

# To put an end to car dependence

Final report of the scoping review of the literature on the modal shift from the car to alternative modes 2010-2020

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# Table of Content

List of Figures .....	iv
List of Tables .....	v
List of Acronyms .....	vi
Thanks .....	vii
Résumé .....	viii
Abstract .....	ix
Introduction .....	1
Context .....	1
Research Objectives .....	2
Methodology .....	3
1) Identification of Relevant Studies .....	3
2) Selection of Studies .....	5
3) Data Mapping .....	7
4) Gather, Summarize and Report the Results .....	8
Results .....	8
Basic Characteristics of the Selected Literature .....	9
Geographical Distribution of Cases Discussed .....	10
Chronology of the Publications Analyzed .....	12
Who Is Targeted by Modal Shift Research? .....	12
The Alternative Modes Studied .....	13
Approaches and Design of Admitted Studies .....	15
Urban Structure of the Fieldwork Studied .....	15
Analysis of Research Findings .....	16
The Effect of Interventions on Modal Shift Depending on their Type .....	18
A) Habits Anchored in the Daily Life of Motorists .....	19
B) Values, Preferences, and Lifestyles .....	21

C) Impact of Economic Levers such as Pricing of Public Transport or Automobility Externalities .....	22
D) Automobile Alternative Transport Supply (Effects of) and the Spatial Distribution of its Infrastructure.....	23
E) Land Use Planning (Effects of) and Residential Locations .....	26
The Effect of Modal Shift Strategies Tested According to their Type (Carrot or Stick) .....	27
“Carrot”-Type Measures .....	28
“Stick”-Type Measures.....	35
Implications for Policy, Practice and Research.....	36
Mostly Conclusive Results.....	36
A Growing Research Topic .....	36
A Mostly Quantitative Research.....	37
Diversified Research, but Which Would Benefit From Being More Varied.....	37
Research That Does Not yet Take New Policies into Account.....	38
And Canadian Research in All of This .....	39
Conclusion .....	39
Main Findings .....	39
Limits of our Approach .....	40
Next Steps.....	41
At the Research Level.....	41
Communications With Practitioners .....	41
Scientific Communications.....	42
Appendix.....	I
Appendix 1 - List of Cited References.....	I
Appendix 2 - Documentary Search Strategy .....	VIII
Appendix 3 - Data Tables.....	IX
Appendix 4 - Bibliography of Works Included in the Scoping Review.....	XIII

## List of Figures

Figure 1 – Diagram of the analytical framework of the scoping review .....	3
Figure 2 – Methodology of the scoping review .....	3
Figure 3 – Process for identifying and selection of articles .....	9
Figure 4 – Map of cases reported in the articles analyzed.....	11
Figure 5 – Timeline of articles analyzed.....	12
Figure 6 – Target audience of the articles analyzed .....	13
Figure 7 – Mode of transport towards which the modal shift is analyzed.....	13
Figure 8 – Chronology of the articles analyzed according to the modes of transport.....	14
Figure 9 – Type of research approach.....	15
Figure 10 – Research design.....	15
Figure 11 – Urban structure of the fieldwork studied .....	16
Figure 12 – Result of interventions aimed at generating modal shift .....	17
Figure 13 – Effect of interventions by mode of transport.....	17
Figure 14 – Type of intervention studied.....	18
Figure 15 – Effect of interventions on the habits anchored in the daily life of motorists.....	20
Figure 16 – Effect of habit-type interventions depending on the mode of transport .....	20
Figure 17 – Effect of interventions addressing values, preferences, and lifestyles .....	21
Figure 18 – Effect of value-type interventions depending on the mode of transport.....	22
Figure 19 – Effect of interventions on the impacts of economic levers.....	23
Figure 20 – Effect of economic lever-type interventions depending on the mode of transport.	23
Figure 21 – Effect of automobile alternative transport supply and the spatial distribution of its infrastructure.....	24
Figure 22 – Effect of alternative supply type interventions depending on the mode of transport .....	25
Figure 23 – Effect of interventions relating to land use planning and residential locations .....	26
Figure 24 – Effect of land use planning type interventions depending on the mode of transport .....	27

Figure 25 – Effect of strategies according to their type.....	28
Figure 26 – Effect of free or financial incentive-type interventions .....	29
Figure 27 – Effect of trial period type interventions .....	29
Figure 28 – Effect of information, marketing and real-time information interventions.....	30
Figure 29 – Effect of interventions such as improving quality, efficiency or accessibility .....	31
Figure 30 – Effect of park-and-ride type interventions.....	32
Figure 31 – Effect of supplying a shared mobility service type interventions.....	32
Figure 32 – Effect of interventions such as adding a transport infrastructure .....	33
Figure 33 – Effect of interventions adding new transport infrastructure depending on the mode of transport.....	33
Figure 34 – Effect of interventions such as tariff constraints on the automobile .....	35
Figure 35 – Effect of interventions such as changes in the space dedicated to the automobile	36

## List of Tables

Table 1 – Sources consulted.....	5
Table 2 – Article eligibility criteria .....	6
Table 3 – Exclusion criteria.....	7
Table 4 – Documentary Search Strategy .....	VIII
Table 5 – Types of intervention discussed in the literature .....	IX
Table 6 – Carrot and stick measures analyzed in the literature .....	X
Table 7 – The modal shift strategies that have been tested in the literature.....	XI

## List of Acronyms

BRT	Bus Rapid Transit
GHG	Greenhouse Gas
P&R	Incentive Parking
AT	Active Transport
PT	Public Transport

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## Résumé

Cette recherche répond à la question suivante : quelles sont les principales stratégies de transfert modal discutées dans la littérature des 10 dernières années. Elle entreprend aussi d'analyser les impacts de chacune des stratégies présentes dans littérature. Elle présente une étude de la portée de la littérature visant à dresser un portrait à jour de l'abondante littérature sur le transfert modal afin de la synthétiser et de la présenter de façon organisée et d'en tirer des constats pour la recherche future et les politiques de transport et d'aménagement visant à réduire la dépendance automobile et à induire un transfert modal de l'automobile vers les modes de transports alternatifs. Nous avons révisé 2872 études publiées entre 2010-2020 et en avons retenu 108 que nous avons analysées en détail.

Plus de deux tiers des études rapportent des résultats positifs de transfert modal de la voiture au profit des mobilités alternatives. Ce qui nous porte à croire qu'il est possible de mettre en place des politiques publiques afin de faciliter le transfert modal et d'ainsi contribuer à réduire la dépendance à l'automobile. Parmi les recherches portant sur les transports en commun, une grande majorité rapporte des exemples positifs. Cependant, du côté des études portant sur le transport actif, nous notons que la presque totalité des recherches (92 %) rapporte des succès. En portant attention au degré de coercition des interventions enquêtées dans la littérature, on constate que les mesures « carotte » qui cherchent à induire le transfert modal en offrant un bénéfice ont plus de succès que les mesures de type « bâton » qui visent à restreindre certains choix (tarification, péage, diminution des espaces de stationnement). Cependant, les recherches portant sur la combinaison « carotte et bâton » rapportent les résultats les plus positifs. Ceci nous amène à conclure que la recherche sur ce type d'intervention devrait continuer à être développée, voire encouragée, et à suggérer aux décideurs publics de tenir compte des effets bénéfiques pour le transfert modal provenant de la combinaison des deux types d'interventions simultanément « carotte et bâton ».

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## Abstract

This research answers the following question: what are the main modal shift strategies discussed in the literature of the last 10 years? It also undertakes to analyze the impacts of each of the strategies present in the literature. It presents a scoping review of the literature aiming to draw an up-to-date portrait of the abundant literature on modal shift in order to synthesize it and present it in an organized manner and draw conclusions for future research and transport and development policies aimed at reducing automobile dependence and inducing a modal shift from the automobile to alternative modes of transport. We reviewed 2,872 studies published between 2010 and 2020 and retained 108 that we analyzed in detail.

More than two thirds of studies report positive results of modal shift from the car towards alternative mobility. This leads us to believe that it is possible to implement public policies to facilitate modal shift and thus help reduce car dependence. A large majority of research on public transport reports positive examples. However, for studies on active transportation, we note that almost all of the research (92%) reports successes. By paying attention to the degree of coercion of the interventions investigated in the literature, we see that the “carrot” measures which seek to induce the modal shift by offering a benefit are more successful than the “stick” type measures which aim to restrict certain choices (pricing, tolls, reduction of parking spaces). However, research on the “carrot and stick” combination approach reports the most positive results. This leads us to conclude that research on this type of intervention should continue to be developed, even encouraged, and to suggest that public decision-makers take into account the beneficial effects for modal shift resulting from the combination of the two types of interventions simultaneously “carrot and stick”.

# Introduction

## Context

The Canadian population living in urban centres represented approximately 82% of the total population in 2020 (Banque Mondiale, 2021). Municipalities must juggle the mobility needs of the population to maximize land use and reduce the resulting economic, social and environmental pressures. A growing number of studies report government and municipal initiatives that have addressed this challenge through modal shift interventions. The objective of this synthesis of knowledge on modal shift practices is above all to help enlighten public decision makers in their projects aimed at implementing public modal shift policies. The general objective of this research is to produce a synthesis of scientific knowledge from the past ten years on practices aimed at modal shift. It also aims to enlighten the scientific community on the blind spots of existing research, in order to properly direct subsequent research projects.

Urban populations are increasingly mobile and Western cities are built on this model of increasing mobility (Amin & Thrift, 2002, p. 43). However, this high mobility comes at a cost; negative repercussions (or externalities) of mobility systems. Personal automobile-based mobility is a significant contributor to greenhouse gas (GHG) emissions (Sims et al., 2014). The transport sector is one of the main generators of GHGs. This is why, and especially since the signing of the Paris Agreement (of which Canada is a party), nations must step up efforts to reduce these emissions. However, a large majority of households in Western cities still depend exclusively on the automobile for their mobility (P. Jones, 2011, p. 43), in particular for long journeys (Villeneuve, 2017). While at another time, the public authorities transformed cities to adapt them to the automobile under the pressure of powerful lobbies (Bergeron, 2005), the use of the car has become essential for many individuals in order to deploy increasingly complex activity programs (Dupuy, 1999; Newman & Kenworthy, 1989). This situation explains the growth in automobile use, even in urban areas. This mode of transport is currently the one that offers the most combinations of activities to the user in time and space. This is all the more true as the temporal coverage of public transport services is generally incomplete, making it difficult to deploy complex activity programs based solely on the use of this mode of transport. Perl & Pucher (1995, p. 262) already denounced this situation in Canada in 1995: “[...] we detect symptoms of declining [public transit] performance which threaten public finance, environmental quality, and a host of other factors that contribute to Canada's high quality of urban life”. They established the important link between increased automobile use in Canadian cities and land use planning: “unless the last decade's trend towards low-density, dispersed land use can be reversed, the automobile will become the sole urban transport option for more and more Canadians” (idem, p. 279).

In developed countries, household car ownership has increased significantly over the past 40 years (D. W. Jones, 2008). The phenomenon is well documented in Canada (Vandersmissen et al., 2004) as well as in France (Collet, 2007; Dupuy, 2000; Gallez & Madre, 1993; Petev & Coulangeon, 2012) and in the United States of America (DW Jones, 2008; Seiler, 2008). This high rate of automobile ownership and the organization of society around the automobile can lead to what some authors have called car dependence. According to Dupuy (1999, p. 50) “[...] when the automobile system grows, it is common for alternative systems to deteriorate”, in particular the public transport system (PT) which loses customers to the benefit of the automobile, thus reducing its efficiency, as it becomes more and more expensive to provide service over longer distances for fewer customers. In order to avoid this vicious cycle and reduce the negative externalities of automobile use, transport and planning policies increasingly rely on a modal shift from the automobile to public transport or non-motorized alternatives (Batty et al., 2015; Hausser et al., 2020).

An important literature has developed exploring the question of modal shift in several contexts. Although a few reviews of the literature exist on modal choices, such as Redman et al. (2013) who provide a review of research on aspects of PT that represent a potential attraction for motorists; Wu et al. (2020) who review the literature on the environmental impacts of modal choices and Nikulina et al. (2019) who present a review of the literature on the types of arrangements likely to generate more sustainable mobility for people, to date we have not found any literature reviews or meta-analysis that can be used to synthesize the results of research focusing more specifically on modal shift.

## Research Objectives

This research answers the following question: what are the main modal shift strategies discussed in the literature of the last 10 years? For each of the strategies present in the literature, we have also undertaken to study the impacts.

Thus, this scoping review of the literature aims to provide an up-to-date portrait of the abundant literature on modal shift in order to synthesize it and present it in an organized manner. The research question is therefore divided into five specific sub-objectives linked to the challenges of modal shift, represented in Figure 1, among which will be identified the different modal shift strategies, namely: A) the habits anchored in the daily life of motorists (Bouscasse et al., 2018; Cass & Faulconbridge, 2016; Meissonnier & Richer, 2020); B) values, preferences, and lifestyles (Anable, 2005; Beirão & Sarsfield Cabral, 2007; Scheiner & Kasper, 2003); C) the impact of economic levers such as public transport pricing or automobility externalities (Blanquart, 2017; Brakewood et al., 2020; Štraub, 2020); D) the effects of the supply of alternative transport and the spatial distribution of their infrastructure (Cheng & Chen, 2015; Clayton et al., 2014; Coll et al., 2014; Grisé & El-Geneidy, 2018; Kimpton et al., 2020); and E) effects related to land use

planning and residential locations (Holz-Rau et al., 2014; Humphreys & Ahern, 2019; Scheiner & Kasper, 2003).

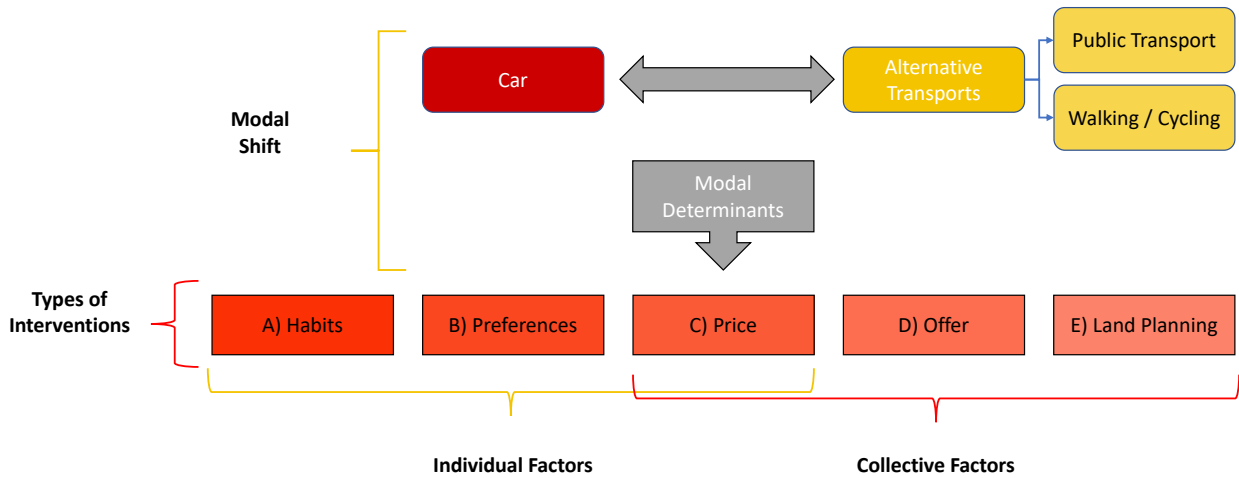


Figure 1 – Diagram of the analytical framework of the scoping review

## Methodology

The knowledge synthesis project is based on the scoping review approach since we believe that the large number of articles and the diversity of approaches that should be included make the systematic review less relevant. To do this, we borrowed a method typically used in health research and applied it to study a transportation challenge as if it were a health problem. The modal shift being the “medical treatment” that we are trying to examine through this project. We used the literature scoping review methodology suggested by Arksey and O’Malley (2005) incorporating improvements proposed by Levac et al. (2010) and Teare and Taks (2020). According to this protocol, the methodology is deployed in 4 phases (Figure 2).

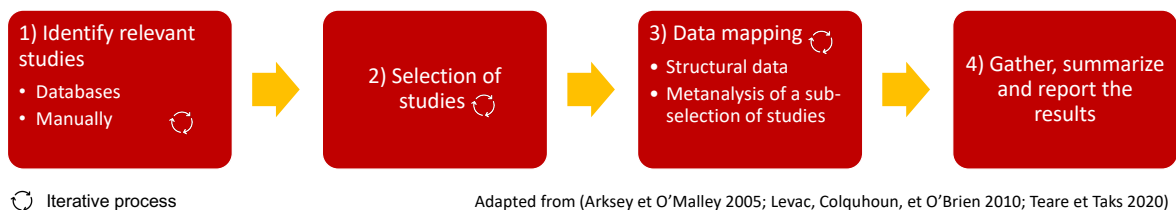


Figure 2 – Methodology of the scoping review

### 1) Identification of Relevant Studies

This phase consists of identifying the relevant studies. As suggested by Teare and Taks (ibid.), we used the dual strategy of searching databases using keywords, but also manual searching in the

most important scientific journals according to the perceptions of the members of the research team.

