips) resulted in a total increment of 0.79 premature deaths per year. The only scenario yielding transport-related health benefits was the ideal-case scenario. A reduction in car and motorcycle trips and an increase in walking and public transport trips resulted in a total reduction of 13.72 premature deaths per year and USD 23 millions of economic benefits related to averted mortality (paper IV).

If PQHIAs are well integrated, they provide opportunity to bring health into urban transport policy agendas through evidence-based policy making (paper V). Based on the quantification of health trade-offs, the PQHIA recommended that policies to reduce all forms of motorization with specific focus on motorcycle mode reduction are needed to reduce transport-related mortality. Policies aiming at car-reduction only, are not enough to achieve health benefits in LMICs (paper IV). The PQHIA model engaged stakeholders at every stage which enabled them to identify and assess the magnitude of harmful and beneficial transport-related health impacts, which they would not have considered otherwise (paper V). PQHIA provided a novel, transparent and inclusive process for contextualising quantitative modelling, co-designing HIA with local stakeholders and influencing the uptake of HIA outcomes. By bringing health to urban transport planning, this process thereby provided opportunities for inclusive development.

The novelty afforded by combining participatory approaches with quantitative modeling (paper IV) was useful to address the main research question on how HIA of urban transport planning can contribute to inclusive development in LMICs. PQHIAs contribute to inclusive development, as framed in the context of this thesis (chapter 3), in two ways: (1) multilevel and multisectoral stakeholder engagement and (2) use of quantitative evidence on transport-related health impacts to favour social and environmental goals while considering economic agendas.

Multilevel and multisectoral stakeholder engagement is influential in translating health outcomes into policy decisions in settings facing unequal economic growth and health burden. Cities like Port Louis are at risk of staying locked in unsustainable systems if transport policies do not meet social needs of citizens and do not cater for health and socio-environmental concerns (Paper III). Such HIA-driven policy can work in favor of inclusive development if stakeholders across different sectors and at varying levels of decision-making are provided with tools to understand and estimate health, environmental and social impacts. By estimating mortality burden and economic value of health loss in Port Louis, the HIA outcomes provide an insight on how potential future scenarios can align health and socio-economic agendas, which is something that current policies lack (Paper III). Considering that not all policies may require an HIA, when they do, the selection of the type and scope of HIA in consultation with local stakeholders is an important step, especially in LMICs (paper IV). Participatory approaches in quantitative HIA are complex and demand a nuanced understanding of the needs and affordances of the setting (paper V).

With quantitative evidence, HIAs can highlight that the cost of inaction is greater than the cost of action by indicating the number of lives that can be saved and costs that can be reduced. Although, HIA remains widely under-practiced in LMICs (Paper I), it is possible to assess health impacts of urban transport planning even in a setting where baseline data is scarce, technical and institutional expertise are lacking, policy is inexistent and financial resources are limited (paper IV). HIAs do not need to be expensive or time consuming but they do need to be properly integrated in order to provide health benefits (paper V). In summary, the thesis showed that health can be considered in urban transport planning in LMICs by applying a context-specific PQHIA model combining participatory approaches with quantitative modelling. PQHIA also contribute to inclusive development by involving and considering of different local stakeholders from different sectors in the process of achieving health as well as social and environmental goals.

9.3 Contribution to current knowledge

This thesis contributes significantly to the general state of knowledge related to LMIC-based HIAs (papers I-V). The thesis substantiates current evidence that HIAs are vital to define the linkages between environment and health in poorer countries (1, 15). Particularly, it adds empirical value to studies estimating transport-related health impacts in LMICs (52–55, 57). It confirms that if well integrated, HIAs can enable policy makers to identify the most healthy and sustainable transport policy measures in cities facing environmental hazards and high levels of social inequity (38,89).

Theoretical Reflexions

The combination of the DPSEEA framework and inclusive development theory in the context of HIA was innovative and useful to achieve the overall research aim of integrating health into the agenda of urban transport planning.

DPSEEA functioned as a roadmap to define linkages between driving forces such as motorization and how they subsequently alter states, effects and actions. Equally, DPSEEA provided the opportunity to expose contradictions between driving forces, pressures, states, exposures, effects, and actions. LMICs suffer most (effects) from the externalities of environmental degradation (exposures), yet have less access to resources and tools (such as HIAs) to identify and mitigate health risks (actions). The DPSEEA framework also proved essential to accentuate different entry points for action and evidence-base policy-making. These points (states, exposures and effects) were variables which could be influenced positively by inclusive development approaches.

