Protocol of an Interdisciplinary and Multidimensional Assessment of Pollution Reduction Measures in Urban Areas: MobilAir Project

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1 Introduction

A large literature explores the impact, in the economic evaluation of climate policies, of integrating air pollution reduction as a co-benefit of these policies. This literature shows that considering pollution reductions induced by climate policies leads to an extremely significant reduction in the cost of reducing greenhouse gas emissions (Ekins 1996; Nemet et al. 2010; Vandyck et al. 2018). It also increases the willingness to pay on the part of the population to reduce GHG emissions (Longo et al. 2012). The co-benefits of climate policies encourage an increase in the ambition of national policies to reduce GHG emissions (Zenghelis 2017). This is why these pollution reduction policies are perceived as a political lever to obtain short-term benefits relevant for the implementation of climate policies whose specific benefits will only be felt in the long term (Aunan et al. 2003; Altemeyer-Bartscher et al.

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W. Buchholz et al. (eds.), *Ancillary Benefits of Climate Policy*, Springer Climate,
https://doi.org/10.1007/978-3-030-30978-7_18

2014). These pollution reduction policies are all the more relevant in the case of urban areas (Krupnick et al. 2000; Jack and Kinney 2010; Harlan and Ruddell 2011). Indeed, in many countries, they face an alarming health impact from air pollution, and they are central actors in implementing actions to reduce greenhouse gas emissions with decisive sectoral issues, whether for the energy consumption of residential and tertiary buildings or the organization of mobility in the catchment area between home, leisure and professional activities. This is why the MobilAir project, whose protocol we present here, focuses on policies to reduce pollution and greenhouse gas emissions in an urban area. Nevertheless, we consider here that the agglomeration is setting up a programme to reduce particulate air pollution in order to reduce its impacts in the short term. Air quality is thus the primary benefit of the MobilAir project while greenhouse gas emission reduction can be considered as secondary benefits.

Reducing air pollution and combating climate change are two inextricably linked issues. In many cities, the main sectors contributing to these two major environmental problems are transport and heating. Reducing fuel consumption in road transport and the share of individual cars in mobility are the main common challenge facing the transport sector. In the buildings and residential sector, the coherence of the actions to be taken to fight on both fronts is more complex. Indeed, in this sector, the major problem in combating global warming is to reduce energy consumption and promote the penetration of non-carbon energies, including wood heating that is considered as carbon neutral. On the other hand, wood heating, if it is not efficient, is a major source of air pollution.

Outdoor air pollution kills more than three million people across the world every year and causes health problems from asthma to heart disease for many more (OECD 2014; Lelieveld et al. 2015; WHO 2016). The cost of the health impact of air pollution in OECD countries (including deaths and illness) was about USD 1.7 trillion in 2010 (OECD 2014). Nevertheless, despite these alarming figures, there are few examples of the implementation of programmes at urban levels that have significantly reduced the impacts of air pollution.

A first explanation lies in the difficulty that the measures implemented have in structurally changing individual behaviour towards sustainable practices. It seems necessary to make progress in understanding the determinants of individual behaviour. It is clear that developing infrastructures for road alternative mobility, e.g., bike lane is not enough to strongly increase bike use. Mobility behaviours are complex and are not determined only by cost of transport, time spent in transportation, and transport offer. Individual drivers related to altruism, perceptions, and social norms, as well as habits, also play a role. It is thus important to improve the comprehension of mobility behaviours. Identifying if subjects being offered adapted alternative (cleaner) transportation modes can adopt these modes, and if not, understanding which obstacles exist, would be very innovative.

A second explanation is that policies to reduce pollution are often dimensioned without explicit consideration of a targeted health impact. At the best, they rely on an ex ante environmental evaluation ignoring any health consequence. Starting from a target health impact to appropriately dimension urban policy measures would be a logical and important change of approach. It raises scientific challenges, implying to develop a reverse approach consisting of starting from a target formulated in terms of improvement of health (e.g., a reduction by 20% in PM-related mortality) and subsequently identifying policy measures allowing to reach such a health target. Such an approach would be of great relevance to decision-making.