For the first step, a search strategy was developed by one of the co-investigators, then revised by the rest of the team. The latter allowed the identification of a set of keywords related to modal shift (see Table 4 in the appendix) that can be used to carry out a systematic search in seven databases, namely Web of Science, Pubmed, GeoBase, Embase , Ovid, Érudit and CAIRN. In order to ensure that we include scientific literature published in French, we carried out the search strategy in English and French.

For the manual search, we consulted all the issues of the journals Transport Geography, Transport Policy, Transportation Research Part A: Policy and Practice, Espace populations sociétés, Flux, VertigO, Les Cahiers scientifiques du transport et Espaces et sociétés published between January 1 2010 and December 31, 2020. In addition, in order to include gray literature in our results, the websites of the main non-governmental organizations (for example Vivre en Ville, Accès Transports Viables and Victoria Transport Policy Institute) were consulted on the subject (see Table 1 for the full list).

Table 1 – Sources consulted

Sources consulted	Identified articles
<i>In scientific journals</i>	
Transport Geography	90
Transport Policy	56
Transportation Research Part A	30
Flux	6
Espace populations sociétés	4
Cahiers scientifiques du transport (Les)	0
Espaces et sociétés	0
VertigO	0
<i>In gray literature</i>	
Vélo Québec	3
Ordre des Urbanistes du Québec	2
Vivre en Ville & Équiterre	2
Alliance pour le financement des transports collectifs au Québec (TRANSIT)	1
Transportation For America Home	1
Union Internationale des Transports Publics	1
Vivre en Ville	1
Accès Transports Viables	0
Association canadienne du transport urbain	0
Association québécoise des transports	0
Atelier parisien d'urbanisme	0
Association transports et Environnement	0
Collectivités Viables	0
David Suzuki Foundation	0
Institut Paris Région	0
Piéton Québec	0
Trajectoire Québec	0
Victoria Transport Policy Institute	0

## 2) Selection of Studies

Using criteria established by the researchers, studies identified in the earlier phase were analyzed to assess their eligibility. Covidence software, a specialized tool for performing systematic reviews of the literature (Covidence, n. d.) was used to manage this process.

To begin with, the team of researchers met to develop the selection mechanism. On the one hand, the research question was clarified and, on the other hand, the eligibility criteria were defined (Table 2). The first step in the process, in which the titles and abstracts of the papers are reviewed, was performed by three researchers independently. To be admitted or excluded, a study had to obtain the opinion of at least two of them. When a conflict arose, a meeting was scheduled to resolve it by consensus.

Table 2 – Article eligibility criteria

Criteria	Description
<b>Modal shift</b>	A modal shift strategy must be explicitly included in the research objectives for the study to be considered. Thus, articles dealing only with modal choices without presenting a strategy are not selected. In addition, only research concerning passenger transport and the modal shift from the automobile to an alternative mode of transport (public transport (PT), active transport (AT) or cars in shared mode) are taken into account.
<b>Recent research</b>	In order to explore only recent scientific knowledge, the year of publication of the articles must be, inclusive, between 2010 and 2020. In addition, the data used by the researchers must not entirely date before 2005.
<b>Results</b>	The results should be at the urban scale, if not at the maximum metropolitan scale, and should not be based solely on a simulation.

Admitted studies are moved to the next step, selection from full text. At this point, the research team met again to clarify the criteria justifying the potential exclusion of an article (Table 3). The inclusion of each of the studies was then assessed by two investigators. Where consensus could not be reached, the advice of a third party enabled conflict resolution.

Table 3 – Exclusion criteria

Exclusion criteria	Description
<b>Irrelevant content</b>	Where a modal shift strategy is discussed superficially or the focus is more on the effects of modal shift (e.g. GHG reduction) or on modal choices, the article was excluded. Research that deals with the transport of goods or a modal shift from the private automobile to a car service (e.g. Uber) was also not considered.
<b>Type of study</b>	Editorials, literature reviews and methodological protocols have been excluded to retain only research that reports new knowledge.
<b>Full text not available</b>	Articles for which the full text was not available, either in our databases or in the English or French language, were excluded.
<b>Results based on simulations</b>	Articles for which the results were based only on a simulation were excluded.
<b>Publication or data outside the study year range</b>	Articles published outside our study range (2010 to 2020) were excluded, as were articles that based their results only on data prior to 2005.
<b>Interregional scale</b>	Articles which deal with modal shift in interregional or interurban scales have been excluded.
<b>Duplicates</b>	Duplicates that were not spotted in previous phases were excluded with this criterion.
<b>Other</b>	Other reasons, e.g. a poor translation which makes the article incomprehensible to the reader.

### 3) Data Mapping

This step consists of extracting data from the included studies. The development of the charter containing all the data to be extracted was co-constructed by the researchers, then iteratively improved. In its final form and following the data mapping by the researchers, the charter contains the following information:

- Basic characteristics (authors, year of publication, scientific journal or institution, type of literature and language);
- Study participants (location of the study, type of urban structure, target audience and alternative mode of transport proposed, type of territory surveyed);



- Methodology (theme (according to the sub-objectives established for the scoping review), intervention carried out by the authors, objective of the study, type of modal shift strategy tested, stick or carrot type of intervention, hardness of intervention, type of study (quantitative, qualitative or mixed), method of data collection and indicators measured);
- Results (effects of interventions (positive, neutral, negative or unspecified), quality of results and description of key results).
- For the articles reporting quantified data on the modal shift from the car to alternative modes, we also collected these precise results and their indicator of significance and whether they were revealed or declared preferences in order to subsequently carry out a meta-analysis of these results.

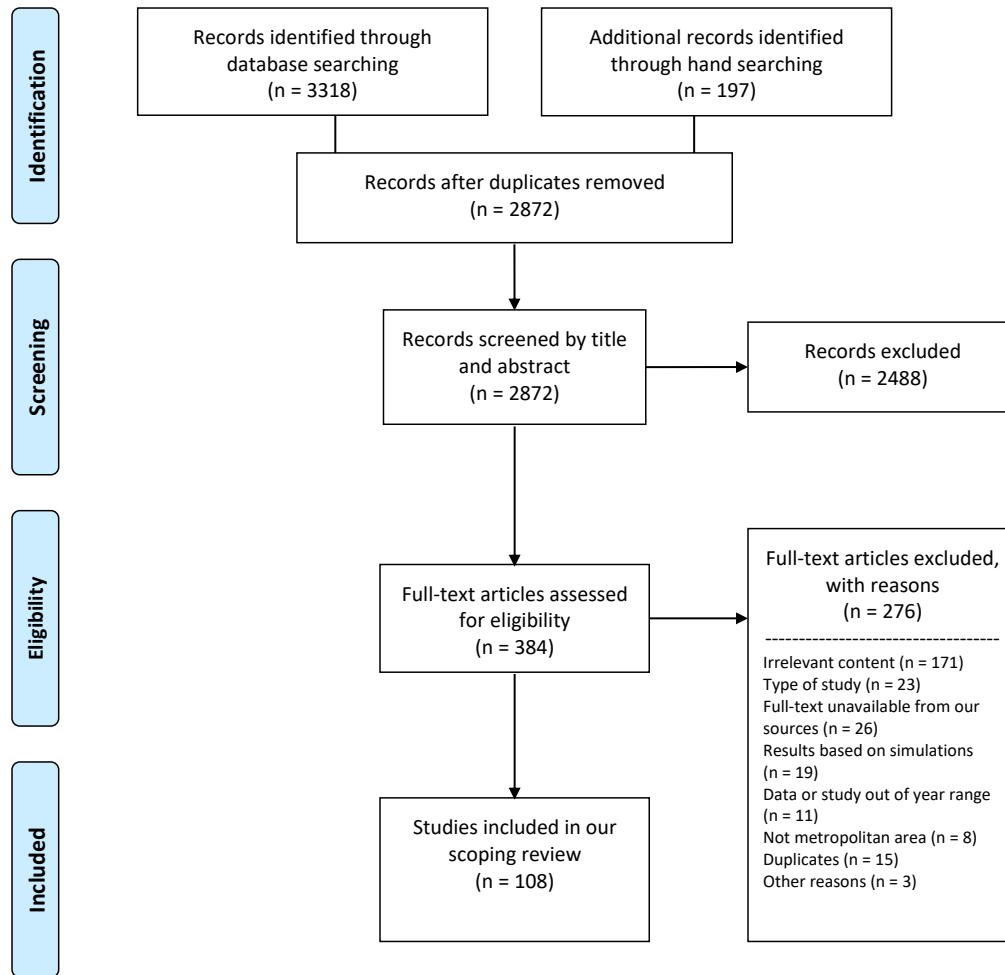
## 4) Gather, Summarize and Report the Results

Once the data was mapped for all articles included in the scoping review, we produced descriptive statistics describing the literature surveyed. These statistics were then discussed within the research team in order to identify the most interesting results and analyze their significance. This is what we present in the next section. In a later step, we will also validate these results with the scientific community and the community of practice.

## Results

The systematic database search identified 3318 potential documents (Web of Science: n = 493, Pubmed: n = 49, Embase: n = 47, Geobase: n = 1896, Ovid: n = 819, Cairn : n = 14). We then performed a manual review with 24 sources (see Table 1), which added 197 documents to this number.

After the removal of the duplicates, 2,872 articles were imported into the Covidence software for the selection process. Of these, 2,488 were excluded by title and abstract review, leaving 384 articles eligible for full-text review. At this stage, 276 additional articles were excluded because they met at least one of our exclusion criteria (Figure 3). In the end, therefore, 108 articles were retained in our scoping review of the literature on modal shift.



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

Figure 3 – Process for identifying and selection of articles

## Basic Characteristics of the Selected Literature

The first finding of our scoping review is that modal shift is almost exclusively discussed in the scientific literature. Indeed, of the 108 articles included in our analysis, 104 came from scientific journals, 2 from grey literature and 2 from government documents. This result is not surprising since the vast majority of the texts came from research carried out in scientific databases.

The second observation is that the literature on modal shift is essentially English-speaking. It appears, 105 included articles were written in English while only 3 included articles were produced in French. In this regard, however, we have made efforts to include several French-language journals, manually revising all their issues published between 2010 and 2020 in order to identify articles relating to modal shift. In this way, 19 articles were identified, but most were excluded since their research topics did not specifically address modal shift. While a number of articles analyzed presented cases from French-speaking countries (19% of the articles, i.e. 2 articles from Belgium, 6 articles from Canada, 3 articles from France, 7 articles from Switzerland), the only articles in French came from Switzerland (2) and France (1). This observation leads to the conclusion that few researchers publish on this subject in the language of Molière.

### Geographical Distribution of Cases Discussed

The map (Figure 4) shows the geographical distribution of cases discussed in the literature for the decade 2010-2020. The United States ( $n = 24$ ), China ( $n = 19$ ) and the United Kingdom ( $n = 10$ ) are the most studied countries. We found with surprise that the countries included in East Asia and the Pacific are, the most covered, in particular by China, Malaysia ( $n = 6$  articles) and Australia ( $n = 6$ ). The countries of Europe and North America, including Switzerland ( $n = 6$ ) and Canada ( $n = 6$ ) follow closely behind. For their part, the countries of South Asia, Latin America and the Caribbean, the Middle East and North Africa are under-represented, while the countries of sub-Saharan Africa are completely absent from the literature on modal shift.

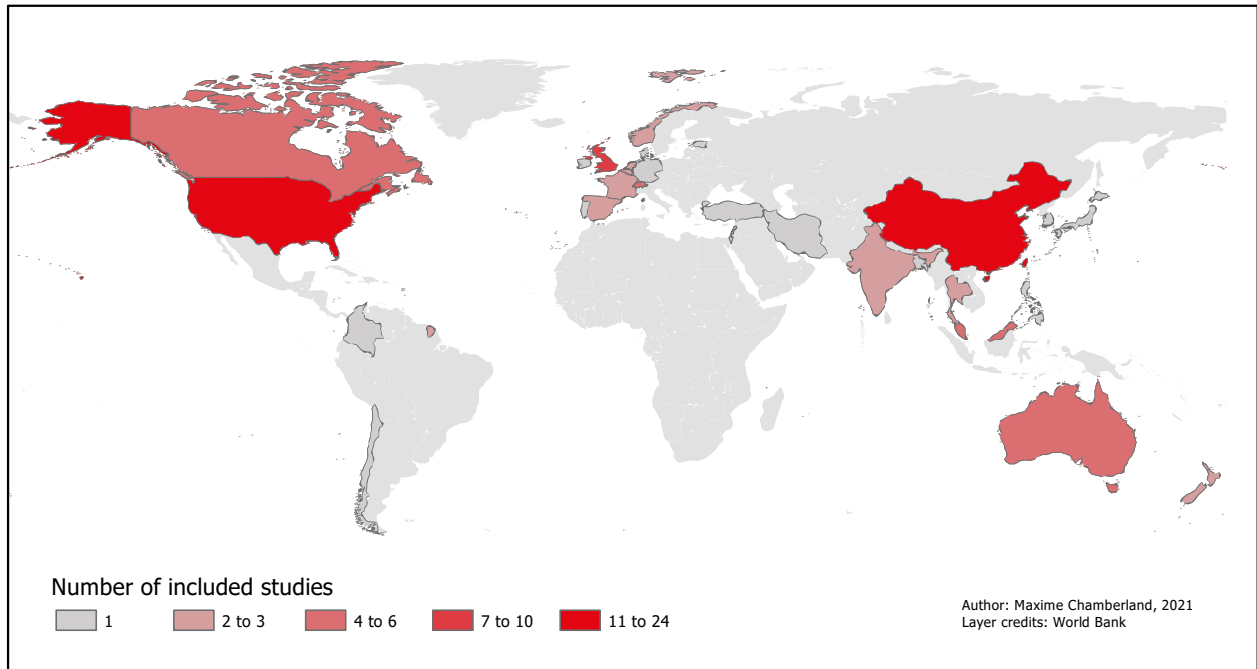


Figure 4 – Map of cases reported in the articles analyzed

## Chronology of the Publications Analyzed

The chronological analysis of the articles included in the study our scoping review shows a strong tendency for the number of articles to increase between 2010 (n = 2) and 2017 (n = 18), followed by a slight decline in 2018 and 2019 and a return to the rise in 2020 (n = 17). This analysis shows that the number of research studies on modal shift exceeds the number of 11 articles published annually since 2016.

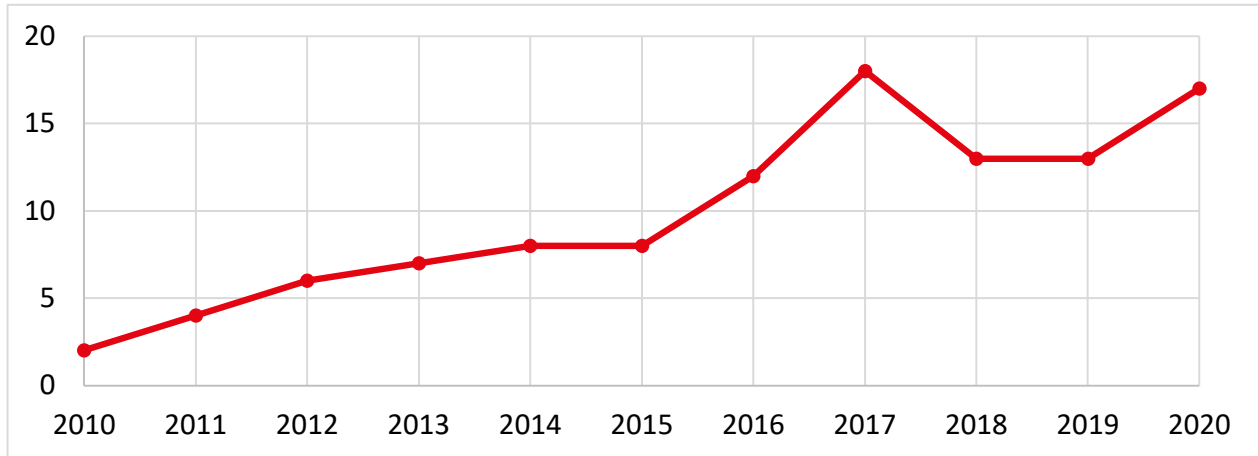


Figure 5 – Timeline of articles analyzed

## Who Is Targeted by Modal Shift Research?

Modal shift research covers a wide variety of target audiences (Figure 6), yet three types of target audience are particularly represented: commuters (n = 37), motorists (n = 28) and the general population (n = 28). It is not surprising that the most frequently studied target audience is commuters. This is the population for whom the supply of alternative transport, in particular public transport, is most likely to allow a modal shift with a minimum of obstacles. This target audience represents the proverbial “low hanging fruit” who should be easier to convince to abandon the car for other alternatives.