The concept of inclusivity was useful to frame the participatory dimension of PQHIA. Inclusive development encourages participatory development and focuses on participation in policy making, one of the main rationales of HIA (chapter 8). As a systematic approach, HIA identifies the environmental (218), biological and social (287) factors determining population health outcomes that can be further translated into different policy decisions and actions. Hence, the inclusion of local stakeholders in the design and implementation of PQHIA was conceptualized as a form of action for health and environmental protection. Inclusive development recognises that some populations, areas, regions or sectors may be at disadvantage, hence requiring more adapted approaches to their specific needs. Because LMICs suffer most from unequal economic growth, the inclusive development approach acknowledged structural inequalities faced by urban populations in rapidly developing countries (paper I-II). Particularly, transport is an important measure for economic growth in LMICs while influencing health and social determinants. Therefore, applying inclusive development lens to transport-related HIA is useful to examine trends in policies that may involve environment and social trade-offs in favour of economic development (paper III).

In summary, the theoretical lens framed context-specific PHIA (accounting for DPSEEA variables and inclusivity) as tools that can support evidence-based actions towards achieving development targets. The recent advent of Covid-19 showed that events and exposures initiated in one particular location can affect populations far from the initial point of exposure. Hence, inclusive development provides an important base to examine how LMICs can garner tools such as HIA to compensate for unequal distribution of death and disease within larger processes of urbanization, mass motorization and emergence of transboundary health threats such as air pollution.

Practical Reflexions

This thesis provides an opportunity to address practical aspects of HIA by examining the development and testing of a PQHIA of urban transport policy in the context of LMICs. A relatively recent publication in the *Lancet* stated HIAs can jumpstart proactive action to preserve health by enabling transdisciplinary research, consultation with primary stakeholders and end users, and science-based policy actions, but provided little indication on practical steps to achieve this goal (138).

Building on the important variation and low uniformity in HIA practices, the thesis underlines that countries do not necessarily showcase compliance with existing procedural guidelines (123,150–156), rather they seek to practice HIA within the levels of flexibility and diversity afforded in their own contexts (paper I). This contradicts calls for compliance to standardized HIA practices (82). Many existing guidelines are validated from HIA experts in developed countries (157), and do not cater for variation in political, legal and governance contexts, all of which influence HIA practice.

Indeed, general and opinionated papers (not case studies) substantiate that context-sensitivity is critical by reporting the need for HIA practice targeted at particular regions, specific countries and even, stand-alone institutions (148) (149). HIA needs in Latin America (15, 21) are different from those in South East Asia (139). Approaches to HIA in Nigeria (140) differ from those in Iran (141,142), Thailand (143,144), India (145) or China (146,147). Variations in HIA needs may result from the fact that countries differ in recognition of social determinants of health and approaches to intersectoral responsibility for health (12). Scholars have generally stated that the lack of capacity, technical limitations, lack of data and resources hinder HIA in LMICs (24). They have also generally recommended HIA training, investment in baseline data collection systems and good political timing (15, 17). This thesis contributes further by identifying context-specific elements that can facilitate HIA implementation such as HIA knowledge and interest of stakeholders, social responsibility of policymakers, existing policies, data, citizen organization and participation, multi-level stakeholder engagement and multisectoral coordination (paper V).

Alarming numbers demand serious rethinking and redirecting strategies for participatory quantitative modelling of transport-related health impacts in LMICs. In Asia for example, it is estimated that Bangkok will expand 200 kilometres from its current centre in less than 10 years (168). The situation in Africa is particularly alarming. Every year, 22 million people are added to African cities with 1.34 billion predicted to move to urban settlements by 2050 (169). It is estimated that 60% of African urban populations reside in slums and squatter settlements where quantitative data is practically inexistent and hard to collect (170). Soaring numbers of traffic deaths are also astounding. Africa claims 11.1% of all road deaths even if only 2.8% of vehicles in the world are on the continent (75). Currently 91% of the world's population live in settings not meeting WHO air quality guidelines (288). Air pollution in the Vaal triangle of South Africa, peaked to 281.2 micrograms/m³ (PM₁₀) from 2011-2016 (unpublished data, ISEE conference 2020), more than twenty times the value of WHO guideline level of 10 µg/m.

The findings of this thesis corroborate with existing evidence (28) that very few quantitative HIAs address health impacts and assess large variations in exposures in poor countries (Paper I). Dannenberg and al. explain that clarifying what type of evidence is needed for a rigorous HIA depends on whether the assessment is being conducted on policies or projects (102). This thesis shows it also depends on what is important and relevant for local stakeholders. Not only because they use the quantitative results of HIA but also because they invest, directly or indirectly, human and financial resources for the HIA to be completed. Stakeholder involvement was pivotal to specify what types of data was relevant and what quality of data was available (paper IV).

Undeniably, this process was more proactive than carrying out literature searches (158) or using population profile data from other settings (172).