Finally, when these air pollution reduction programmes are implemented, they are not subject to a systematic multi-dimensional assessment approach. Cities in Europe and elsewhere have undertaken measures to limit air pollution emission, especially from transportation and heating sources. In France, in 2012, "ZAPA" (meaning "priority action area for air", an ancient acronym for low emission zones—LEZ) had been planned, but abandoned. A reason put forward was that such measures were deemed socially unequal (with the more deprived people being disproportionally touched by traffic restriction measures). However, very few, if any, rigorous evaluations of any social inequality in cost (and also benefit) of low emission zones have to our knowledge been conducted. In cities where ambitious programs were implemented, environmental evaluations have documented decreases in PM_{10} by as much as 50% in Tokyo between 2001 and 2010 (Hara et al. 2013), and between 5% and 13% in Germany (Cyrys et al. 2014; Fensterer et al. 2014). ADEME's review of LEZ (ADEME is the French Environment and Energy Management Agency; ADEME 2017) shows that only in rare cases was the environmental evaluation supplemented with a Health Impact Assessment, or HIA (Clancy et al. 2002; Cesaroni et al. 2012). Estimating the cost of the measures taken by the local authorities would also be very important, and would allow conducting cost–benefit analyses of such policies. In the USA, analyses of benefits and costs of the Clean Air Act law are planned by the law and indicate that the benefits exceed costs by a factor of 30–90. No such figure is available in France. Making such figures available in the French and European context, where atmospheric pollution standards are much higher than in the USA (regulatory limit of 25 $\mu g/m^3$ for $PM_{2.5}$ yearly concentration in Europe, compared to 10 in the USA), would be very relevant for citizens and decision-makers.

The MobilAir project, therefore, aims to contribute to the significant reduction of air pollution and greenhouse gas emissions in urban areas. To that end, it relies on an interdisciplinary methodology.

2 MobilAir Project

2.1 Objectives

MobilAir overarching aim is to contribute to air quality improvement in urban areas. To do so, two major scientific issues will be investigated: the characterization of the exposure level of the population to atmospheric pollution and of its health impact (WP1), and a better comprehension of levers and obstacles to air quality improvement, particularly concerning mobility from behaviours to urban planning

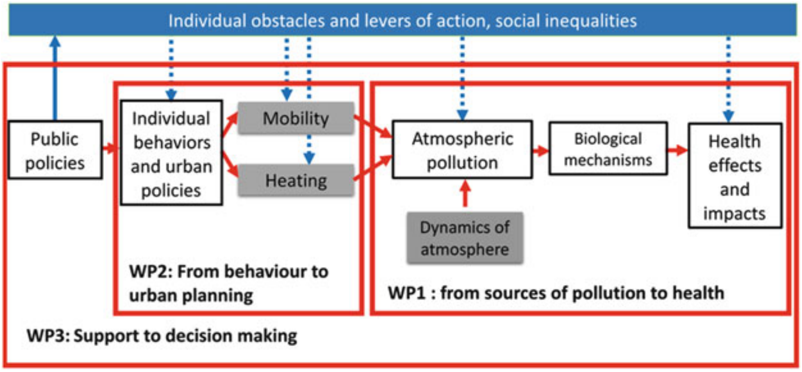

Fig. 1 Structure of the MobilAir project

(WP2). These two WPs will provide inputs to build an interdisciplinary modelling tool to provide support to decision-making towards healthier cities (WP3) (Fig. 1).