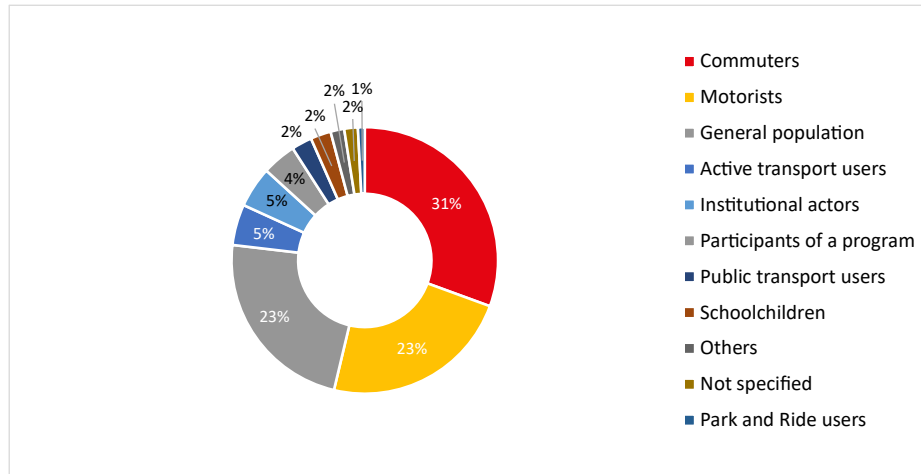


Figure 6 – Target audience of the articles analyzed

### The Alternative Modes Studied

Many alternative modes have been proposed to replace automobile use (Figure 7), but PT (bus, bus rapid transit (BRT), metro, tram, etc.) is the most frequent mode discussed in the literature (n = 45), followed by AT (walking, cycling, bicycle-sharing, electric-assisted bicycles) (n = 26). The car in collective or shared mode (carpooling and carsharing) is, however, very little covered (n = 4). Of these, only one discusses carsharing. It is, however, an emerging mode of transport frequently cited in the public sphere, but which is absent from the scientific literature. More research focusing on this mode of transport as a modal transfer lever could thus be beneficial.

Among the other articles, 24 consider both PT and AT as an alternative to the car, while 9 articles also include the automobile in collective or shared mode.

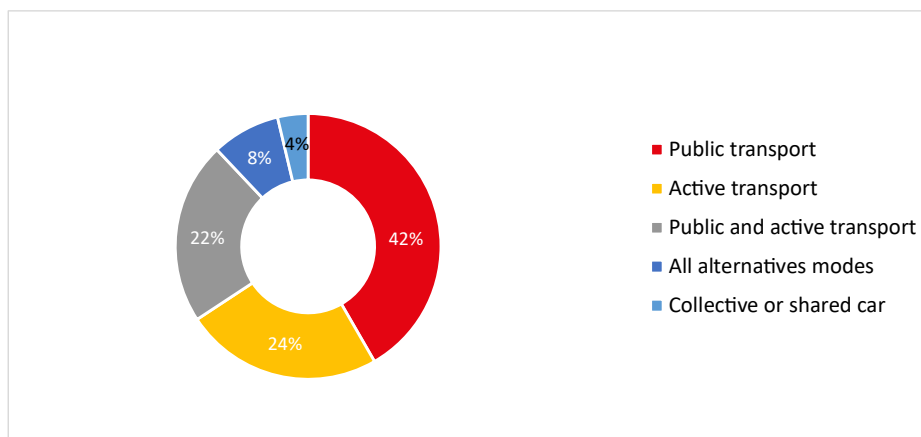


Figure 7 – Mode of transport towards which the modal shift is analyzed

Chronological analysis, by alternative modes of transport studied (Figure 8), reveals that public transport has very generally been the mode most studied as an alternative to the car. AT, little studied at the start of our study period, became frequent in the literature from 2016 and remained fairly constant until 2020. In addition, studies focusing only on PT decreased in frequency since 2017: instead, it seems that research is increasingly focused on combining both PT and AT as alternatives to the automobile and this represents a growing trend that has been observed since 2013.

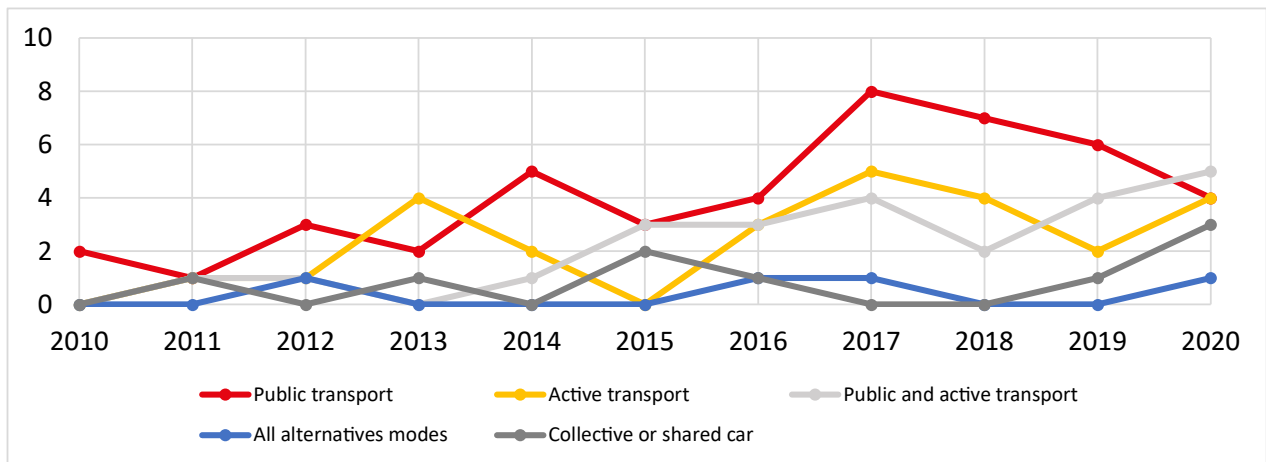


Figure 8 – Chronology of the articles analyzed according to the modes of transport

## Approaches and Design of Admitted Studies

The methods used by accepted research (Figure 9) largely correspond to a quantitative approach (n = 99). Qualitative or mixed studies are indeed rare, since these approaches are only used for, respectively, four (4) and five (5) articles.

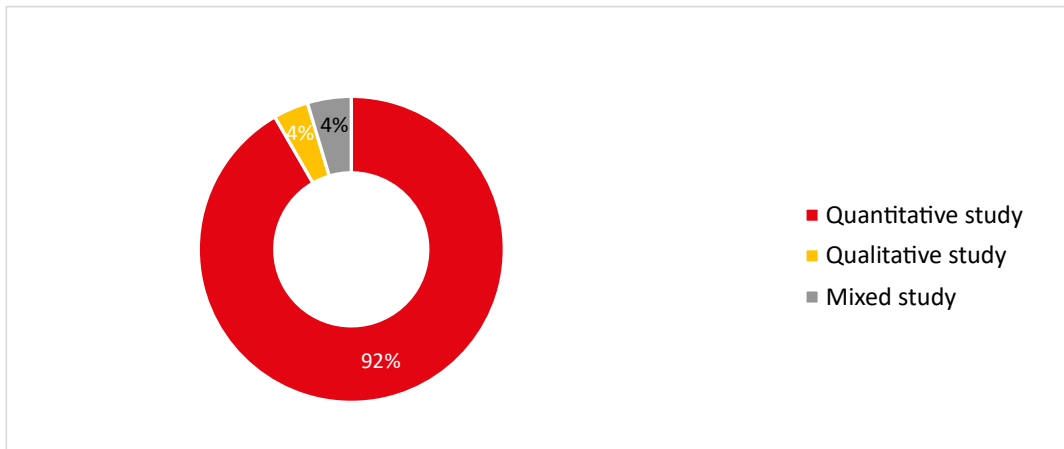


Figure 9 – Type of research approach

Regarding the study designs used (Figure 10), the cross-sectional approach is the most frequently used (n = 80), followed by the longitudinal approach (n = 15). All other types of designs are rather rare and only have one (1) to five (5) studies for each.

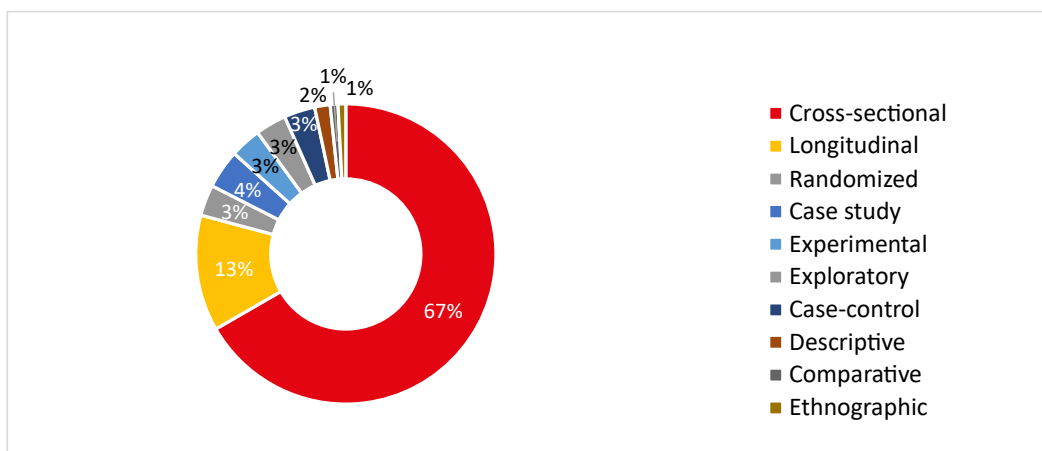


Figure 10 – Research design

## Urban Structure of the Fieldwork Studied

A large majority (63%) of the articles retained in the scoping review of the literature investigated land combining several types of urban structures, for example an urban region comprising both



the city centre and the surrounding crowns. (Figure 11). The second type of urban structure most often studied is unsurprisingly urban space (26%) since alternatives to the car are more developed in the heart of cities than in outlying areas. On the other hand, it appears essential to recall that the peri-urban and rural sectors also represent a large part of the population and have particular challenges for modal shift. It is therefore important for future research to look at these types of territories, since the literature from 2010 to 2020 only looks very little (periurban 6%; rural 1%) to this type of territory.

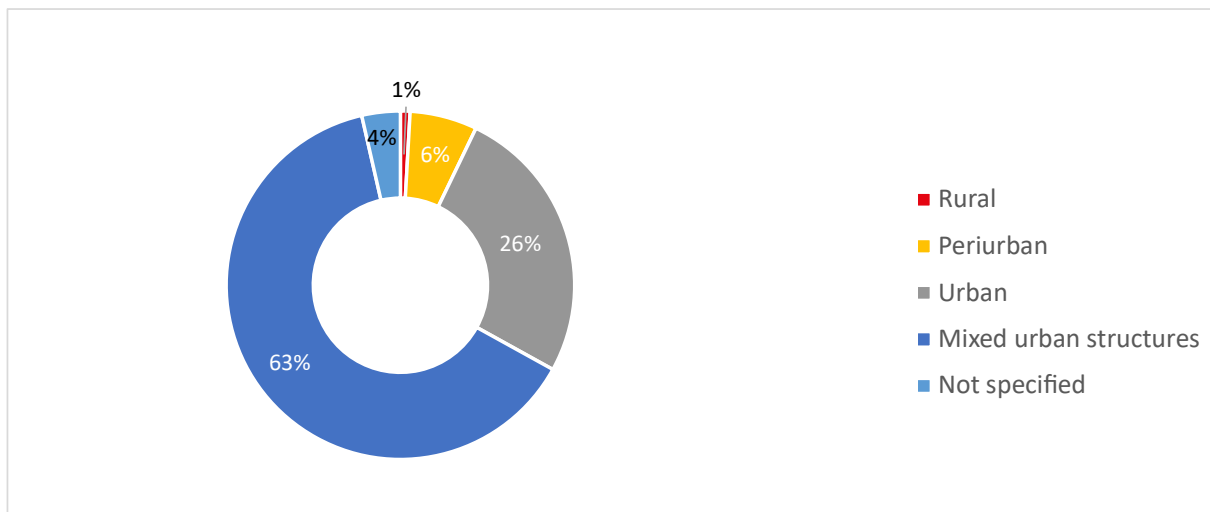


Figure 11 – Urban structure of the fieldwork studied

## Analysis of Research Findings

of all the research admitted into the scoping review, 17% did not specify the effect of the strategy they are discussing on modal shift. Some of these contributions, for example, address strategies without necessarily experimenting with their effectiveness or discuss theoretical aspects<sup>1</sup>.

So if we only consider research that has measured the effect of a modal shift strategy, 67% of studies report positive results. No effect is reported in 31% of cases while only 2% of studies report effects contrary to those expected. It therefore appears that the vast majority of interventions tested in the literature have succeeded in generating a modal shift from the car to alternative modes.

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<sup>1</sup> It should be noted that, in this section and those that follow, these articles were excluded from our analysis when we report the proportion of articles having presented positive, neutral or negative results on a modal shift strategy.

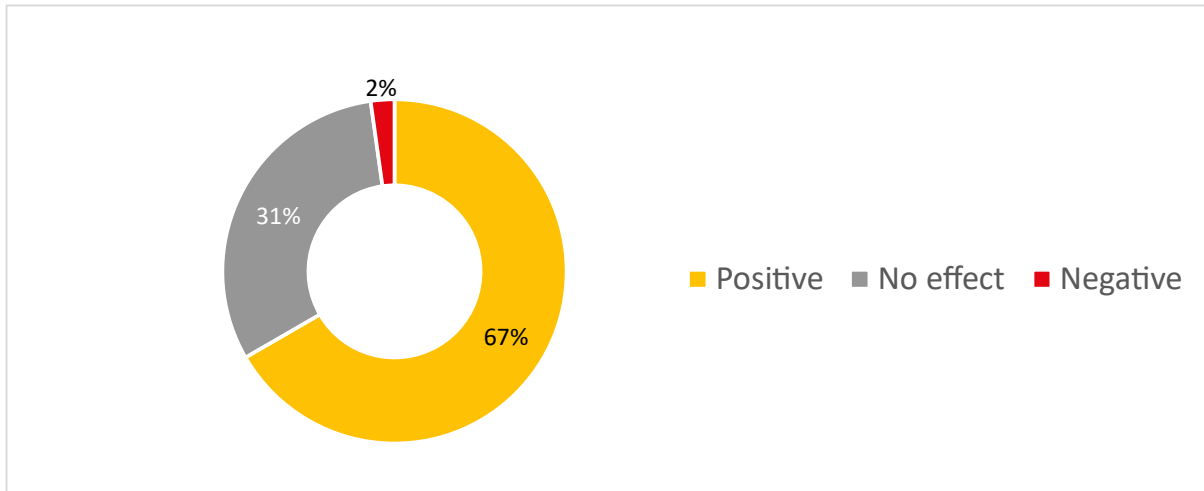


Figure 12 – Result of interventions aimed at generating modal shift

Among these studies, those which targeted AT as an alternative to the automobile have overwhelmingly reported positive results (81%) (Figure 13) Thus, it seems that the measures which aim to encourage AT are a significant lever to reduce car dependence. Acting on public transport is also very positive (67%), as is the car in collective or shared mode (67%) (although this type of transport mode has been very little discussed in the literature and additional research is needed in order to draw reliable conclusions).