In Nigeria, Abah et al (2012) recommend to conduct comprehensive health surveys and cross-sectional studies for compensating the lack of reliable health data (140). This was feasible in Mauritius where a full travel survey was deployed and health and demographic data was collected from scratch (paper V). This has also been done in Algeria (172) and Morocco (173), but no studies so far have addressed quantitative data modelling issues in with more than 15 million people cities such as Cairo, Lagos and Kinshasa.

HIAs and Urban Transport Planning

The thesis contributes to knowledge on sector specific HIA of urban transport planning (paper III-IV). There is an astounding lack of HIAs of urban transport planning in LMICs (paper I), where health risks related to motorization and urbanization are high. The thesis confirms that sector-specific HIA of urban and transport planning policies is a promising ground to encourage health and evidence-based decision-making (25). It also highlights that urban transport planning is a policy area likely to have health impacts that can be scientifically estimated, and where there is higher chance for political will to allow the analysis to have a real influence on the outcome (158). Consequently, this thesis emphasized the importance of collaboratively adapting study designs to data availability, considering the capacity of a city to practice HIA, finding ways to recurrently engage stakeholders and considering elements that influence whether or not outcomes can lead to evidence-based policy actions (Paper III-V).

Although no urban transport planning HIAs have been conducted in Africa (paper I), they exist in Asia and Latin America, addressing similar exposures as those presented in this thesis (50–57). The original PQHIA (paper IV) reports that in Port Louis, shifts in transport modes can significantly affect health. Even on a small sample ($n = 77271$), urban transport planning affects mortality. A reduction of car trips from 10% to 1% combined with reduction of motorcycle trips from 16% to 10% can save up to 14 lives per year (half of the average number of people dying on roads in Port Louis). By focusing on the combined health impacts of air pollution, physical activity and traffic deaths, the HIA differs from existing studies focusing on health impacts of air pollutants caused by road traffic (52,56,159,160), and emission of green-house gases (161,162). The lack of data on noise levels and cycling travel mode limited the scope of the proposed HIA, and hindered the possibility of comparison with health impacts of noise emissions from road transportation systems in Turkey (57) and benefits of active travel in Brazil (163).

9.4 Strengths, limitations and scientific validity

This thesis provided valuable insight on the circumstances under which PQHIA can be implemented (paper III), feasible (paper IV) and to what extent elements can influence its implementation (paper V). The proposed PQHIA model was designed in response to different process evaluation aspects lacking in existing case studies (paper I). The model aimed for inclusivity and transparency, the methods were reported in detail, the costs for fieldwork were disclosed, policy recommendations were provided and local stakeholders were engaged various times and throughout the entire process (paper IV and paper V).

Strengths

The main strength of this thesis lied in its empirical approach. It addressed practice rather than potential of HIA in LMICs, a major shortcoming of current studies (17). It focused on regions that have received little attention from HIA scholars. The thesis was also used to build and test the first full chain PQHIA of urban transport planning in Africa. The main strengths were: the novelty of participatory quantitative approach, the process of co-designing scenarios, clear reporting of HIA processes and strategic partnerships.

Novel participatory quantitative approach. The thesis used qualitative information for informing quantitative modelling, a novel approach in the field of transport-related HIA. In transport planning, HIAs are often qualitative, assessing general schemes and effects (96). Yet, qualitative assessments of transport do not provide quantitative and objective estimations that stakeholders apply directly to interventions and policies (291). In quantitative transport-related HIAs, communities (decision makers and citizens) are very rarely involved, which diminished HIA potential for inclusivity, successful implementation or policy utility (96). Therefore, PQHIA was valuable to address local needs and expectations while increasing policy relevance of quantitative HIA estimates.

Co-designed scenarios. The process of co-designing scenarios for quantitative modelling was a strong point of this research. It helped stakeholders to easily understand and embrace HIA, when current studies show that stakeholders in non-health sectors often have insufficient understanding of health consequences of their actions and still perceive health to be associated with diseases and health promotion as opposed to a wider process involving ecosystems and environments (17,102). The scenarios emerged as practical operational tools and 'learning machines' (165) rather than predictive events normally subject to quantitative HIA modelling. This process stood out from other forms of scenario building including modelling around international standards (166) or thresholds set by high income settings (167).

Clear reporting. The thesis adopted clear reporting processes of HIA in LMICs across each study. The process evaluation assessment ran on 57 case studies (paper I) and the quality criteria assessment applied to the participatory quantitative model (paper V) were useful to support this intention. Clear reporting of processes can further support the promising rise in HIA activity (112) by adding evidence on empirical HIA practices.