To meet these scientific challenges, the MobilAir project relies on a set of disciplinary skills existing on a specific aspect related to air pollution in the laboratories of the Grenoble university campus. Seven research laboratories working in seven different disciplines make up the MobilAir consortium:

– In sociology, geography, and planning, the PACTE laboratory is implied in research related to barriers to behavioural change, mobility, and urban planning.
– In behavioural psychology, the SENS laboratory studies the motivation for physical and sports activities, or active mobility.
– In environmental economics, the GAEL laboratory is involved in transport and health economics, consumption behaviour, and cost–benefit analyses of environmental policies.
– In biology and health, the IAB evaluates the health impact of early exposures and mechanisms for the action of pollutants.
– In air quality, the IGE analyses the particulate matter toxicity.
– The LEGI develops atmospheric dispersion models.
– The INRIA has built a land use and transport interaction model.
– The observatory of air quality in the Rhone Alps region ATMO-AURA develops and uses a numerical model to assess particulate matter concentrations based on emission scenarios.

2.2 *Grenoble Urban Area as Study Field*

Grenoble is the main city located inside the Alps. About 500,000 inhabitants live in the urban area called Grenoble Alpes Métropole, which is composed of 49 municipalities. Grenoble is known in France for its long-standing commitment to the fight against climate change and to programmes to reduce air pollution.

In July 2005, the Grenoble Alpes Métropole was the first urban area in France to sign a local climate plan. By 2014, it sets a "3 × 14" target, namely a reduction of at least 14% in greenhouse gas emissions compared to 2005, a 14% reduction in per capita energy consumption compared to 2005 and an increase in the share of renewable energy to 14% of the agglomeration's total energy consumption. The mitigation objective in 2020 is set to −35%, and in 2030 to −50% compared to 2005.

In 2015, emission reduction observed go beyond targets, with GHG emission level 23% lower than in 2005. This is the result of the reduction in the use of fossil fuels in favour of renewable energies and electricity, but also, to a large extent, of a significant reduction in energy consumption in the industry as a result of gains in energy efficiency but also and above all of a decrease in industrial activity. Even if all sectors are down, this decrease remains less marked in the residential, tertiary, and transportation sectors, which are major sources of energy consumption and also the main sources of atmospheric pollution.

Grenoble is one of the French cities with high air pollution exposure (mean yearly population $PM_{2.5}$ exposure, 18 μg/m^3 (Morelli et al. 2016; Fig. 2). The vast majority of residents (96%) are exposed to an average $PM_{2.5}$ level higher than the WHO guideline (10 μg/m^3). These high levels are partly explained by the basin configuration of Grenoble, the low winds, specific winter meteorological conditions (low mixing height) and frequent use of old (inefficient) wood heating

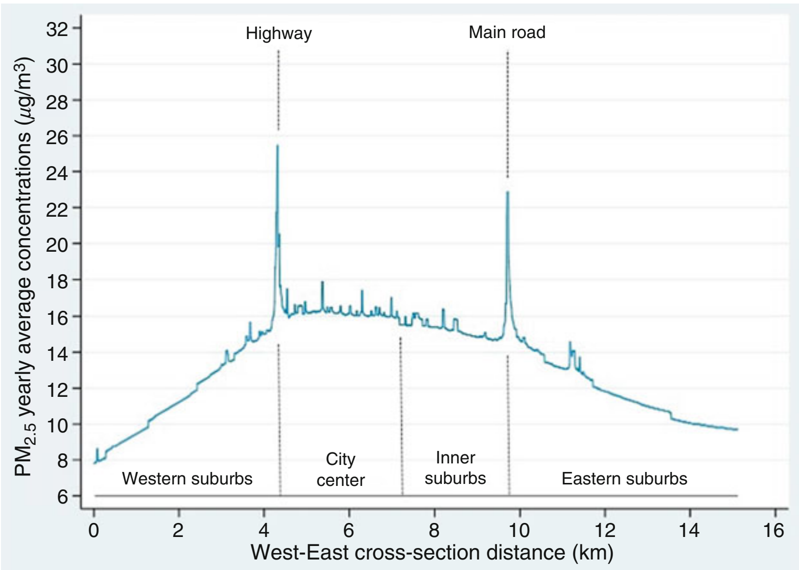

Fig. 2 PM2.5 levels in a West-East cross section passing through the city centre and going through the suburban cities of (i) Grenoble conurbation (yearly average concentrations during the period 2015–2017, in μg/m^3). From Morelli et al. (2019)