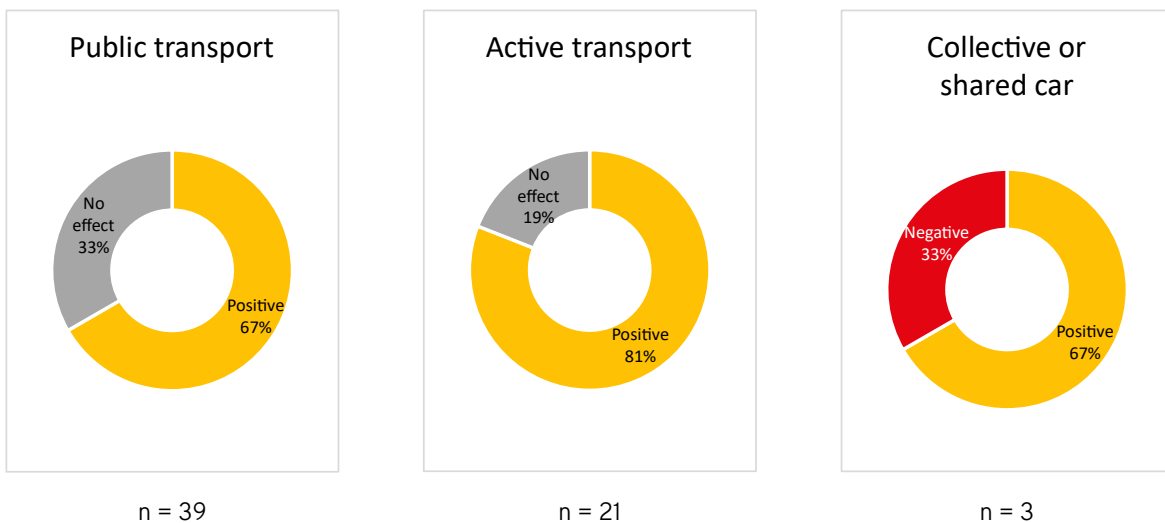


Figure 13 – Effect of interventions by mode of transport

## The Effect of Interventions on Modal Shift Depending on their Type

When creating the study design, we established five main categories of intervention type (see Figure 1) in order to subgroup the various modal shift strategies (Figure 14). The most frequent type of intervention surveyed is that in which we find studies on the effects of an improvement in the supply of alternative transport to the car (35%). Then we find studies on economic levers (26%) and those relating to values, preferences or lifestyles (21%). Two types of interventions seem less studied, namely that relating to the habits anchored in the daily life of motorists (10%) and that relating to land use planning (8%).

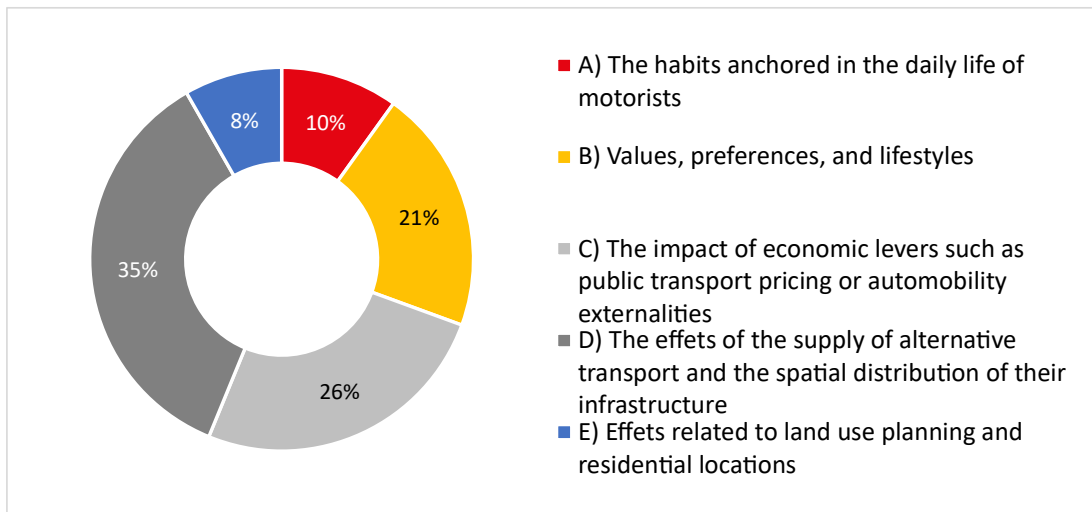


Figure 14 – Type of intervention studied

In all these categories of type of intervention, a majority of the research analyzed report positive results (see Table 5 in the appendix). With 73% of the studies attesting to the positive effects, the interventions relating to the habits anchored in the daily lives of motorists and those relating to the effects of the supply of alternative transport to the automobile and the spatial distribution of its infrastructures seem to be the most promising, whereas interventions focusing on the effects of land use planning and residential locations are the least conclusive, only yielding positive results in 57% of cases. We now present the results for each type of intervention, detailing their results for PT, AT, or a combination of the two.

## A) Habits Anchored in the Daily Life of Motorists

This category includes research on interventions aimed at changing the habits of motorists in order to generate a modal shift. The studies included here attempt to change the habits of motorists by allowing them to experience new transportation options that are different from their habits.

Twelve (12) articles are included in this category, making it the second-smallest category of intervention type. Yet this type of intervention is among the most successful (Figure 15). Indeed, 73% of the studies included in this category report positive results and none report negative results.

Some interventions of this type test the free use of an alternative mode by participants such as Abou Zeid & Ben Akiva (2012) who offer their participants a free PT pass on condition that they try to take the bus at least 2 or 3 days and Moser et al. (2018) who offer their participants free use of an electric bicycle for two weeks.

But most research of this type explores the potential of one-on-one social marketing campaigns aimed at breaking habits. For example, Hino et al. (2019) assess a municipal campaign using pedometers as a motivator while Riggs (2015) explores the potential of an awareness campaign including events, personalized monitoring and a survey to assess potential modal shifts. In this particular case, 8% of the participants requested personalized assistance and 45% of them changed their mode of transport. Thus, a personalized awareness campaign can help induce a modal shift from the car, but should preferably be accompanied by other measures (e.g. tariffs, PT alternatives, etc.).

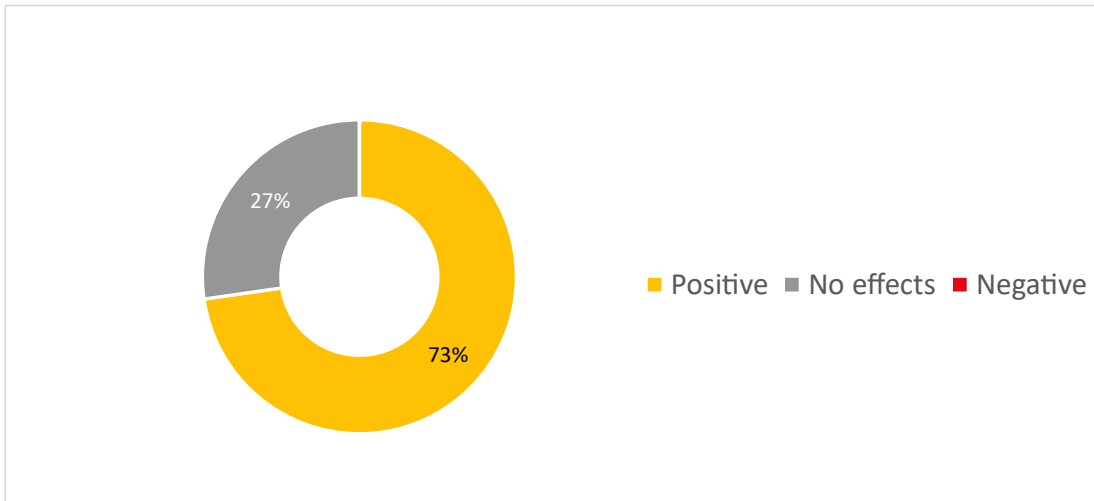


Figure 15 – Effect of interventions on the habits anchored in the daily life of motorists

This type of intervention seems particularly appropriate when aiming for a shift to AT modes (100%) or a combination of active modes and PT (67%) (Figure 16). On the other hand, research of this type of intervention targeting only PT has had mixed success (50%). But the low number of studies reporting measured results in this type of intervention does not allow a reliable conclusion to be drawn.

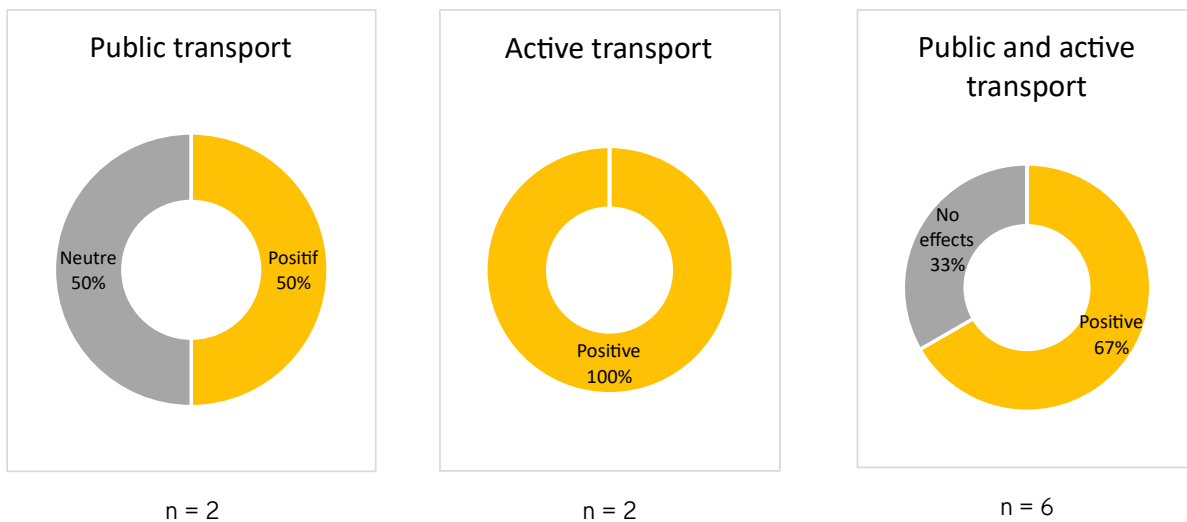


Figure 16 – Effect of habit-type interventions depending on the mode of transport

## B) Values, Preferences, and Lifestyles

Interventions focusing on values, preferences, and lifestyles make up the third-smallest category with a total of 25 articles (of which 12 do not specify the effect of their results on modal shift). The majority of the 13 articles presenting results on modal shift (62%) report positive results and none report negative effects (Figure 17). For example, Salameh & Jawad (2019) examine the intention of young adults to use the BRT by understanding the psychological factors and modal shift behaviours of this population. They conclude that the attitude of the respondents towards BRT is very good, so that 93% of the respondents say they intend to use BRT in the future. In this type of intervention studying preferences and reporting positive results, two studies (Abdulrazzaq et al., 2020; Chowdhury et al., 2016) report that motorists place more importance on reducing travel time than on cost reduction.

On the other hand, in the research on values there is still a portion of 38% of the studies that do not report any effects resulting from this type of intervention. We draw your attention in particular to two studies (Elias & Shiftan, 2012; Geng et al., 2020) which demonstrate that environmental awareness and information on the negative effects of individual automobile mobility do not guarantee modal transfer. The two studies testing this kind of intervention did not report any effects on modal shift.

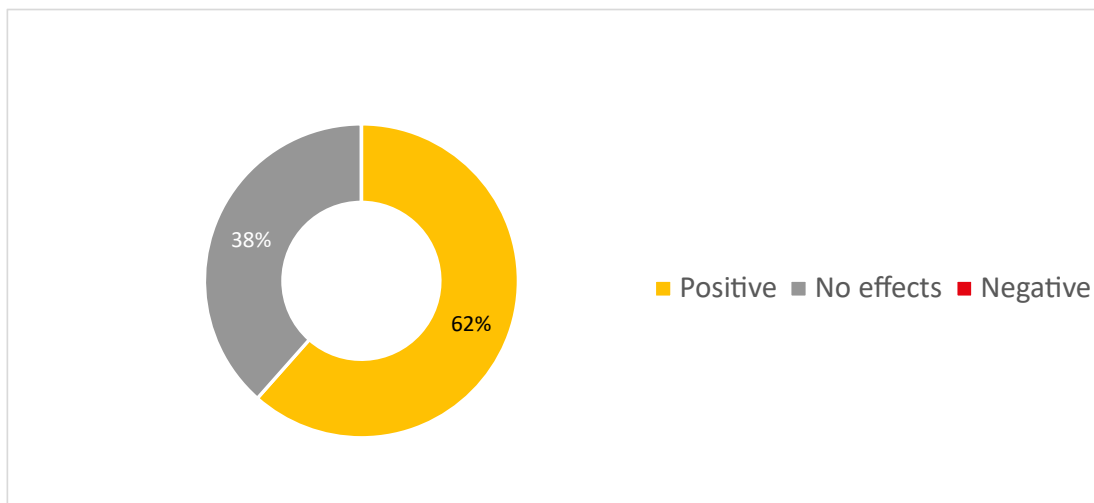


Figure 17 – Effect of interventions addressing values, preferences, and lifestyles

The success rate of research on this type of intervention seems to be greater when PT is part of the strategy studied (Figure 18). On the other hand, the small number of studies focusing only on AT ( $n = 2$ ) does not allow us to conclude with certainty about its potential for success. It appears necessary to do more research either on the combination of AT and PT or only on the AT with the values of the participants.

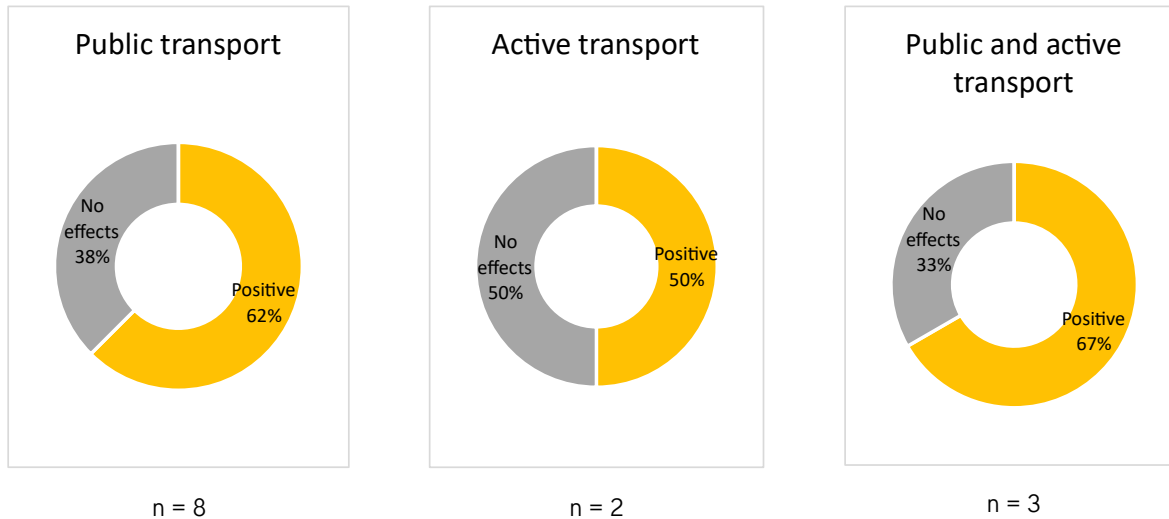


Figure 18 – Effect of value-type interventions depending on the mode of transport

### C) Impact of Economic Levers such as Pricing of Public Transport or Automobility Externalities

Research on interventions targeting economic levers represents the second-largest group of articles (n = 31). The vast majority of these interventions show positive effects, but a third of them still report neutral effects (Figure 19). Among the research reporting positive effects, the article by Kaffashi et al. (2016) which surveys participants on their intention to make a modal shift according to different scenarios modifying the time, cost and comfort of the journey. The authors report that in general, the implementation of a congestion charge is the most effective measure to generate a modal shift and reduce the number of vehicles on the road. They also state that combining pricing measures that increase the cost of car use with measures that increase the quality of PT will have a marked effect on reducing car use.

In this type of intervention, only one article, that of Guensler et al. (2016), shows negative effects. Clearly, the authors are trying to understand the behaviour of motorists when setting up a paid carpool lane (HOT Lane) and its effect on carpooling. They have shown that the majority of people using carpooling, after the introduction of the priced carpooling lane, were already carpoolers even before the creation of the priced carpooling lane. Which suggests that this new infrastructure has failed to stimulate carpooling. In addition, respondents who have a positive perception of the paid carpool lane are less likely to carpool. The authors suggest that when the performance of the priced carpooling lane becomes better, it is likely to negatively affect the use of carpooling. As this article does not focus on PT or AT, but rather on a shared form of automobile transport, it does not appear in the statistics reported in Figure 20.