Strategic partnerships. Finally, the thesis provided avenue for strategic partnerships. In LMICs, 61% (n = 35) of HIAs were published jointly by local and foreign researchers (paper I). During the thesis strategic partnerships were formed between health impact practitioners but also between the researcher and local partners across various institutions and bodies. These partnerships were useful to conduct PQHIA but can also fuel activities, devise strategies for scaling HIAs in LMICs based on local experience, and investing in HIA technical capacity.

Limitations

The thesis had several limitations in terms of inclusivity, sample size of PQHIA, complexity of modelling and generalisability.

Inclusivity. Not all policies, plans or programs require a HIA, but if they do, uncertainty about who decides to conduct and who selects the scope and design of HIA remain. During the PQHIA case study, the screening and scoping steps were important stages to define whether the HIA was needed and its scope (indicator selection, data collection, scenario building, etc.). The participants sampled to address such decision was small and purposefully selected (paper V). Even if self-selected and purposeful sampling is common in qualitative HIA (86), the selection of an ‘elite’ sample was disturbing. selection bias remained a major concern. Beyond the recognised limitations of qualitative methods (small sample size, subjective bias, lack of triangulation, influence of researcher), it is possible that not all relevant stakeholders participated and marginalized (hard to reach) groups were not included.

Sample sizes. The qualitative and quantitative sample sizes used in the PQHIA study were small. For the qualitative sample (n=14), the purpose did not lie in statistical representativity of stakeholders but rather in the ability for HIA practitioners to gather experience, knowledge and opinions, and gain the trust and support of those most likely to be affected by and act on HIA outcomes. Validity was increased using recurrence in meetings, data saturation techniques and feedback exercises. The value of inclusivity and recurrence received more attention than the issue of sample size. For the quantitative sample (n=600), high quality data was collected. Data triangulation was performed between the survey results, government reports and police records.

Modelling of transport-related exposures. The PQHIA was conducted on only three physical exposures and did not include social or mental health determinants of transport-related impacts. Only one fixed monitoring station existed for air pollution data in Port Louis. It did not provide visibility spatial and temporal variability of personal exposures. The impact of traffic air pollution was conservative due to the availability of PM10 data as sole indicator of traffic-related air pollution. Mortality was also the only health endpoints which could be quantitatively estimated and translated into monetary values for further assessment. Risk factors can have joint effects and inferences were necessary to reduce bias caused by discounting (289). Yet, uncertainty remained on the causal network of interaction between AP, PA and traffic fatality in Port Louis. The exposure-response functions for modelling were not based on epidemiological studies from Mauritius but from high-income settings or populations. These included dose–response relationships (RR), the relation between daily and weekly travel behaviour for walking and cycling, mode-specific ventilation rates and air pollution ratios by microenvironments. This may have led to underestimation of mortality effects in LMICs with different conditions and exposures. Similarly, economic evaluation of mortality must be interpreted with care and understood as a change in exposure-related mortality risk of a population (290), rather than the economic value of attributable deaths.

Generalizability. Finally, the complexity of urban areas as well as the varying size, density and infrastructure of transport systems in cities of LMICs (22) challenges some attempt, if any, to generalize findings. The proposed PQHIA model was tested on only one case study setting. Some form of generalization would have been possible to ensure if one could define what a good quality HIA looks like. For generalisation of approach and findings, the issue of HIA quality is important especially considering aforementioned uncertainties and methodological assumptions involved in quantitative modelling (32,166). Similarly to 15 years ago, the majority of HIAs are still conducted outside legislative or regulatory requirements (174). This may partly explain challenges to generalization because HIAs are being instigated in ways that may be hard to evaluate (219) and increasing the complexity in defining what high-quality HIA looks like. As it stands, the thesis supports that some aspects of quality may lie in practical lessons learnt rather than generalizability. Overall, several practical processes that may contribute to increase HIA quality include (1) transparency in participatory and modelling processes (2) recurrence in meetings with participants (3) participants feeling that their input was valuable and considered (4) review of modelling techniques within research teams (5) comparison of techniques with other HIAs from similar sector and settings, (6) systematic and detailed reporting of each step and (7) submitting HIA to peer-reviewed journals for scientific validation.