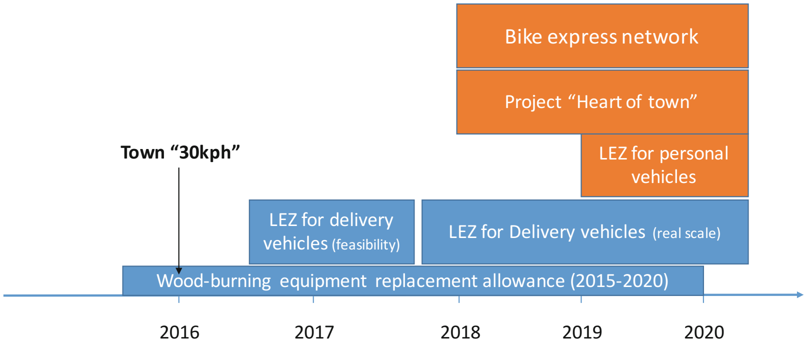

Fig. 3 Time-scale of the main policy measures aiming at reducing air pollution currently planned in Grenoble urban area. Town 30 kph: Restriction of maximal speed to 30 km/h for all vehicles

stoves. One partner of the MobilAir consortium evaluated the health impacts of air pollution exposure in the year 2012, concluding that at this time, $PM_{2.5}$ exposure was responsible of an estimated 3–10% of non-accidental mortality cases and lung cancers (Morelli et al. 2016).

Grenoble Metropole has undertaken several measures (Fig. 3) to improve air quality through the Ministry of the Environment's program "Breathable cities within 5 years". The plan targets the transportation of goods and mobility and non-efficient individual wood heating.

To reduce particulate emissions from wood heating, an air–wood premium has been in place since 2015. It aims to encourage the replacement of inefficient and highly polluting installations with the most efficient stoves on the market. The level of the premium was set at 800€, recently its level has been doubled to 1600€ and the most modest households benefit from a higher premium of 2000€.

In transport, in 2016, the speed limit was reduced to 30 km/h on most roads within the urban area except the main roads. To accelerate the shift in the current vehicle fleet composition towards a more sustainable and less polluting vehicle fleet, vehicles are classified into different categories (Crit'Air sticker) based on their particulate matters emissions. The higher level of sticker, the higher the level of pollution.

Since 2017, a "commercial LEZ" only for goods transport vehicles (light commercial vehicles and heavy goods vehicles), is implemented in the extended city centre of Grenoble. Only the unclassified (the less efficient) goods transport vehicles are banned from driving in the LEZ between 6 am and 7 pm Monday to Friday. In June 2019, the LEZ for good transports has been extended to 10 new volunteer municipalities. A progressive ban is planned, in 2019 diesel Euro III vehicles will be first concerned until 2025 when all diesel vehicles will be banned from the LEZ. Consideration is being given to extending the low-emission area to all vehicles to also cover passenger cars. Similarly, the "city centre" project aims to reduce the amount of road space dedicated to individual motorized transport to give pedestrians more space, and to increase the network of cycle paths.

Thus, the territory of the Grenoble urban area appears to be particularly well adapted by its particularly high exposure to pollution problems, by its determination in the fight against climate change and the reduction of air pollution, by the richness and disciplinary diversity of research on issues related to pollution and global warming. For all these reasons, Grenoble can be a pilot city to test the implementation of the MobilAir protocol.

3 Better Understanding of Individual Drivers in Mobility Behaviour

Despite the many negative externalities of the private car (health and well-being impacts related to pollution, noise, increased sedentarization, contribution to climate change, accidents, etc.), public policies have most often failed to significantly change individual behaviour in the transport sector. The use of private cars remains the norm. Quantitative surveys show that a large number of people are aware of the need to reduce car use and agree with the idea of changing their mobility habits by considering the possibility of switching from car to another mode of transport (BCG and Ipsos 2017; Kaufmann et al. 2010). However, beyond this stated intention, these same people face multiple obstacles to effectively and sustainably change their travel practices.