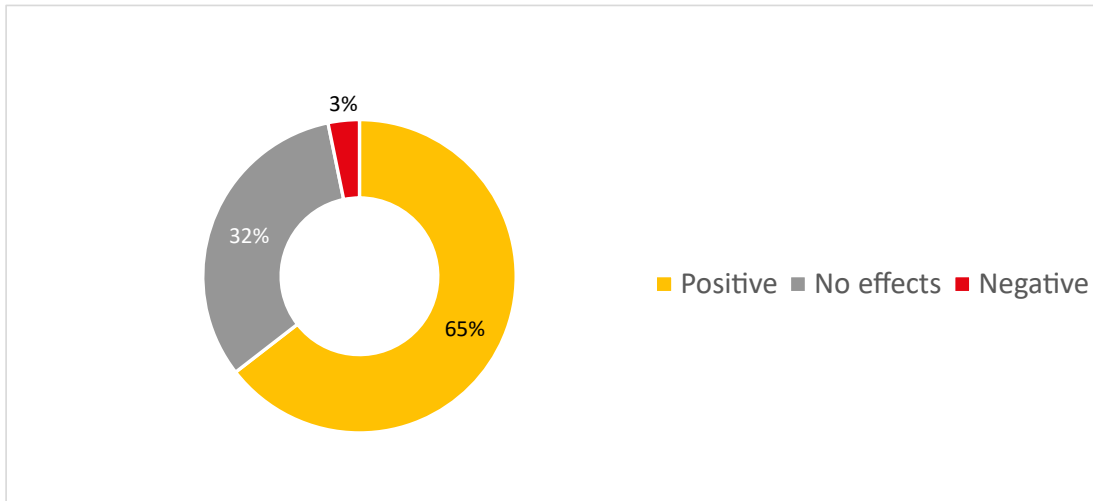


Figure 19 – Effect of interventions on the impacts of economic levers

No research relating to interventions on economic levers has looked only at the modes of AT. Those which focused on financial levers and PT modes had positive effects in 80% of cases. Research on a combination of PT and AT only reports positive effects in 43% of cases and therefore a majority (57%) of these studies report neutral results.

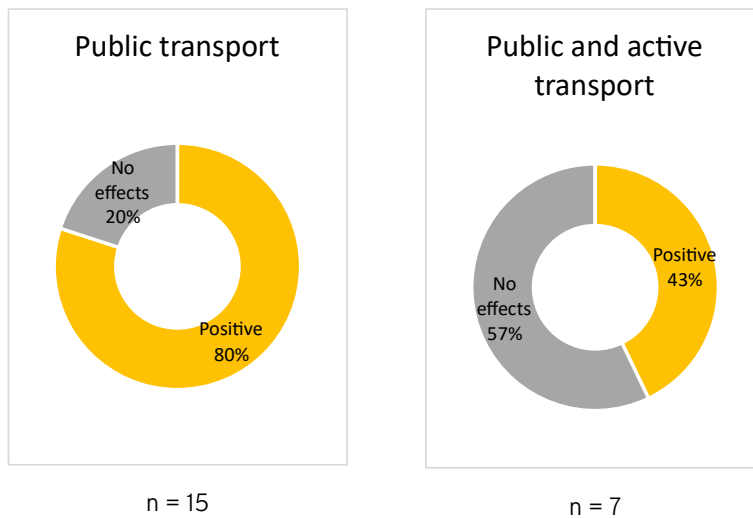


Figure 20 – Effect of economic lever-type interventions depending on the mode of transport

## D) Automobile Alternative Transport Supply (Effects of) and the Spatial Distribution of its Infrastructure



This category includes research on interventions aimed at improving the supply of alternative transport to the car. For example, the establishment of a bicycle-sharing service, the addition of park-and-ride lots or the creation of a new tram line. It also includes improving the existing alternative transport supply such as adding express bus routes or increasing the frequency on an existing PT route in order to reduce congestion of PT vehicles. The studies included here attempt to verify the effects of these improvements in the alternative transport supply on the modal shift away from the car.

This intervention type category has 43 articles, making it the largest category by intervention type in the literature reviewed. Of these, 38 articles specify results, and this type of intervention is among the most successful (Figure 21). Indeed, 68% of the studies included in this category report positive results, but it should be noted that 3% (or a single article) report negative results. This negative result is attributable to the only study on a combination of all modes of transport alternative to the private car (including carsharing for example). In this research Pronello et al. (2016) used a smartphone app, which provides real-time multimodal travel information to their participants. After 5 months of use, they measured the changes in their mobility habits. They unfortunately observed that the use of the various modes of transport before and after the intervention remained stable, except for the use of the car which increased a little, which explains the negative results. This is only one study, but it presents disappointing results for the implementation of Mobility as a Service (MaaS). Moreover, the only other study that looked at MaaS (Storme et al., 2020) reports neutral results from this type of initiative. There is therefore an important subject that is not part of the current literature and that deserves attention since several public decision-makers mention wanting to set up this kind of service.

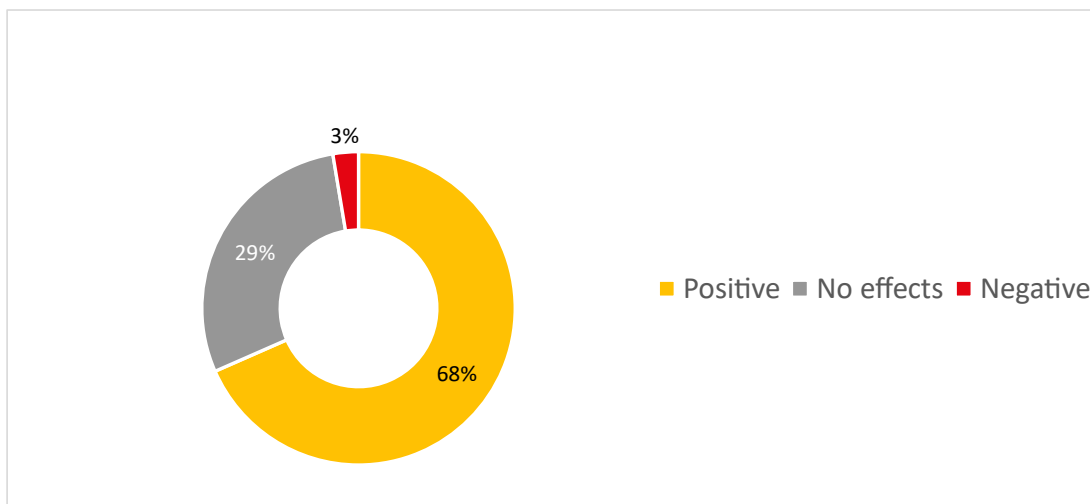


Figure 21 – Effect of automobile alternative transport supply and the spatial distribution of its infrastructure

By consulting Figure 22, it is clear that studies focusing on improvements in the PT supply, or on their location, show high success rates when taken individually. In fact, 59% of the results dealing only with PT are positive and almost all of the research (92%) dealing only with AT also reports success. This is the highest success rate reported for all types of intervention on the PT or AT modes. On the other hand, only one of the two articles dealing with a combination of AT and PT reports success. But the small number of studies allows us to ignore this mixed result for the moment.

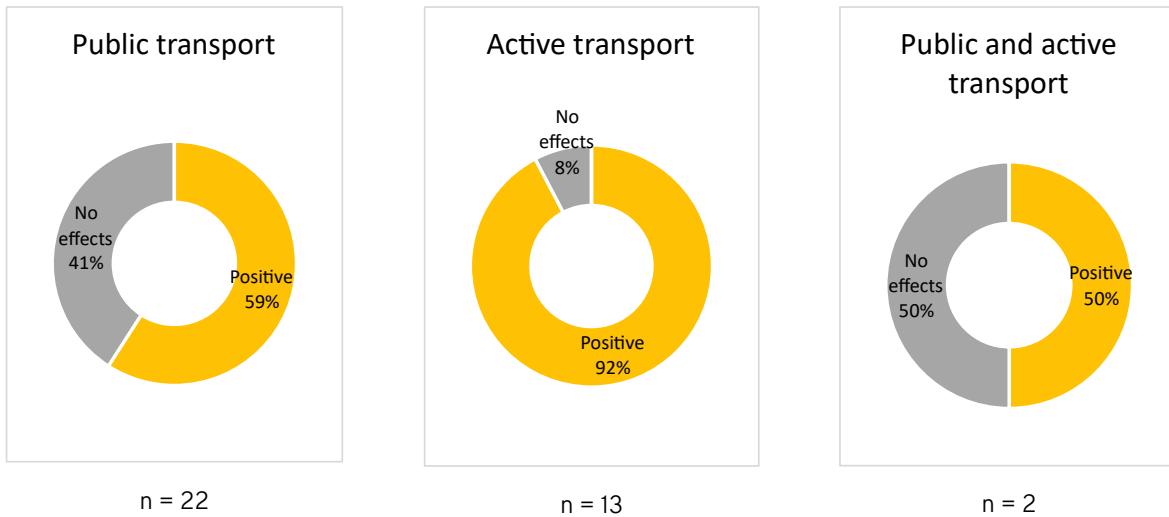


Figure 22 – Effect of alternative supply type interventions depending on the mode of transport

## E) Land Use Planning (Effects of) and Residential Locations

Interventions aimed at modal shift and acting on land use planning or residential locations represent the type of intervention least studied in the literature from 2010 to 2020. In fact, only ten (10) studies correspond to this type of intervention. They also have the lowest success rate with only 57% of research showing positive results (Figure 23). However, none of this research shows negative results. In this category we find, for example, the article by Chung et al. (2012) which relates a research comparing mobility habits and traffic conditions in the short term (a few weeks before and after) and in the long term (5 to 6 years later) during the elimination of an urban motorway and reduction in the number of automobile lanes. The authors indicate that the modal shares for the automobile have decreased from 5.4% to 4.0%, and those for public transport increased from 6% to 10%. They claim that road users have adapted by changing their route, changing mode of transport or changing the time of their travel, so that the traffic condition (volume and travel time) has remained comparable to the condition observed before the intervention.

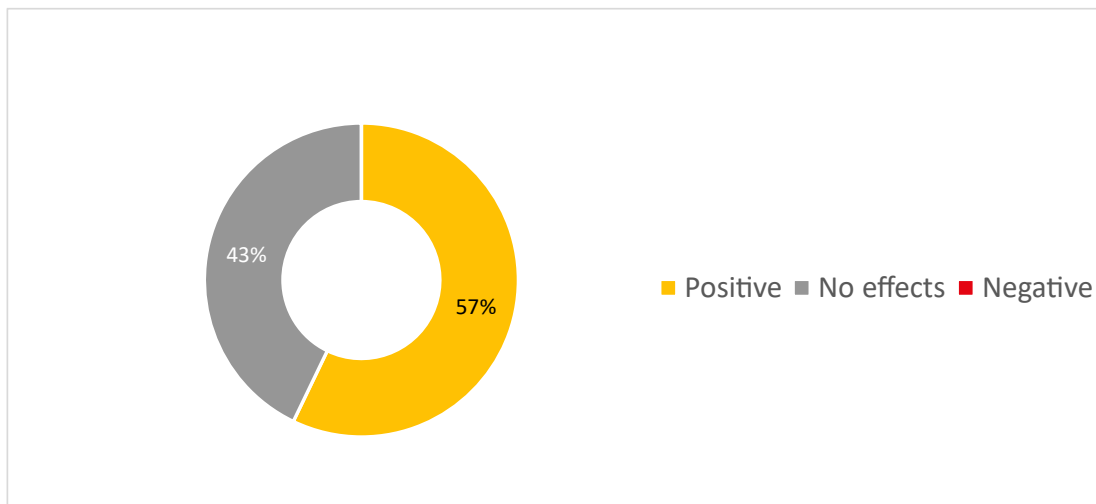


Figure 23 – Effect of interventions relating to land use planning and residential locations

No study of this type of intervention looked only at AT. As shown in Figure 24, those who studied PT alone report a success rate of 50%, while those who studied on a combination between the AT and PT reported a higher success rate (67%).

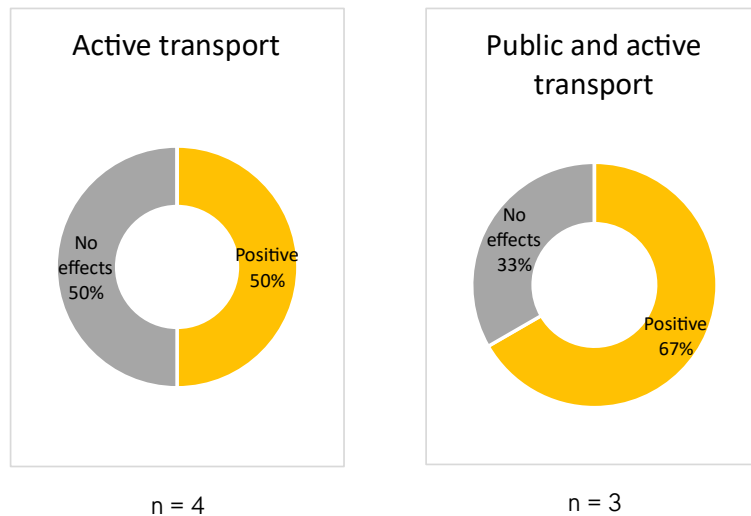


Figure 24 – Effect of land use planning type interventions depending on the mode of transport

## The Effect of Modal Shift Strategies Tested According to their Type (Carrot or Stick)

The selected articles measured the effectiveness of a large number of strategies in generating a modal shift from the automobile to alternative transport (Figure 25 and see Table 6 and Table 7 in the appendix). “Carrot”-type measures, i.e. the implementation of attractive measures in favour of alternative transport (Piatkowski et al., 2017), are the most studied (n = 62). Studies looking at “stick” measures, which aim to discourage motorists from using their car (Piatkowski et al., 2017), are much less common (n = 10)

In general, research that tests “carrot” measures reports positive results on modal shift (64%). The effect of the “stick” measures, on the other hand, is more divided: only 50% of the articles that discuss them obtain positive results.

Only twelve (12) articles have done research that combines the effects of a “carrot” measure with a “stick” measure and the results reported are very positive (75%).

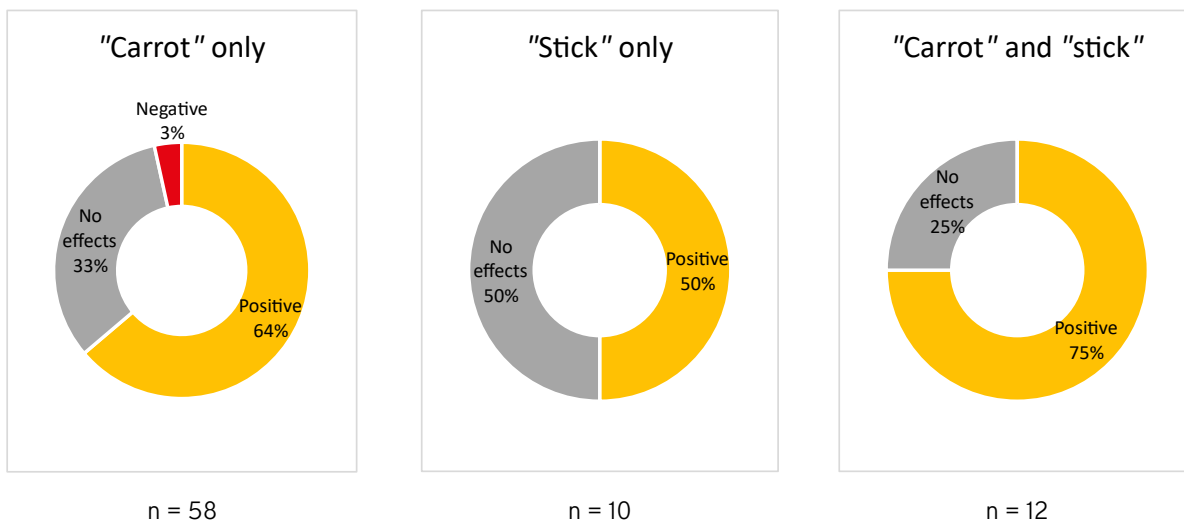


Figure 25 – Effect of strategies according to their type

## “Carrot”-Type Measures

### Freebies or Financial Incentives

Seventeen (17) of the articles admitted measured the effectiveness of financial incentives, ranging from a simple discount to completely free use of an alternative mode of transport, in generating a modal shift. Fifty-nine percent (59 %) of these articles observed a favourable result (Figure 26). Cats et al. (2017) and Huré & Javary (2020), for example, observed a significant and lasting increase in ridership in public transport, in parallel with a certain decrease in car use, when public transport became free for all residents of Tallinn (Estonia) and Dunkirk (France), respectively. However, offering a certain amount of money, such as rewards when a user reduces their frequency of use of their parking lot at work (Rosenfield et al., 2020) or an incentive budget that can be spent on a Mobility as a Service type app (Storme et al., 2020), does not seem to be a sufficient measure.