Scientific validity

The thesis research applied several strategies to increase scientific validity of approach and findings and reduce bias. For paper I and II, bias was reduced by achieving consensus and resolving differences between researchers about eligibility criteria and selection methods. Materials were reviewed by more than one researcher and validation of which case studies and policies were to be included occurred by agreement with all reviewers. For paper III to V, researcher bias was reduced during interviews, focus groups and feedback exercises by avoiding errors related to reactivity (effect of researcher on the setting). A combination of semi-structured guides and open-ended questions were used. After each session, informants were provided feedback material. The data obtained was translated verbatim, the coding of qualitative data was cross checked by a second researcher, and qualitative interviews were stopped once data saturation was achieved. For paper IV, error in data collection was reduced by contracting fieldworkers who were trained and experienced. They also followed two supplementary training specific to the data collection technique and software. For the quantitative component, the questionnaires were completed with the assistance of trained research assistants. The questionnaire was prepared, piloted, validated and back-translated in collaboration with the Mauritian fieldwork manager. The questionnaire and interview guides were also piloted before data collection to ensure content validity. Finally, to reduce error in quantitative modelling, sensitivity analysis was conducted for indicators with less robust primary data (air pollution and physical activity) (chapter 7).

9.5 Implications for Public Health

The findings of this thesis can guide and inform HIA practice and policy in LMICs. This section presents the implications for public health and advancement in PQHIA and concludes on future research priorities.

Public health implications

Car centric trends and motorization contribute to burden of death in urban settings like Port Louis (paper IV and V). LMICs will benefit strongly from HIA tools focusing on urban transport which is currently a sector receiving less academic attention by HIA practitioners (paper I). Strong policies accounting for different exposures are needed to achieve health benefits through urban transport planning are needed. Physical activity decreases with urbanization and motorization. In LMICs, the walking mode share is already very high, so the need to focus on alternative forms of active travel to increase level of physical activity is necessary. Cycling can offer many health benefits by reducing sedentary lifestyles and encouraging regular levels of physical activity. Besides enhancing health, cycling is environmentally-friendly, cheap, offers flexible mobility and supports multimodal transport connections (26,295). In many cities of LMICs, bicycle mode share is considerably low, despite growing evidence of health utility of cycling (296). Some evidence indicates that negative image of cycling, lack of infrastructure and failure to incorporate cycling into transport planning may explain low cycling adoption (297). Therefore, in order to use cycling as a means of public health promotion and reduce car-dependency, groundwork may involve changing perceptions on cycling, but also changing attributes of the environment (traffic signals and calming congestion measures) that can positively influence attitudes and behaviour about cycling.

Practice implications for HIA advancement

The wide practice of HIA in high-income settings (13, 16, 34,171) results in guidance documents mostly developed by experts from richer countries, and based on local evidence and experience (17). In order to build practice guidelines that also consider features of LMIC-based HIAs, this thesis underlines the importance for HIA practitioners in LMICs to define, detail and report their approaches carefully and with rigour; so that research activities are clear, systematic, transparent and replicable. HIA-related data and outcomes can also become accessible to wider audiences including affected communities using existing open access databases, journals and reference directories (<https://www.who.int/heli/impacts/impactdirectory/en/index12.html>.) Increased visibility on lessons learnt, challenges and best practices of HIA in LMICs is needed. HIA training activities can then be developed while providing flexibility for settings with varying experience, limited resources and technical expertise in HIA. Educative programs and capacity building will fill both gaps in human resources addressing health in non-health sectors such as transport. In LMICs already practicing HIA, monitoring and post-evaluation exercises to follow-up on health impacts that have already been identified and estimated can be organised. In the case of prospective HIAs, these exercises can help validate methods, further test assumptions and verify whether extrapolations are still valid.

Policy implications for HIA advancement

Focusing on policy implications of HIA provides some insight on how HIA is effective once it is implemented (174,177,178). There is a necessity for policymakers and urban planners to become more aware of the uneven distribution of needs across population groups and cater for needs most likely to be expressed by vulnerable populations (paper III). In this way, urban transport policies can promote inclusive social agendas responding to citizen needs. If policy makers are to introduce HIA legislation in LMICs (paper II). City level legislation may be faster and easier to establish because cities evolve fast and react quicker than countries (176). Examples from other LMICs are available and can be used as blueprints (see Thailand, paper II). Further, if HIAs are incorporated in local policies and governance systems, it is crucial to establish evaluation and monitoring processes that assess their progress and effectiveness. For example, the thesis suggests the use of HIAs to operationalise the SGD framework (paper II). This may (1) enable the monitoring of HIA implementation at national levels (2) afford comparability and progress of HIA across countries and (3) establish a roadmap for integrating health effectively in decision-making.

This thesis focused on HIA for policy (not plans, programs or projects). Policy-makers are to be reminded that not all policies, plans or programs require an HIA. Nonetheless, stakeholders in LMICs should be aware of this approach as key tool to integrate health in all policies(12). If they are aware of HIA, they should have access to resources that enable them to find answers to policy or research questions in previous HIAs. HIA is a fairly new field and the lack of awareness about how to use this tool and what it implies is common among stakeholders, including health practitioners. Context specific methods must be encouraged to inform policy makers that HIAs are not necessarily expensive, time consuming, and restricted to academia.