Research distinguishes obstacles that act at different levels (Sallis et al. 2006): in terms of the urban environment, we find, for example, the low access to public transport network (in terms of distance from dwelling to transport network, frequency of urban public transport, difficult implementation of multimodality), the lack of secure cycle paths, or the lack of walkability (i.e. extent to which an area is walkable); economically, the cost of cycling equipment or the cost of public transport can be a barrier, especially for the most disadvantaged populations; at the personal level, the well-anchored habits, the lack of knowledge about pollution exposure for each mode of transport or the health benefits of active modes, or the lack of confidence in people's ability to change their own behaviour in a sustainable manner, can also explain the difficulty of reducing personal car use, as well as family constraints (e.g. accompanying children) or the sequence of activities (work, leisure, shopping).

Among the behavioural theories, the Theory of Planned behaviour (TPB; Ajzen 1991) has been successfully used to explain mode choice (see, e.g. Bamberg et al. 2003). This theory posits that behaviour, in order to be effective, must first be decided/planned and that it is necessary to act on three types of factors: judgments about the desirability of the behaviour and its consequences (attitudes); the influence and opinion of others on the behaviour (subjective norms) and beliefs about the subject's ability to succeed in the behaviour (self-efficacy). According to the TPB, these three factors influence intentions which, in turn, influence actual behaviour. To study situations characterized by high behavioural costs like a mode shift, the TPB is considered as more powerful than other theories (Gifford et al. 2011) like the norm-activation modal (Schwartz 1977) or the value-belief-norm theory (VBN theory; Stern et al. 1999) used in environmental psychology. Our research, therefore, draws on the TPB.

However, the literature has shown that, even though intentions are the main predictor of behaviour—theoretically but also empirically, see for instance Lanzini and Khan 2017—there is still a gap between intentions and behaviours that needs to be understood (Sheeran 2002). Several avenues of research have been explored by psychologists to bridge this gap. For instance, Verplanken et al. (2008), Chen and Chao (2011) or Bamberg and Schmidt (2003) studied the role of habits, a key variable of the Triandis model (1977). One key area of research is to study how habit strength moderate the intention–behaviour relationship in the TPB (see for instance De Bruijn 2010, for an application on fruit consumption). To this end, we do not only consider habits as the intensity of use of a transport mode but we also measure the automatic nature of modal choice habits as well as test the impact of disrupting habits.

Other variables may be used to reinforce the predictive power of the TPB. One originality of our research is to consider the use of alternative transport modes, and in particular actives modes, as a pro-environmental behaviour but also as a physical activity. We therefore draw on this strand of literature, in particular by using intrinsic and extrinsic self-determined motivations[1] (Deci and Ryan 2002). Both are supposed to influence the strength of the relationship between intention and behaviour.

Therefore, MobilAir research questions on mobility behaviours deal with:

- The formation of intentions for transport mode choice: We will assess the extent to which the impact of transport modes on individual and collective health can be a lever for changing transport mode choices, as well as the role of various psychological variable.
- Understanding the determinants of the transition from intentions to effective and sustainable behavioural change: We will deploy a population-based intervention on the territory of the Grenoble urban area aimed at changing the modes of transport of the participants in the intervention.

[1]The self-determination theory posits that there are two main types of motivation—intrinsic and extrinsic—and that they are both powerful forces in shaping who individuals are and how they act. Intrinsic motivation is endogenous to the individual and depends on the personal values, interest or sense of morality. Extrinsic motivation is a drive to behave in ways that comes from external incitation and results in external rewards (e.g. evaluations and admiration of others).

3.1 What Role Does the Impact of Transport Modes on Public and Individual Health Play in Our Mobility Choices?

Walking and cycling for transportation provide substantial health benefits from increased physical activity. Globally, more than 30% of all adults are estimated to perform insufficient physical activity (Hallal et al. 2012). A lack of physical activity is associated with all-cause mortality, cardiovascular diseases, type 2 diabetes, cancer, and impaired mental health (Physical Activity Guidelines Advisory Committee 2008). The promotion of walking and cycling for transportation complemented by public transportation, presents a promising strategy to not only address problems of urban traffic strain, environmental pollution and climate change, but also to provide substantial health co-benefits (De Hartog et al. 2010).