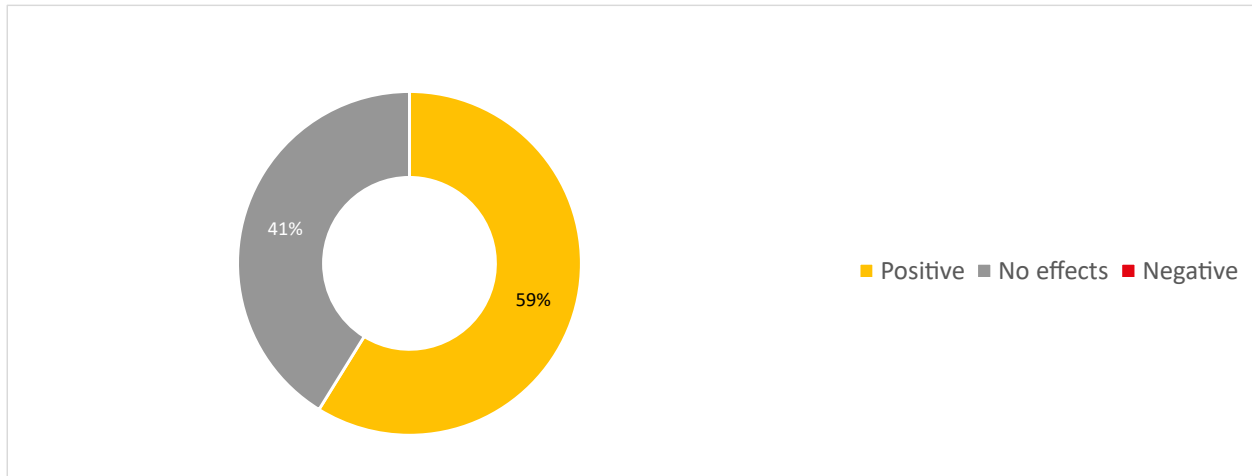


Figure 26 – Effect of free or financial incentive-type interventions

### Trial Period

Some research (n = 6) tested the effect of allowing individuals to experience alternative transport over a period of time on modal shift. Four (4) of these articles reported a positive effect (Figure 27). For example, offering an electrically assisted bicycle free of charge to motorists for 2 weeks (Moser et al., 2018) or for 6 to 8 weeks (Cairns et al., 2017) gave participants a much more positive perception in regards to cycling as a mode of transportation and increased their chances of using the bicycle in the future.

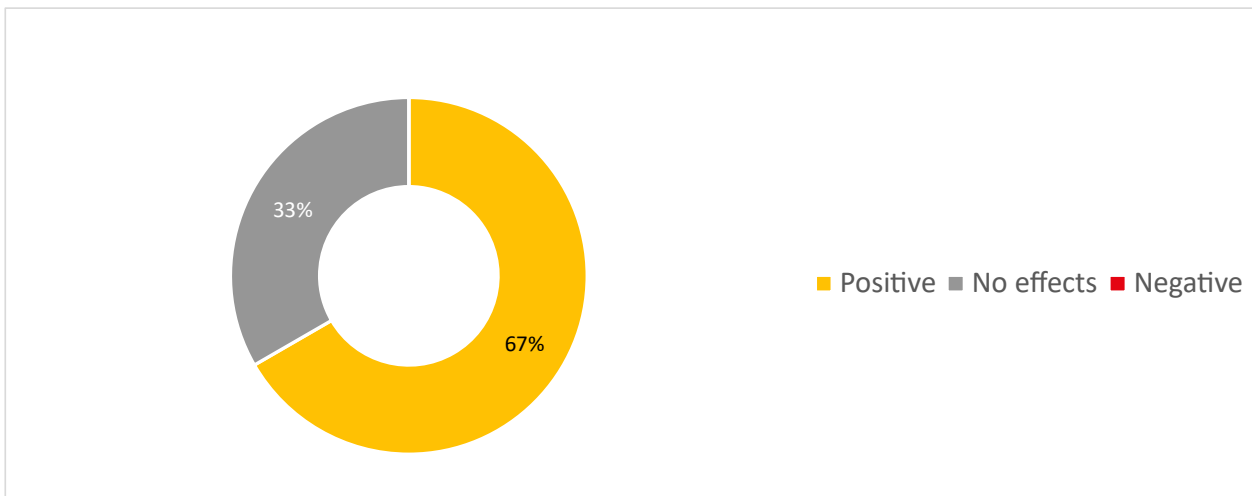


Figure 27 – Effect of trial period type interventions

### Information, Marketing, Real-Time Information

Carrying out an information or marketing campaign to encourage the population to abandon the car for another mode is a strategy frequently discussed in the literature (n = 18). The majority of articles reporting a positive effect with this measure (56%) (Figure 28). For example, three articles discussed real-time news and these obtained conflicting results. One of them indicates that this measure has a significant modal shift potential (Gan & Ye, 2018), the other observed no change in the behaviour of its participants (Ge et al., 2017) while the latter observed an opposite effect, i.e. car use increased rather than decreased (Pronello et al., 2016). Conversely, studies that tested a personalized and supportive program have found generally positive results (Abrahamse & Keall, 2012; Castel et al., 2019; Riggs, 2015; Shaheen et al., 2010).

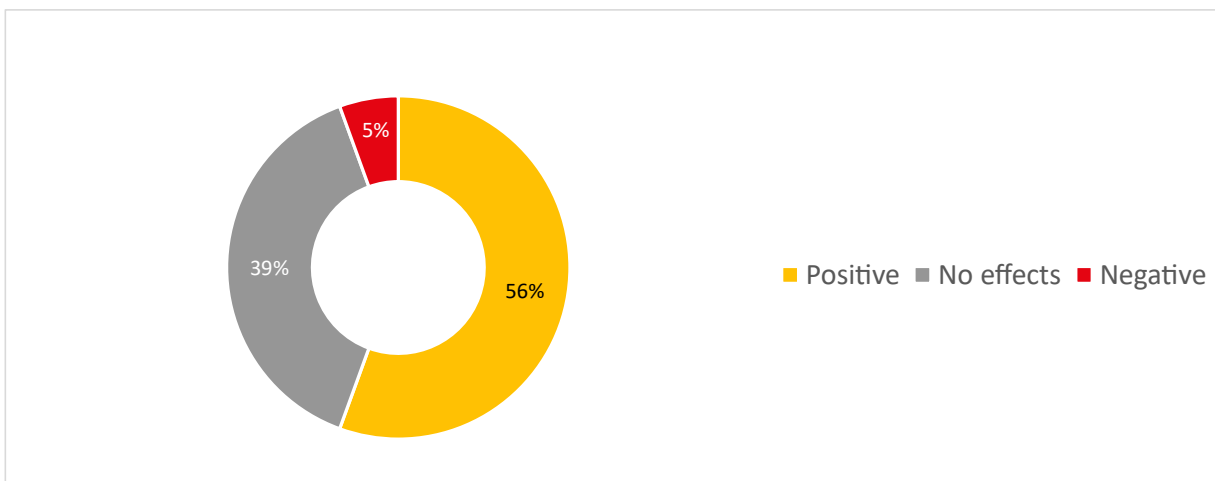


Figure 28 – Effect of information, marketing and real-time information interventions

### Improving Quality, Efficiency or Accessibility

Improving the quality, efficiency or accessibility of alternative transport modes is also a type of strategy that is very frequently discussed in the literature (n = 21). In addition, these measures appear to be very effective in attracting motorists to other modes, as 79% of the articles reported positive results in this regard (Figure 29). Among these articles, this strategy is often combined with a “stick”-type measure that supports and, in some cases, finances, improving the quality of PT (Dale et al., 2019; Kaffashi et al., 2016; Luathep et al., 2016; Luathep et al. al., 2015; Salameh & Jawad, 2019; Tu et al., 2019). A study in India (Bhaduri et al., 2020) even suggests that improving an already existing transport network has effects comparable to adding a whole new metro system on modal shift, but at much better cost.

Reduction in travel time and cost are the main attributes studied, in addition to reliability, frequency, comfort and extent of service. With regard to PT and between travel time and cost of

travel, travel time would generally be the most significant variable to generate a modal shift (Abdulrazzaq et al., 2020; Chowdhury et al., 2016).

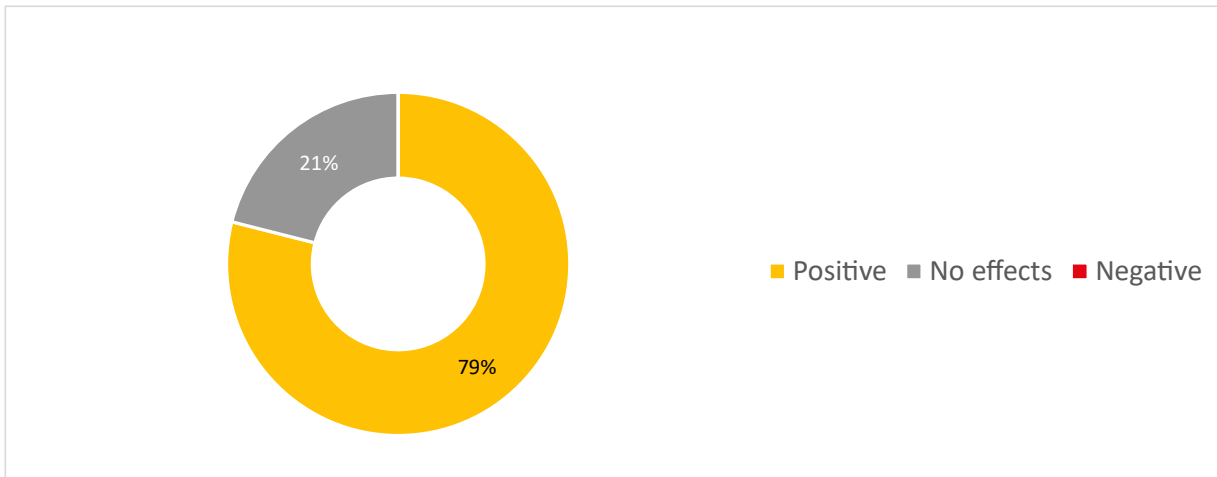


Figure 29 – Effect of interventions such as improving quality, efficiency or accessibility

### Park-and-Ride Type Interventions

Although park-and-ride lots are a measure frequently supported by public decision makers to encourage the population to use PT, few articles discuss this measure in the modal shift literature ( $n = 4$ ). Among the articles in which the effects of park-and-ride on modal shift are exposed, two reported a positive effect (67%), compared with one article for which the effect was neutral (Figure 30). Indeed, research conducted by Anwar & Yang (2017) reports that, in the presence of park-and-ride parking, commuters have a 47% probability of using public transit, against 36% if there is none. The research by Chalermpong et al. (2018) also underlines the power of park-and-ride systems to reduce the mileage of motorists, but also raises an important nuance that outweighs the positive effects. Because this measure also attracts “unwanted” users, that is to say users who would have used the public transit for their entire trips before the park-and-ride was put in place. Thus, to respond to the political buzz surrounding park-and-ride lots, more research is needed to fully understand their effect on modal shift.



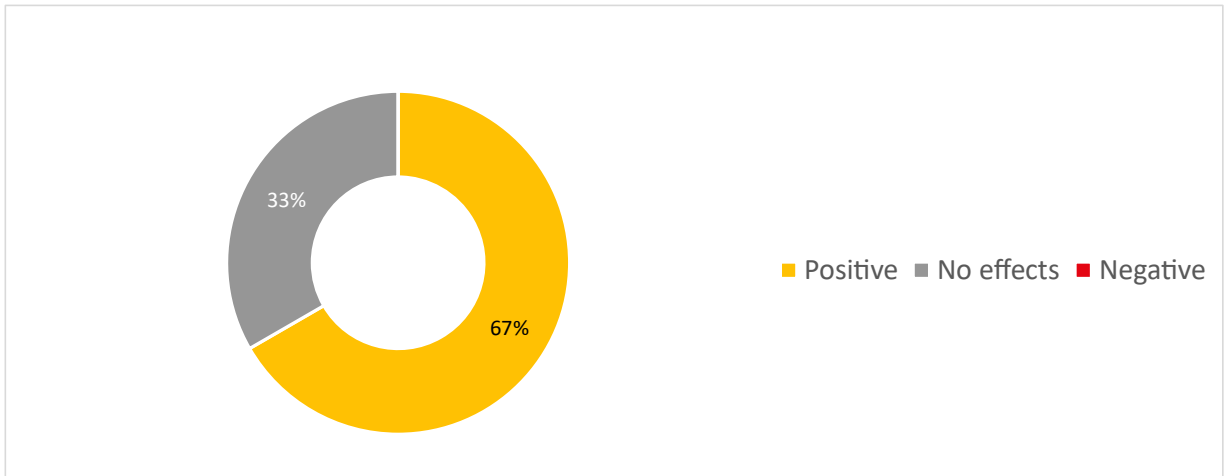


Figure 30 – Effect of park-and-ride type interventions

### Supplying a Shared Mobility Service (Bicycle, Electric Bicycle, Automobile)

A few articles (n = 10) have explored shared mobility in order to generate a modal shift towards alternative transport. In this category, bike-sharing is the most discussed mode in the literature (n = 9). It is, moreover, the most effective strategy, reporting the highest proportion of positive effects (88%), among the articles reporting the effects of their results (Figure 31). In fact, only one (1) article reports a neutral result (Fuller et al., 2013), since the substitution effect is higher for the PT rather than for the car. All the other research also mentions the effect of substitution (or complementarity) that bike-sharing has with public transport, or even traditional cycling or walking, but these articles remain very positive with regard to the reduction of the use of the car with a modal shift sometimes being important.

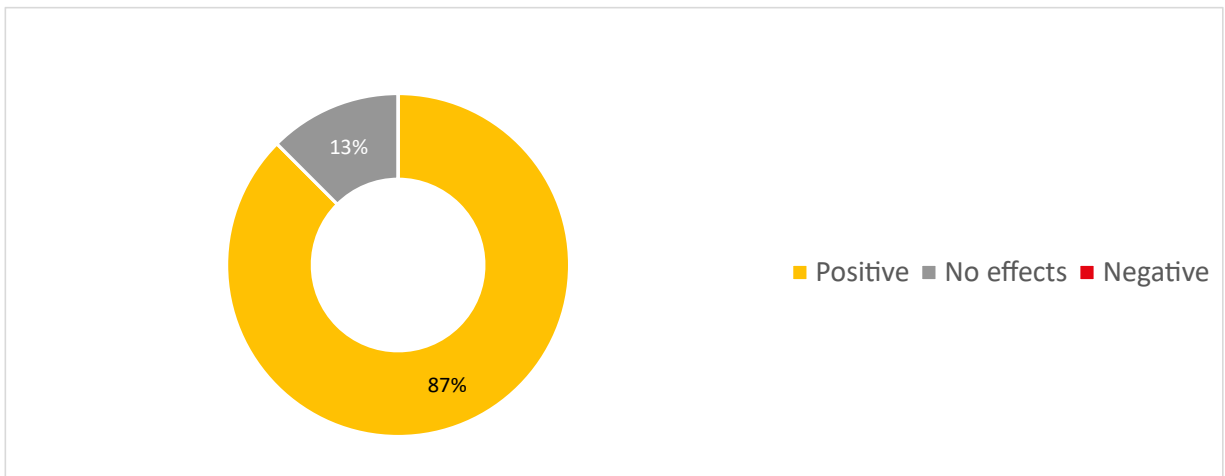


Figure 31 – Effect of supplying a shared mobility service type interventions

### Adding a New Transport Infrastructure

Twenty-one (21) articles discuss adding new transport infrastructure as a strategy to generate modal shift. Of those reporting effects on modal shift, 57% reported a positive effect, 38 % reported a neutral effect and 5% reported a negative effect. In fact, only one article reported a negative effect: the latter discussed the conversion of a carpool lane to a paid carpool lane (HOT Lane) in order to encourage motorists to carpool (Guensler et al., 2016 ).