9.6 Future research priorities

Future research needs on HIAs in LMICs must align with three major priorities: health inequity, climate change and data systems.

Health inequity

The widening inequities in cities of LMICs mandate for HIAs assessing equity impacts of urban policies (54). Health impacts are likely to vary in population groups of different age, sex, ethnicity or socio-economic status. Equity impacts in HIAs can be estimated using specific metrics and indicators of multiple deprivation as indicated in existing LMIC literature (181): access to clean water, availability of indoor lavatory and drainage system, type of houses and roofing sheet, type of cooking fuel and location of cooking area, access to electricity, and traffic density. Given the linkages between low socio-economic status and use of active travel modes (walking and cycling), particular attention is needed on the net health effects of cycling modes in LMICs (182). Other relationships between travel patterns and risk factors that have not yet been addressed in LMICs are of importance, particularly noise, heat, social cohesion, quality of life, violence and mental health.

Climate change

Recent urban history in Africa brings evidence that climate change affects cities in four major ways: rising sea levels, flooding in urban coastal areas, infrastructure damage, and reduction in availability of water (64,183). In the USA, HIA has already been used to assess climate change impacts (184), indicating cases of policy-driven HIAs on cap-and-trade legislation, heat-wave and sea-level-rise mitigation and adaptation, transportation policy impacts of climate change, carbon-reduction strategy scenarios, soil- and water-conservation strategies, urban forest canopy for climate adaptation, overheating buildings, and regional transportation plan and sustainable community strategies. It is estimated that LMICs will bear the highest burden of climate change, despite contributing the least to its causes. Already, sub-Saharan Africa bears 34% of global DALYs attributable to effects of climate change and has limited tools to relate climate to disease (183,185). Climate change provides an overarching structure upon which HIAs in LMICs can develop. Not only in terms of increased vulnerability to global changes such as demographic growth patterns, land use changes and depletion of natural resources that themselves magnified implications for health, but also in terms of accessing funding and support to mitigate climate change effects.

Data systems

Future studies should focus on data collection and integration programs to facilitate practice and application HIA in policy making (52). Technology and data management systems are needed to standardise and regularise data on mobility survey, environmental monitoring and measuring. Research should focus on gathering context- and population-specific evidence on exposure-risk gradients (example ERFs) in tropical areas. Beyond quantitative data, studies should also focus on frameworks and guideline to collect qualitative information and examine participatory HIA processes in contexts with low governance. Adequate data systems are needed to provide relevant and time-sensitive information. It is crucial to assess the time-lag between immediate and long-term health impacts especially because land use patterns and demographic shift in cities of LMICs are occurring rapidly.

Concluding Note

In summary, this thesis concludes that while several barriers to implementation of HIAs worldwide remain, there are opportunities to bring health to urban transport planning agendas using participatory quantitative HIAs. PQHIAs can assess transport-related health impacts by examining the effects of policy (ex: car and motorcycle reduction) on physical (traffic deaths), behavioural (physical activity) and environmental (air pollution) health determinants. The PQHIA case study indicates that 14 lives per year can be saved in the city of Port Louis policies reduce cars and motorcycle mode shares in favour of public transport and walking mode shares. Because walking mode share in Port Louis is high (as it is in many LMIC cities), policies toward promoting cycling to increase physical activity should be explored.

PQHIAs provide flexibility in participatory methodology and quantitative modelling that can benefit LMICs even if samples are small, resources are limited and data is scarce.

Participatory input in quantitative modelling is useful to assess which policies currently exist, what resources are available, the feasible scale for assessment, what data is available, what data can be collected, which indicators count the most and whether stakeholders are able and willing to uptake the results after HIA is completed. Finally, the thesis helped identify different areas of opportunities for investing in participatory quantitative HIAs that can be used as building blocks for knowledge sharing and exchange in countries most vulnerable to environmental and health risks. With clear implementation protocols, adapted legislation, good governance and strong evidence-based policy-making, HIAs can be properly integrated in LMICs, in favour of healthy and environmentally sustainable transport systems and cities.

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ANNEXES

Annex A: Co-authorships

Book

Zaheer Allam, David Jones and Meelan Thondoo (2020). 'Cities and Climate Change: Climate Policy, Economic Resilience and Urban Sustainability'. Palgrave Macmillan.

Scientific Articles

Ramirez-Rubio, O., Daher, [...], Thondoo, M. et al. (2019). 'Urban health: an example of a "Health in All Policies" approach in the context of SDGs implementation'. *Global Health* 15(1):87.

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Thondoo M., Rojas-Rueda, D., de Vries, D., Gupta, J., Naraynen N., Nieuwenhuijsen, M.J. (2020). 'Data for a city-level health impact assessment of urban transport in Mauritius'. *Under review*.