In MobilAir, we will implement a protocol to evaluate to what extent the impact of modal choice on public or individual health has a leverage effect on intentions towards active modes of transport or towards public transports.

Modal choice is multifactorial and depends on economic constraints (travel cost), time constraints (travel time), quality of service (frequency of public transport use, comfort), spatial characteristics (density, topography) and individual characteristics (age, gender, attitudes, perceptions).

Until recently, the analysis of mode choice and its behavioural determinants have been partitioned between disciplines. On the one hand, economists explain modal choice with observable explanatory variables (cost, time, service level, age, gender) using discrete choice models. On the other hand, psychologists rely on theories that chart the path between different internal mental states that lead to a decision, as in the TPB previously described. The combination of these two approaches, economic and psychological, has only been possible in recent years thanks to the development of new statistical tools, hybrid choice models (Walker 2001). Hybrid choice models make it possible to model choices and calculate economic quantities based on observable quantities (time, cost, etc.) but also unobservable variables such as attitudes or perceptions. Introducing this type of variable into economic models makes it possible to better understand the process of choice formation and thus to identify public policies that can influence choices towards mobility practices that favour "soft" modes (public transport and active modes) (Bouscasse 2017, p. 108). While these models are beginning to be applied fairly widely worldwide in transport, they still struggle to fully integrate the theories of environmental psychology (Bouscasse 2018).

Discrete choice models explaining mode choice have rarely incorporated observable health variables (see Sottile et al. 2015a, b for exceptions). However, the modal choice may be influenced by public health considerations (atmospheric pollution level) and individual health considerations (cardiovascular diseases related to inadequate physical activity). For instance, are people conscious of the consequences of car pollution or aware that walking or biking can improve their own health more likely to adopt an active mode of transport?

One reason explaining the low integration of environmental psychology theories in discrete choice models is the lack of data encompassing the psychological, sociological and economic dimensions.

Therefore, we propose to implement a phone survey (1300 individuals representative of the Grenoble urban area) collecting data on knowledge and perceptions of pollution combined with a web stated preferences survey (1000 individuals) also including measures of the components of the TPB, as well as habits, altruism and satisfaction when using different transport modes (Ettema et al. 2011). The stated preferences survey (choice experiment) consists in asking the respondent to choose between options (here transport mode) described by objective attributes such as travel mode, travel cost and sanitary risks (see Fig. 4).

The objective of the choice experiment is to simulate situations of modal choice and to build an economic model based on the choices made.

Each interviewee will have to make eight series of choices between different modes of transport (car, public transport, cycling, walking) that exist in real life in the Grenoble metropolitan area. These choices will be personalized (origin, destination, time, cost) for each individual through a trip he or she will have described beforehand. If the distance of the reference trip is more than three kilometers, the walking alternative will not be presented to the respondent. With regard to the bicycle alternative, either the conventional bicycle or the electric bicycle will be presented to the respondent according to the latter's stated preferences.

First, a route calculation tool will be used to describe all the trips that can be made within the Grenoble metropolitan area for the various modes of transportation considered.

Mode of transport				
Travel time	**30** min	**20** min	**35** min	**25** min
Cost per trip	**1,50 €**	**-**	**-**	**0,50 €**
Physical activity By using this mode of transport every day, your risk of developing cardiovascular disease...	is equal to **28%**	is equal to **24%**	is equal to **20%**	is equal to **30%**
Air Pollution If 75% of the population adopts this mode of transport, the average risk of developing cardiovascular disease for a person in the agglomeration...	is equal to **29%**	is equal to **26%**	is equal to **25%**	is equal to **30%**
What is your choice?	☐	☐	☐	☐

Fig. 4 Example of a choice sheet

Each of the possible modes of travel will be described with a number of attributes, including time, cost and frequency of public transport use and impact on individual and public health of transport mode choices. More precisely, scenarios will include various reductions in relative risk of developing cardiovascular and respiratory diseases.