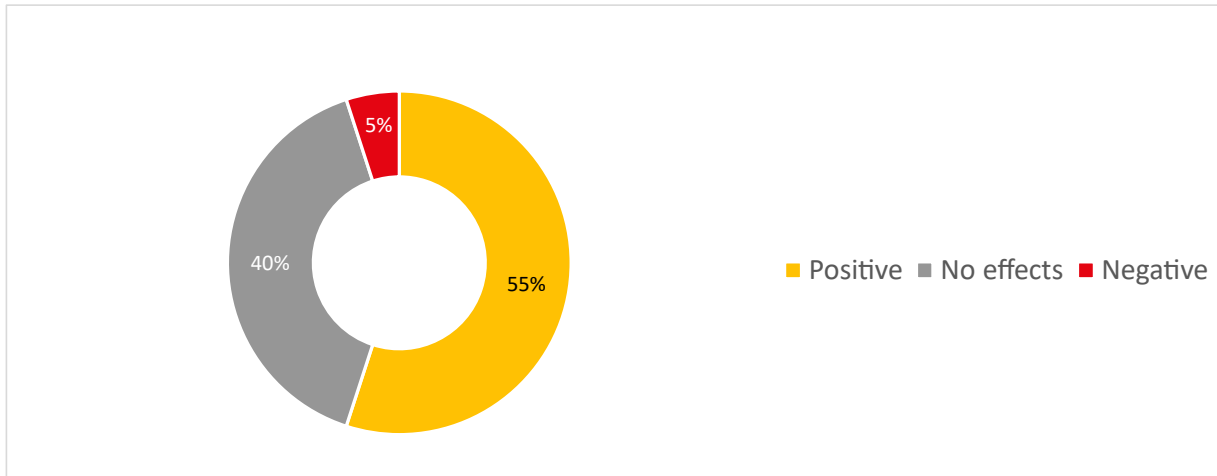


Figure 32 – Effect of interventions such as adding a transport infrastructure

Adding infrastructure dedicated to AT seems very successful in generating a modal shift towards these modes, since 75% of the articles discussing it obtained a positive effect (Mitra et al., 2017; Song et al., 2017; Thakuriah et al. , 2012) (Figure 33).

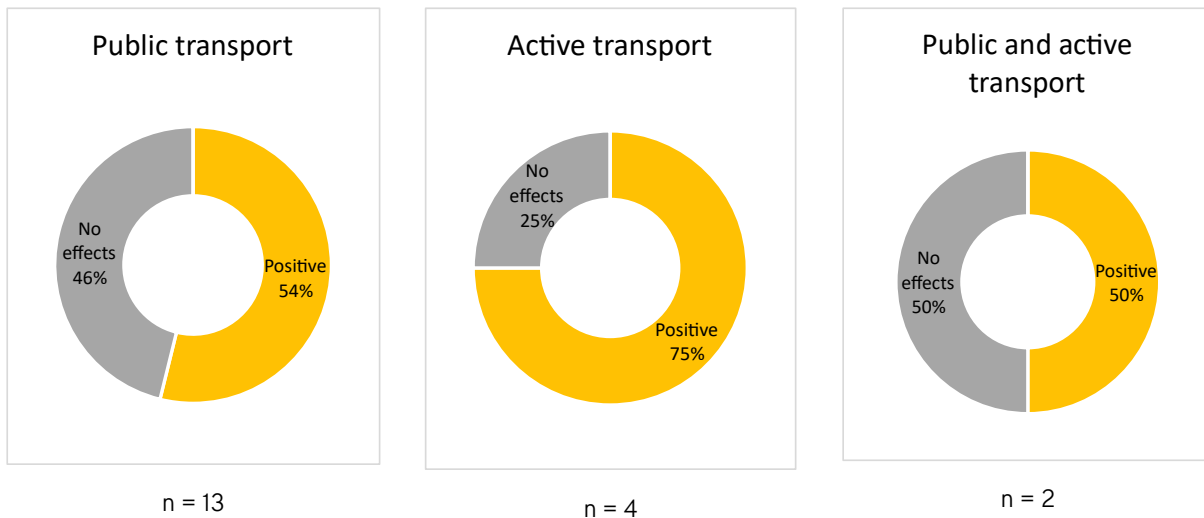


Figure 33 – Effect of interventions adding new transport infrastructure depending on the mode of transport



## “Stick”-Type Measures

### Car Pricing Constraints (e.g. Tolls, Parking Fees)

The pricing constraints that aim to dissuade motorists from continuing to use their car are the most studied modal shift strategy (n = 24). Seventy-one percent (71 %) of these articles report positive results (Figure 34). Thus, increasing the cost of car use very generally turns out to be an effective modal shift measure.

Moreover, it is interesting to note that this modal shift strategy is rarely studied alone (n = 7 only). Most of the time, pricing constraints support other measures. The combination with improving the quality, efficiency or accessibility of alternative transport is the most frequent (n = 8) and 100% of these articles report positive results. Luathep et al. (2015), for example, claim that the shorter travel and waiting times for a bus service generated a number of modal shifts, while the modal shift effect was much more significant when at the same time, the introduction of a parking tariff was imposed.

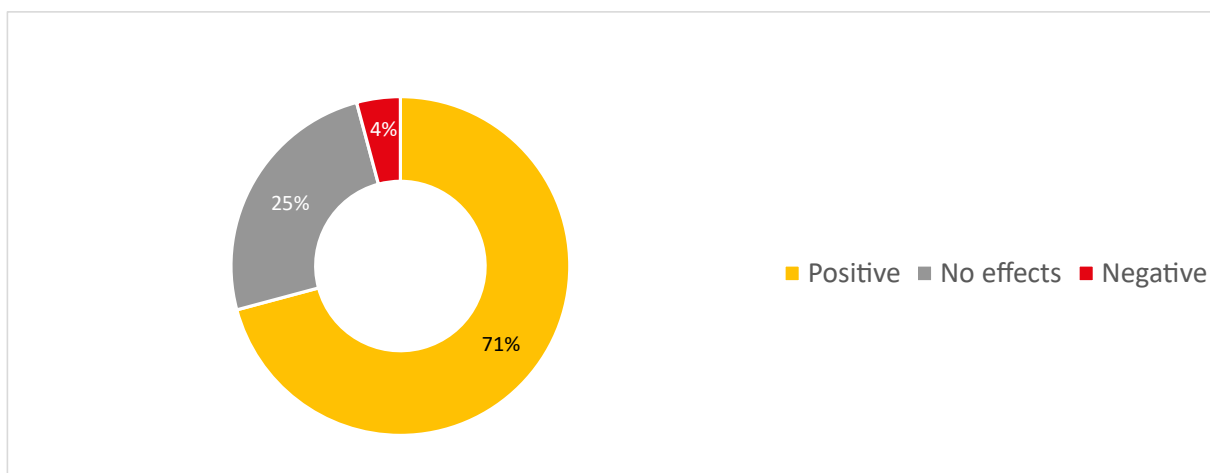


Figure 34 – Effect of interventions such as tariff constraints on the automobile

### Changes in Space Dedicated to the Car (e.g. Lanes, Parking Lots)

Only six (6) articles discuss reducing the space dedicated to the car to stimulate modal shift. Although more research would be needed to draw true conclusions, only 50% of these articles reported positive results, the other 50% being neutral results (Figure 35). For example, Chung et al. (2012) found that the conversion of a major urban highway to a linear park has lowered the modal share of the automobile in favour of public transport. For their part, Melia and Shergold (2018) do not notice a change in the use in the car when certain streets in a historic and tourist district are pedestrianized.

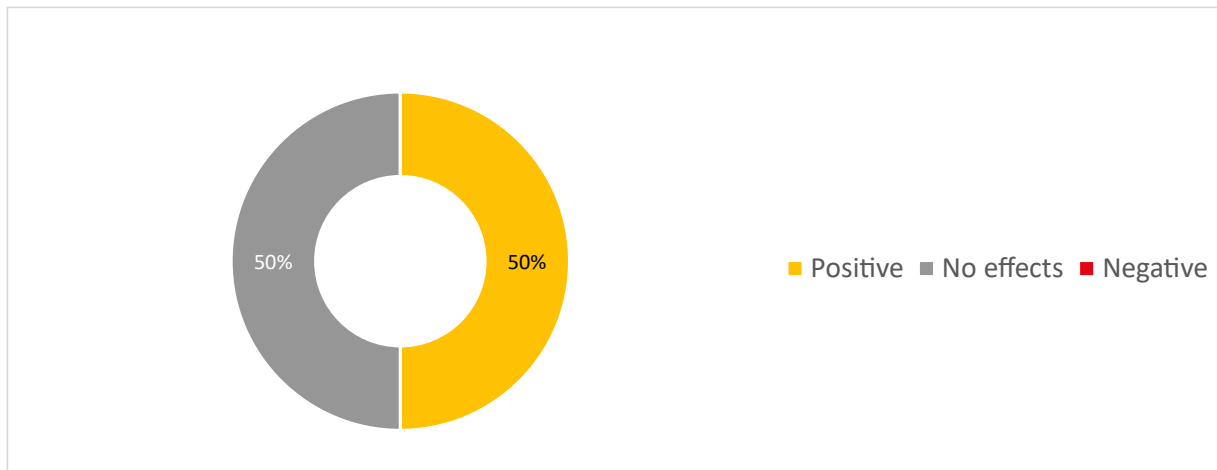


Figure 35 – Effect of interventions such as changes in the space dedicated to the automobile

## Implications for Policy, Practice and Research

### Mostly Conclusive Results

Examining the scope of the literature from 2010 to 2020 on modal shift reveals some strengths as well as some weaknesses in modal shift research over the past 10 years. First of all, it should be noted that more than two thirds of research reports positive results and that a tiny part of the research reports effects contrary to the expected results of modal shift in favour of alternative mobility. Which leads us to believe that it is therefore possible to put in place public policies to induce modal shift and finally reduce our car dependence. In fact, in some cases our scoping review reports very high success rates. For example, studies of adding a new active transportation supply report success in almost all cases (92%). This great potential for success leads us to believe that it is therefore important to encourage cities to attempt interventions aimed at modal shift towards AT. We also encourage transport researchers to further explore the successes of this type of intervention.

We also note two categories of interventions in particular that show exceptionally positive results. Indeed, shared mobility is the most effective strategy in itself with a success rate of 88%. But the effectiveness of interventions also often comes from the combination of them. For example, the combination of automobile pricing constraints with improved quality, efficiency or accessibility to alternative transport generates a modal shift in 100% of the cases reported.

### A Growing Research Topic

It is also important to note that the number of research studies focusing on modal shift is growing strongly, particularly between 2014 and 2017. This literature also turned out to be almost non-

existent in French despite our efforts to manually include French language transport and planning scientific journals. It appears, as is the case with Lachapelle (2015) and Castel (2019), that researchers investigating French-speaking fieldwork publish their results in English.

## A Mostly Quantitative Research

We note that very few qualitative or at least mixed studies (combining quantitative and qualitative methods) are present in the studies listed. It would then be relevant to encourage qualitative research on modal shift in order to better understand the reasons that make it work when it does and how the individuals who make the modal shift perceive it. Qualitative research could also shed light on the reasons behind the lack of success of some modal shift approaches. In addition, for the quantitative literature on modal shift, there is no generalized way to quantify modal shift. Sometimes researchers report a percentage of modal shift from the private car to alternative modes, sometimes they report the reduction in percentage points in the modal share of the automobile, sometimes they report the decrease in the number of vehicles on a road or the reduction in distances travelled, while sometimes they measure an intention to make modal shift. This makes it very difficult to produce a meta-analysis of our results given the wide variety of types of data reported.

## Diversified Research, but Which Would Benefit From Being More Varied

We grouped the interventions according to the different types related to modal determinants (see Figure 1) and this has identified that little research looks at the habits embedded in the daily life of motorists as well as land-use planning. Yet a large majority of research on habit-related interventions reported positive effects. While those relating to planning seem to have the least success. Research, particularly qualitative research in this case could shed light on this lack of success or confirm it by studying more cases. It therefore appears necessary to suggest encouraging research on these two types of interventions which are, moreover, rather popular with urban and transport planners.

More than a third of all the research carried out focuses on the modal shift linked to the addition of a new transport supply. However, just under two thirds of this research focused solely on PT and a large majority of these studies report positive examples. However, it appears necessary to do more research either on the combination of AT and PT or only on AT in association with the values of the participants. This is all the more so since some research shows that environmental awareness and information on the negative effects of individual automobile mobility do not guarantee modal transfer or have a minor impact (Elias & Shiftan, 2012; Geng et al., 2020 ; Trond et al., 2019).

We note a certain lack of diversity in the literature surveyed with regard to the types of urban structures surveyed. Indeed, only 7 articles (6%) relate to a strictly peri-urban context, and 1 article (1%) relates to a rural context. This seems to represent an important blind spot in the literature on this subject. It can also be due to a lack of experimentation or intervention aimed at modal shift in this type of territory. On the other hand, it appears essential to recall that the peri-urban and rural sectors also represent a significant part of the population as well as particular challenges for modal shift. It is therefore important for future research to look at these types of territories since the literature from 2010 to 2020 does not look very much at this type of territory.

## Research That Does Not yet Take New Policies into Account

Certain transport policy measures currently implemented or discussed by public decision makers are little studied and it appears essential for transport researchers to look more vigorously at the modal shift potential of these types of policy. In particular, park-and-ride lots are poorly evaluated as well as Mobility as a Service appears almost absent from the literature. In addition, the modal shift linked to the car in collective or shared mode (carpooling and carsharing) is hardly covered by research. However, this represents emerging modes of transport that are frequently present in political discourse.

We also make an important observation regarding the degree of coercion of the interventions investigated in the literature. “Carrot” measures which seek to induce modal shift by offering a benefit (e.g. rebates, free, improved PT, new infrastructure) are much more studied in the literature than “stick” measures which aim to restrict certain choices (pricing, tolls, reduction of parking spaces). Although few studies have looked at the “carrot” + “stick” combination (n = 13), this research reports the most positive results. This leads us to encourage research on this type of intervention and to suggest that public decision-makers take into account the beneficial effects for modal shift resulting from the combination of the carrot and the stick. This is the preferred strategy in a comprehensive plan and could be the subject of funding criteria for government funding authorities.

## And Canadian Research in All of This ...

Only six (6) studies included fieldwork carried out in Canada, which represents only 6% of the scientific literature surveyed. Of these articles, three (3) focused on the city of Toronto and two (2) on the city of Montréal. In fact, all of the studies focused on cases located in Quebec or Ontario. Given the diversity of large Canadian cities and the large number of small and medium-sized cities across the country, we believe it is important to urge our fellow researchers and funders to investigate a greater diversity of Canadian cases. This would help decision makers from coast to coast to better understand the modal shift strategies most conducive to inducing modal shift in our context. We cannot rely exclusively on the multitude of research carried out in the United States (a quarter of all the research reviewed), since significant differences exist in mobility behaviour between the two North American neighbours (Pucher, 1988; Pucher & Buehler, 2006; Pucher & Lefèvre, 1996). Of this small amount of research on Canada, only two research looked at PT while three research looked at AT.

## Conclusion

The objective of this research was to carry out a scoping review of the literature in order to identify the different modal shift strategies studied and to report their effects. We were particularly interested in five types of intervention aimed at inducing modal shift among motorists: A) the habits anchored in the daily life of motorists; B) values, preferences, and lifestyles; C) the impact of economic levers such as the pricing of PT or the externalities of automobility; D) the effects of the supply of PT and the spatial distribution of its infrastructure; and E) effects related to land use planning and residential locations.

To this end, we analyzed the titles and abstracts of 2,872 articles published between 2010 and 2020 potentially dealing with modal shift. In the end, 108 articles were analyzed and included in the review.

## Main Findings

- The vast majority of interventions tested in the literature have demonstrated their potential to generate a modal shift from the car to alternative modes (67% positive effects; 31% neutral effects; 2% negative effects).
- There is no generalized way to quantify modal shift in the modal shift literature.
- The literature on modal shift contains very few qualitative or at least mixed-method studies (combining quantitative and qualitative).
- Little research examines the daily habits of motorists as well as land-use planning. Yet a large majority of research on habit-related interventions reported positive effects.



- Some transport policy measures are little studied. In particular park-and-ride lots, Mobility as a Service and cars in collective or shared mode (carpooling and carsharing).
- Only 6% of the scientific literature surveyed included fieldwork carried out in Canada, and this only in Quebec and Ontario.

## Limits of our Approach

Throughout the research project, we have tried to put in place a rigorous methodology by ensuring that at least two researchers evaluate each of the articles and that another researcher is consulted in the event of a conflict between the two reviewers. We had established an exhaustive list of inclusion criteria from the start and have met them to the best of our ability. Certain exclusion factors also remain beyond our control. For example, 26 research (out of 384) could not be rated because we were unable to retrieve the documents due to lack of access through Laval University library subscriptions.

In addition, we did not systematically assess the quality of the studies reviewed, assuming that their inclusion in a scientific database represented a measure of quality. This verification appears to us necessary for a systematic review of the literature aiming to make a complete meta-analysis, but we consider it optional for a scoping review like ours. However, a few studies appeared to us to be of poor quality given the poor writing style that we could not understand. These studies were de facto excluded from the analysis.

Finally, the great variety of fields of investigation where studies are carried out which represent contexts of very varied levels of development, planning and socio-demographic realities and the concentration of a large number of studies from two countries in particular (United-States: 24 articles and China 20: articles) represents a limit which leads us to temper the generalization of the results of this research.