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Annex B: Media Materials

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Bagatelle, Port Louis © Meelan Thondoo

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Sustainable Africa: Why Cities of the Future Must Consider Health in Urban Planning

By Meelan Thondoo and Mark Nieuwenhuijsen | September 29th 2020 | Global Urban Debates, Urban Health, coastal cities, mauritius, port louis

In a rapidly urbanising world, cities must consider the health impacts of urban policies and projects. Meelan Thondoo and Mark Nieuwenhuijsen highlight the situation in Mauritius' capital Port Louis and make a strong case for participatory quantitative Health Impact Assessments, a promising and practical tool to ensure healthy, equity-driven and sustainable cities

Mauritius is a small island nation located in eastern sub-Saharan Africa. It is often pictured as a paradise island with long pristine beaches, yet it is the densest country in Africa. Urban population rates have doubled in the last fifty years and vehicle ownership has increased by 625 per cent in only twenty years. There are five towns across the island, but sixty per cent of the population lives on eight per cent of available land. The concentration and multiplication of urban settlements in restricted corridors causes overcrowded housing, unsafe working conditions, increased congestion and cumulative poor transport planning.

Transport and Public Health in Port Louis

Port Louis, Mauritius' capital, is a coastal city very much comparable to many other African coastal cities. Holding the main port, it is the economic and administrative engine of the island. In the local language, Mauritian Kreol, people often say: "Dan Porlwi? Mari trafik sa!" – meaning "In Port Louis? The traffic jam is too intense!" Indeed, major traffic congestion is caused by over 200,000 people commuting to the city on working days. Despite the introduction of a recent metro rail system, Port Louis remains a car-oriented city with very little green space. Pedestrian movement is also limited to unsafe sidewalks, and traffic flow is hampered by narrow roads and side-street parking spaces.

So, what happens if motorisation further increases? Health risks in cities like Port Louis are likely to grow as well – and the health status of the adult population in Mauritius is already characterised by a strong prevalence of diabetes, hypertension and cardiovascular diseases. There is a risk for physical inactivity to increase, as people choose motorised modes instead of walking and cycling. Also, levels of air pollution and traffic deaths are likely to rise.



Port Louis has a very high population density © Allan Beaufour/flickr (CC BY-NC-ND 2.0)

Indeed, urban transport planning can play a crucial role in either preserving or degrading human health. Unless decision-makers consider the dimension of health on urban transport planning agendas, countries face the risk of getting locked in unhealthy and unsustainable systems. But how can we identify the most healthy and sustainable transport policy measures? Health Impact Assessment (HIA) is a powerful impact assessment tool that does just that.

Participatory Quantitative Health Impact Assessment (PHIA) for Port Louis

HIA is an approach that can judge the potential effects that an intervention, a project, a program or a policy, can have on people's health. Quantitative HIAs are most common and use statistical data and risk assessment modelling to estimate health risks. In contrast, participatory quantitative HIAs (PHIA) are very rare, even though participation and inclusion of stakeholders is highly encouraged and promoted by the scientific community.

Our main goal was to understand and estimate how proposed policies would impact the health of Mauritius' capital. In 2018/2019, we met for eight months with several stakeholders across the public and private sector in order to design and conduct a local model of PHIA in Mauritius. Participants were interviewed about local urban transport policies and provided their views on what health meant to them, and on the potential health impacts of urban transport. By combining the information provided by the stakeholders with policy reviews, the data on travel patterns, air pollution, traffic deaths and physical activity, we then estimated the health impacts of different transport mode shifts in Port Louis, using a risk assessment approach that compares a reference scenario (the current situation) with three alternative scenarios. All scenarios, types of policies and the associated challenges were built in collaboration with stakeholders during focus groups discussions.

What would, for instance, happen if we implement a policy that reduces car use on a large scale? One of the alternative scenarios included a strong reduction in both car and motorcycle use. We found that this would in fact increase physical activity, decrease exposure to air pollution and reduce traffic fatalities. In terms of economic impact, this hypothetical scenario resulted in reductions worth 23 million US Dollars due to the number of averted traffic deaths. In our calculations, the other two scenarios would lead to a significant decrease in the health of the local population.