Since the level of these attributes will vary from one question to another, we will be able, through the discrete choice model, to estimate the weight of each attribute in the modal choice. These models will allow us to evaluate demand elasticities, willingness to pay, time equivalents that can feed into operational evaluation and decision support tools.

The originality of the proposed design lies in two specificities. First, it distinguishes altruistic motivations related to public health (impact of the mode of transport on pollution) from selfish motivations related to individual health (impact of walking or cycling instead of driving on its own physical activity and its own health). Second, the whole design relies on a complete model of environmental psychology to explain individuals' intentions: the TPB.

Our work will also allow us to analyze how norms and altruism may influence intentions to use alternative transport modes and, more specifically, how they may explain the heterogeneity in the weight given to the pollution-related sanitary attribute. The definition of social norms, moral norms and altruism is sometimes floating (Nyborg 2018). Following Nyborg et al. (2016), we retain the definition of a social norm as "a predominant behavioral pattern within a group, supported by a shared understanding of acceptable actions and sustained through social interactions within that group". In the questionnaire, social norms are measured by asking the proportion of persons in their entourage using alternative transport modes, as well as to which extent they are supported and encouraged in their behaviour by their entourage (subjective norm, which is a subset of social norms). Moral norms, "a rule of ethically appropriate behavior, enforced by the individual herself trough inner feelings" (Nyborg 2018), are measured by asking respondents how important it is for them to use alternative transport mode, and how guilty or ashamed they would feel if they did not. Altruism, the fact of "at least partly internalizing the utility of someone else in the individual's own utility function" (Nyborg 2018), is measured by using items of the Big 5 scale (Goldberg 1990).

Overall, this approach will help us to study how intentions, the first predictor of modal choice (Lanzini and Khan 2017), can evolve by highlighting the impact of our modes of transport on individual and collective health, as well as studying precisely the role of psychological variables. However, as mentioned above, there is a gap between intention and actual behaviour. This is why we are also implementing a population-based intervention in MobilAir to identify the levers for active mobility.

3.2 Implementing Lasting Shifts in Transportation Mode Toward Active Modes

Interventions[2] to reduce car use have targeted different levels of barriers identified in research related to determinants of modal choice. More specifically, structural and psychological interventions are distinguished (e.g. Fujii and Kitamura 2003). The first includes so-called "hard" levers for change, by modifying the physical environment (improving the accessibility of public transport, building secure cycle paths) or the economic cost of transport modes (reducing the cost of public transport, tolls at the entrance to cities). The latter include so-called "soft" change levers, which aim to modify beliefs, attitudes or perceptions in order to motivate a voluntary change in mode of transport (Graham-Rowe et al. 2011). However, while many interventions for modal change already exist (for literature reviews, see Chillon et al. 2011; Ogilvie et al. 2007; Scheepers et al. 2008; Yang et al. 2010), several obstacles remain:

1. Most existing interventions target a single level of behaviour change lever (hard or soft); however, interventions that target several levels of factors are needed to promote sustainable behaviour change (Sallis et al. 2006). For example, interventions that include economic incentives (e.g. subsidies for public transit passes) generally only have an effect for the period during which individuals benefit from them, without generating sustainable behavioural change (e.g. Brög et al. 2009). It seems necessary to link these incentives with behaviour change techniques targeting psychological processes, such as habits, attitudes or self-efficacy, in order to promote a change in sustainable transport mode.
2. "Soft" interventions most often seek to promote positive attitudes towards active modes of transport, or to increase the individual's perceived ability to change behaviour, by using informational techniques (information on the availability of alternative transport to the car at the participants' place of residence; information on the health benefits of active travel). However, while attitudes and beliefs significantly predict the intention to change behaviour, intention is not sufficient to implement action, a phenomenon known as the intention–behaviour gap, particularly because past habits and behaviours strongly predict behaviour (Lanzini and Khan 2017). Behaviour change models in health psychology (e.g. health action process approach, Schwarzer 2008) consider that once the individual has decided to modify his/her behaviour, he or she must be able to plan it ("what-where-when-how"?) in order to promote habit change. While some interventions have focused more specifically on the transition from intention to behaviour, these remain rare.
3. Existing interventions have many methodological biases: few randomized controlled trials are conducted, with studies most often conducting pre/post-intervention comparisons without control groups; no systematic evaluation of