## Next Steps

### At the Research Level

Originally, we planned to use the scoping literature review methodology as proposed by Levac et al. (2010), including phase 6 external consultation which is considered optional by the authors. As the number of papers collected in the early stages of data collection far exceeded our expectations, the study selection stage (see Figure 2) required more effort than expected, consuming several weeks of work. As a result, we had to postpone the external consultation to a stage subsequent to the production of this report. We will take advantage of the forum organized by SSHRC to collect the first external opinions on our results, but still plan to try to achieve this step before the publication of scientific articles presenting our results.

We have also updated the mapping of our articles on several occasions in order to clarify our knowledge of the literature more and more. We also aimed to carry out a meta-analysis of the data thus collected. As described above, it turned out that research on modal shift expresses its results with a wide variety of methods, which constrains meta-analysis. Nevertheless, in the coming months, we will carry out a meta-analysis with a subset of the articles listed in order to assess the potential of this approach and if possible to draw conclusions about the modal shift strategies with the greatest potential to induce a modal shift.

### Communications With Practitioners

Once finalized, this research report will be our main communication tool with practitioners. The final version of the report will be translated into English and it will be hosted in CorpusUL, the institutional repository of Université Laval, in order to make it freely accessible, increase its visibility and promote the sharing of knowledge in a sustainable manner with planners, politicians and those responsible for transport systems. We will also propose to distribute the report through the newsletters of the professional associations to which we belong (eg AQTR, CUTA). To facilitate the transfer of knowledge, a communication aiming to present the scoping review of the literature and the recommendations of the report will also be proposed to the Canadian Urban Transport Association as part of its annual conference. We will also take advantage of the forum organized by SSHRC (January 2022) to actively promote our results to the various invited participants.

## Scientific Communications

In order to contribute to the advancement of knowledge on modal shift and open up research possibilities, we will produce a scientific article presenting the scoping review of the literature. We also anticipate writing an article presenting our meta-analysis of a sample of the selected literature. The journals targeted for these publications are those in transport, both French and English (Transport Geography, Transport policy, Transportation Research Part A: Policy and Practice and Flux). In accordance with the policy of free access to scientific publications, accepted manuscripts will be deposited and made available on the institutional repository of Université Laval. Once the articles are published, the research data will be deposited in the Scholars Portal Dataverse repository. Prior to being officially submitted, we also plan to present these results in conference format at the Transportation Research Board Annual Meeting (Jan. 2023).

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## Appendix 2 - Documentary Search Strategy

Table 4 - Documentary Search Strategy

<b>Block 1: Transportation change (to be searched for in titles and abstracts)</b>		<b>Block 2: Use and type of transport (to be searched for in titles and abstracts)</b>	
<i>English</i>	<i>French</i>	<i>English</i>	<i>French</i>
Modal shift*	Transfert modal	Public transport*	Transport public
Mode shift*	Mode de	Public transit	Transports publics
Modal transfer*	substitut*	Mass transit	Transports privé*
Mode transfer*	Substitut* du	Mass transport*	Transport privé*
Modal substitut*	mode	Urban transit	Transport personnel
Mode substitut*	Report modal	Urban transport*	Transports personnels
		Private transport*	Transports alternatifs
		Personal transport*	Transport alternatif
		Collective transport*	Altermobilité
		Mechanized transport*	Altermobiles
		Mechanized transport*	Altermobile
		Motorized transport*	Transport collectif
		Motorized transport*	TC
		Automobile*	Transports collectifs
		Auto	TC
		Autos	Transport mécanisé
		Car	Transport motorisé
		Cars	Transports motorisés
		Bus	Automobile*
		Auto use*	Voiture*
		Traffic*	Bus
		Congestion	Usage de l'auto
		Transit	Usage des autos
		Station*	Trafic
		Alternative transport*	Congestion
		Alternative mobility	Arrêts
			Station*

## Appendix 3 - Data Tables

Table 5 – Types of intervention discussed in the literature

		Effects of interventions		
		Positive	Neutral	Negative
<b>A) Habits Anchored in the Daily Life of Motorists</b>	Cairns et al., 2017; Castel et al., 2019; Colclough & Moscholidou, 2016; <sup>a</sup> Gao et al., 2020; Hino et al., 2019; Jariyasunant et al., 2014; Moser et al., 2018; Riggs, 2015		<sup>a</sup> Abou Zeid & Ben Akiva, 2012; Robbins et al., 2011; Wall et al., 2017	
<b>B) Values, Preferences, and Lifestyles</b>	Abdulrazzaq et al., 2020; Chowdhury et al., 2016; Qin et al., 2017; <sup>a</sup> Salameh & Jawad, 2019; <sup>a</sup> Satiennam et al., 2016; S. A. Shaheen, Zhang, et al., 2011; Zhang et al., 2015		Fenton, 2016; Ge et al., 2017; Geng et al., 2020; <sup>a</sup> Idris et al., 2014	
<b>C) Impact of Economic Levers such as Pricing of Public Transport or Automobility Externalities</b>	<sup>a</sup> Almselati Aldukali Salem et al., 2015; <sup>a</sup> Ding & Zhang, 2017; Huré & Javary, 2020; Kaffashi et al., 2016; Lari et al., 2014; Li et al., 2019; <sup>a</sup> Luathep et al., 2015; Melia & Clark, 2018; <sup>a</sup> Salameh & Jawad, 2019; Siddique Md Abu & Choudhury Charisma, 2017; Stuart & Sarangi, 2011; Trond et al., 2019; Tu et al., 2019		<sup>a</sup> Abou Zeid & Ben Akiva, 2012; Bazrbachi et al., 2017; Chiou Yu & Fu, 2017; <sup>a</sup> Knott et al., 2019; Lachapelle, 2015; Proulx et al., 2014; Rosenfield et al., 2020; Storme et al., 2020; Tørnblad et al., 2014; Yan et al., 2019	Burriss Mark, 2016
<b>D) Automobile Alternative Transport Supply (Effects of) and the Spatial Distribution of its Infrastructure</b>	<sup>a</sup> Almselati Aldukali Salem et al., 2015; Anwar & Yang, 2017; Barbour et al., 2019; Bhaduri et al., 2020; Cherry et al., 2016; <sup>a</sup> Ding & Zhang, 2017; Fishman et al., 2014; Gan & Ye, 2018; Gunay et al., 2016; Hatfield & Boufous, 2016; Huang et al., 2019; Ingvardson & Nielsen, 2018; Kroesen, 2017; <sup>a</sup> Luathep et al., 2015; Ma et al., 2019; H. A. Nguyen et al., 2018; N. T. Nguyen et al., 2018; Perez Martin et al., 2018; Riggs, 2016a; <sup>a</sup> Satiennam et al., 2016; S. A. Shaheen et al., 2010; S. A. Shaheen, Martin Elliot, et al., 2013; Song et al., 2017; Sun et al., 2020; Xu, 2020; Yang et al., 2015		Cao Xinyu, 2019; Chalermpong et al., 2018; Collins Patricia & MacFarlane, 2018; <sup>a</sup> Elias & Shiftan, 2012; Fuller et al., 2013; Heinen et al., 2017; Ian et al., 2019; <sup>a</sup> Idris et al., 2014; Mane et al., 2018; Spears et al., 2017; Wang et al., 2013	Pronello et al., 2016
<b>E) Land Use Planning (Effects of) and Residential Locations</b>	Chung et al., 2012; Henao et al., 2015; Mitra et al., 2017; Thakuriah et al., 2012		Blitz et al., 2020; <sup>a</sup> Knott et al., 2019	

<sup>a</sup> Articles in several categories

Table 6 – Carrot and stick measures analyzed in the literature

Effects of interventions			
	Positive	Neutral	Negative
<b>Carrot only</b>	Abdulrazzaq et al., 2020; Abrahamse & Keall, 2012; Anwar & Yang, 2017; Barbour et al., 2019; Bhaduri et al., 2020; Cairns et al., 2017; Carroll et al., 2017; Castel et al., 2019; Cats et al., 2017; Chowdhury et al., 2016; Colclough & Moscholidou, 2016; Fishman et al., 2014; Gan & Ye, 2018; Gao et al., 2020; Gunay et al., 2016; Henao et al., 2015; Hino et al., 2019; Huang et al., 2019; Huré & Javary, 2020; Ingvardson & Nielsen, 2018; Jariyasunant et al., 2014; Lari et al., 2014; Ma et al., 2019; Mitra et al., 2017; Moser et al., 2018; H. A. Nguyen et al., 2018; N. T. Nguyen et al., 2018; Perez Martin et al., 2018; Riggs, 2015; Shaheen et al., 2010, 2011, 2013; Song et al., 2017; Thakuria et al., 2012; Xu, 2020; Yang et al., 2015; Zhang et al., 2015	Abou Zeid & Ben Akiva, 2012; Blitz et al., 2020; Chalermpong et al., 2018; Collins Patricia & MacFarlane, 2018; Elias & Shifftan, 2012; Fuller et al., 2013; Ge et al., 2017; Geng et al., 2020; Heinen et al., 2017; Ian et al., 2019; Idris et al., 2014; Lachapelle, 2015; Mane et al., 2018; Rosenfield et al., 2020; Spears et al., 2017; Storme et al., 2020; Tørnblad et al., 2014; Wall et al., 2017; Wang et al., 2013	Burris Mark, 2016; Pronello et al., 2016
<b>Stick only</b>	Ahmadi Azari et al., 2013; Chung et al., 2012; Melia & Clark, 2018; Stuart & Sarangi, 2011; Trond et al., 2019	Bazrbachi et al., 2017; Cao Xinyu, 2019; Chiou Yu & Fu, 2017; Knott et al., 2019; Yan et al., 2019	
<b>Both (combined)</b>	Bleechmore et al., 2011; Dale et al., 2019; Ding & Zhang, 2017; Kaffashi et al., 2016; Qin et al., 2017; Salameh & Jawad, 2019; Satiennam et al., 2016; Siddique Md Abu & Choudhury Charisma, 2017; Tu et al., 2019	Fenton, 2016; Melia & Clark, 2018; Proulx et al., 2014	

Table 7 – The modal shift strategies that have been tested in the literature

Effects of interventions			
	Positive	Neutral	Negative
<b>“Carrot”-Type Measures</b>			
<i>Freebies or Financial Incentives</i>	<sup>a</sup> Abrahamse & Keall, 2012; <sup>a</sup> Bleechmore et al., 2011; <sup>a</sup> Carroll et al., 2017; <sup>a</sup> Cats et al., 2017; <sup>a</sup> de Grange et al., 2012; <sup>a</sup> Ding & Zhang, 2017; <sup>a</sup> Huré & Javary, 2020; <sup>a</sup> Lari et al., 2014; <sup>a</sup> Li et al., 2019; <sup>a</sup> Riggs, 2015	<sup>a</sup> Abou Zeid & Ben Akiva, 2012; <sup>a</sup> Lachapelle, 2015; <sup>a</sup> Proulx et al., 2014; <sup>a</sup> Robbins et al., 2011; <sup>a</sup> Rosenfield et al., 2020; <sup>a</sup> Storme et al., 2020; <sup>a</sup> Tørnblad et al., 2014	
<i>Trial Period</i>	<sup>a</sup> Cairns et al., 2017; <sup>a</sup> Castel et al., 2019; <sup>a</sup> Moser et al., 2018; <sup>a</sup> Perez Martin et al., 2018	<sup>a</sup> Abou Zeid & Ben Akiva, 2012; <sup>a</sup> Chalermpong et al., 2018	
<i>Information, Marketing, Real-Time Information</i>	<sup>a</sup> Abrahamse & Keall, 2012; <sup>a</sup> Carroll et al., 2017; <sup>a</sup> Castel et al., 2019; <sup>a</sup> Colclough & Moscholidou, 2016; <sup>a</sup> Gan & Ye, 2018; <sup>a</sup> Hino et al., 2019; <sup>a</sup> Jariyasunant et al., 2014; <sup>a</sup> Riggs, 2015; <sup>a</sup> Shaheen et al., 2010; <sup>a</sup> Zhang et al., 2015	<sup>a</sup> Ge et al., 2017; <sup>a</sup> Geng et al., 2020; <sup>a</sup> Robbins et al., 2011; <sup>a</sup> Rosenfield et al., 2020; <sup>a</sup> Storme et al., 2020; <sup>a</sup> Tørnblad et al., 2014; <sup>a</sup> Wall et al., 2017	<sup>a</sup> Pronello et al., 2016
<i>Improving Quality, Efficiency or Accessibility</i>	<sup>a</sup> Abdulrazzaq et al., 2020; <sup>a</sup> Almselati Aldukali Salem et al., 2015; <sup>a</sup> Anwar & Yang, 2017; <sup>a</sup> Bhaduri et al., 2020; <sup>a</sup> Carroll et al., 2017; <sup>a</sup> Chowdhury et al., 2016; <sup>a</sup> Dale et al., 2019; <sup>a</sup> Gao et al., 2020; <sup>a</sup> Kaffashi et al., 2016; <sup>a</sup> Luathep et al., 2015; <sup>a</sup> N. T. Nguyen et al., 2018; <sup>a</sup> Qin et al., 2017; <sup>a</sup> Salameh & Jawad, 2019; <sup>a</sup> Satiennam et al., 2016; <sup>a</sup> Tu et al., 2019	<sup>a</sup> Collins Patricia & MacFarlane, 2018; <sup>a</sup> Elias & Shifan, 2012; <sup>a</sup> Ian et al., 2019; <sup>a</sup> Idris et al., 2014	
<i>Park-and-Ride Type Interventions</i>	<sup>a</sup> Anwar & Yang, 2017; <sup>a</sup> Gan & Ye, 2018	<sup>a</sup> Chalermpong et al., 2018	
<i>Supplying a Shared Mobility Service (Bicycle, Electric Bicycle, Automobile)</i>	<sup>a</sup> Barbour et al., 2019; <sup>a</sup> Fishman et al., 2014; <sup>a</sup> Ma et al., 2019; <sup>a</sup> Shaheen et al., 2011, 2013; <sup>a</sup> Xu, 2020	<sup>a</sup> Fuller et al., 2013	
<i>Adding a New Transport Infrastructure</i>	<sup>a</sup> de Grange et al., 2012; <sup>a</sup> Ding & Zhang, 2017; <sup>a</sup> Gunay et al., 2016; <sup>a</sup> Henao et al., 2015; <sup>a</sup> Huang et al., 2019; <sup>a</sup> Ingvardson & Nielsen, 2018; <sup>a</sup> Mitra et al., 2017; <sup>a</sup> H. A. Nguyen et al., 2018; <sup>a</sup> N. T. Nguyen et al.,	<sup>a</sup> Blitz et al., 2020; <sup>a</sup> Cao Xinyu, 2019; <sup>a</sup> Elias & Shifan, 2012; <sup>a</sup> Heinen et al., 2017; <sup>a</sup> Ian et al., 2019; <sup>a</sup> Mane et al., 2018; <sup>a</sup> Spears et al., 2017; <sup>a</sup> Wang et al., 2013	<sup>a</sup> Burris Mark, 2016

2018; <sup>a</sup>Perez Martin et al., 2018; Song et al., 2017; Thakuriah et al., 2012

**“Stick”-Type Measures**

*Car Pricing Constraints (e.g. Tolls, Parking Fees)*

Ahmadi Azari et al., 2013; <sup>a</sup>Almselati Aldukali Salem et al., 2015; <sup>a</sup>Bleechmore et al., 2011; <sup>a</sup>Carroll et al., 2017; <sup>a</sup>Dale et al., 2019; <sup>a</sup>de Grange et al., 2012; <sup>a</sup>Ding & Zhang, 2017; <sup>a</sup>Kaffashi et al., 2016; <sup>a</sup>Li et al., 2019; <sup>a</sup>Luathep et al., 2015; Melia & Clark, 2018; <sup>a</sup>Qin et al., 2017; <sup>a</sup>Salameh & Jawad, 2019; Siddique Md Abu & Choudhury Charisma, 2017; <sup>a</sup>Stuart & Sarangi, 2011; Trond et al., 2019; Tu et al., 2019

Bazrbachi et al., 2017; Chiou Yu & Fu, 2017; <sup>a</sup>Knott et al., 2019; <sup>a</sup>Proulx et al., 2014; <sup>a</sup>Robbins et al., 2011; Yan et al., 2019

<sup>a</sup>Burris Mark, 2016

*Changes In Space Dedicated to the Car (e.g. Lanes, Parking Lots)*

Chung et al., 2012; <sup>a</sup>Luathep et al., 2015; <sup>a</sup>Stuart & Sarangi, 2011

<sup>a</sup>Knott et al., 2019; <sup>a</sup>Mane et al., 2018; Melia & Shergold, 2018

<sup>a</sup> Articles in several categories

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