Port Louis Harbour view © carrotmadman6 / flickr (CC BY 2.0)

Implications for Policy Makers

A scenario aiming at decreasing motorisation significantly is thus highly recommended for cities similar to Port Louis. This, however, would require strong, rather than mild policies targeted at different modes of motorisation – and not only the reduction of private cars. With the increase in motorcycle use in African coastal cities such as Lagos, Accra and Mombasa, the existing policies aimed at taxation on private vehicles or restriction on vehicle purchase based on age may not be enough. They may also be weak to counter the tendency of policy to favour car mobility in a world where transport agendas often disregard health. What's more is that in cities like Port Louis, car-dependent designs strongly contradict the main mean of mobility adopted by more than half of urban populations: walking. Given that many African cities are relatively new or yet to be built, it is crucial to consider strong policies that aim at reducing all forms of motorisation. Instead, we need to invest in ways to maintain and increase the protective effects of active travel modes such as walking and cycling.

The Future of HIA in African Coastal Cities

Tools such as the HIA are known to support the integration of health into wider policy agendas focused on urban development. But in reality, many political and institutional decisions are taken without considering their related health impacts. Coastal cities in Africa will bear the unjust burden of climate change effect due to rising sea levels, flooding in urban coastal areas, infrastructure damage and reduction in the availability of water. Therefore, it is crucial to extend the application of HIAs.

We consider that using a participatory approach to conduct HIAs in settings such as Mauritius is valuable, and should be conducted in other cities, too. Participatory quantitative HIAs can improve the development of healthy and sustainable transport networks while encouraging stakeholders to actively contribute to the future of their cities. HIAs can facilitate dialogue, bring local knowledge to the table, and use scientific data modelling methods to generate powerful impact estimations. Participatory approaches can help stakeholders to understand the HIA process and encourage them to use HIA outcomes in the field of urban development, climate change and, ultimately, in favour of people and planet.

Annex C: Comparative table of Impact Assessments

Assessment type	Definition	Pros	Cons	Health mentioned in at least one
Health Impact Assessment (HIA)	‘ a combination of procedures, methods and tools by which a policy, programme or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population’ (33)	Potential to change or influence decisions, build strong and enduring relationships with other sectors, and develop an understanding of the priorities and perspectives of different stakeholders (103)	Lack of agreed methods and gaps in the evidence base for health impacts (81)	Gothenburg Consensus Paper (33)
Environmental Impact Assessment (EIA)	‘ a planning instrument for predicting the effects on the environment from altering or building a new establishment’ (105)	Universally recognised as a key instrument for environmental management & embedded in domestic and international environmental law (97)	Poor quality of reports and unclear purpose (106)	National Environmental Policy Act (NEPA) (1969) (96)
Strategic Environmental Assessment	‘ a decision making support instrument for the formulation of sustainable spatial and sector policies, plans and programmes, aiming to ensure an appropriate consideration of the environment’ (107)	Extends IA to higher level decision making, less project oriented than EIA & real influence on the choice of alternative developments during the earlier stages of decision-making (108)	Patchy compliance to recommendations due to flexible process, weak implementation process and poor follow-up (108)	Esposo Convention (2003) & Budapest Declaration on Environment (2004)
Sustainability Assessment	‘ a process by which the implications of an initiative on sustainability are evaluated, where the initiative can be a proposed or existing policy, plan, program, project, piece of legislation, or a current practice or activity’ (95)	Specifically focuses on sustainability criteria & promotes sustainable development through the integration of social, environmental, and economic consideration in development plans (97)	Subjective approaches and understandings of sustainability (97). No reference to environmental authorities to be consulted and no final report on public	The Equator Principles (2003) (111)

Table 4: Comparative Table of Impact Assessment tools

Annex D: About the Author



Meelan Thondoo was born on the 5th of September in Mhangura, Zimbabwe. She spent her childhood in the Seychelles. In 2000, she moved with her family to Switzerland to continue her education. Meelan holds a Bsc. in Biology (University of Geneva), Msc. in Medical Anthropology (University College London) and Msc. in Public Health Economics (London School of Hygiene and Tropical Medicine). Her passion for improving health in vulnerable populations across the globe led her to apply for the position of doctoral candidate for the Transglobal Health - Erasmus Mundus Joint Doctorate Program. In 2017, she was selected to develop a Health Impact Assessment (HIA) model applicable to fast developing cities in low- and middle-income settings.

Meelan is interested in applying evidence-based research for increasing quality of life in vulnerable populations. She applies mixed-method approaches to address human condition in a dynamic, creative and context-specific manner. She has worked for the Government of Mauritius, University College London and the World Health Organisation. She has participated in projects funded by DFID UK and Bill and Melinda Gates Foundation. She has completed community-based fieldwork in East Africa (Mauritius, Tanzania & Mozambique), Latin America (Ecuador & Uruguay) and South-East Asia & Pacific (Nepal, Philippines & Laos).

Over the last three years, Meelan has studied and obtained empirical experience in HIAs of Urban transport policies in resource-constrained settings. She hopes this PhD can bring a humble contribution to increasing positive health impacts of urbanization and implementing policies in favour of the health of people and planet.