[2]Behavioural intervention is an action aimed at changing behaviour.

the statistical significance of the results; lack of objective measures, particularly to measure mobility behaviour itself, with studies most often using self-reported behavioural measures; relatively short duration of intervention and monitoring, which do not allow for a possible assessment of sustainable changes.

The MobilAir project aims to address these obstacles by pursuing the following objectives:

1. Quantify to what extent an intervention comparing hard (economic incentives) and soft (psychological incentives) levers can permanently change behaviour towards the adoption of sustainable mobility (walking, cycling, urban public transport). In order to study this objective, the project is based on an innovative interdisciplinary collaboration between economists, geographers, psychologists and epidemiologists. This collaboration will make it possible to: (1) compare the weight of a hard intervention with that of a soft intervention, but also to (2) understand the socio-spatial (e.g. location of activities, urban planning) and socio-demographic (e.g. age, income) factors that promote or hinder the effectiveness of the intervention and (3) identify the psychological mechanisms (attitudes, intention, perceived behavioural control, social norms, etc.) that can explain why the intervention is effective.
2. Test soft levers that have so far been little studied in the literature, based on the most recent knowledge in health and physical activity psychology, developed as part of the health action process approach (Schwarzer 2008), studies on habits (e.g. Gardner 2009), or studies on self-control (Kotabe and Hofmann 2015). This will involve a combination of pre-intentional techniques (e.g. information on the risks of the car and the benefits of alternative transportation modes) to promote the development of the intention to change behaviour, with post-intentional techniques to promote the transition from intention to actual behaviour change (e.g. setting individualized objectives, daily monitoring logbook, identifying barriers and resolution strategies, social support).
3. Test the effectiveness of this intervention using a rigorous methodology, involving the implementation of a randomized controlled trial in which participants will be randomly assigned to one of the intervention groups, or to the control group that will not benefit from the intervention. The effect of the intervention will be analyzed using appropriate inference statistical tests, based on an a priori power analysis that will allow us to limit the type II error (i.e. not detecting an effect due to lack of statistical power). In addition, the project will include subjective measures of psychological constructs coupled with objective measures of behaviour (i.e. GPS to measure daily mobility, accelerometers to measure physical activity). Finally, the measurements will be carried out over a period of 2 years to assess whether the behavioural changes that are taking place are sustainable.

4 Support to Decision-Making Towards Healthier Cities

4.1 Interdisciplinary and Multidimensional Assessment of Pollution Mitigation Measures

The aim of this task is to build an interdisciplinary modelling chain at the urban area scale, to assess actions leading to lower greenhouse gas emissions and lower pollutants emissions.

First, measures actually implemented by the Grenoble urban area will be evaluated based on the combination of the modelling chain, field measurement, and population surveys related to population perception, mobility, wood heating and quality of life. Such measurements at different years can be confounded by differences in meteorological conditions between the compared years, an issue that can be limited by first modelling the influence of meteorology, season and year on PM levels over the whole period through a regression model, and adjusting for this influence.

Then, more theoretical and contrasted scenarios of measures will be assessed. They will include already planned measures (wood heater replacement incentive), hypothesized (e.g. ban of Euro 1-2-3 vehicles in the city centre) or possible measures (taken, e.g. from examples implemented in other cities).

The approach is described in Fig. 5. The left side describes the methodology that will be developed for the assessment of measures already implemented and the right side the modelling approach that will be implemented for the assessment of scenarios.

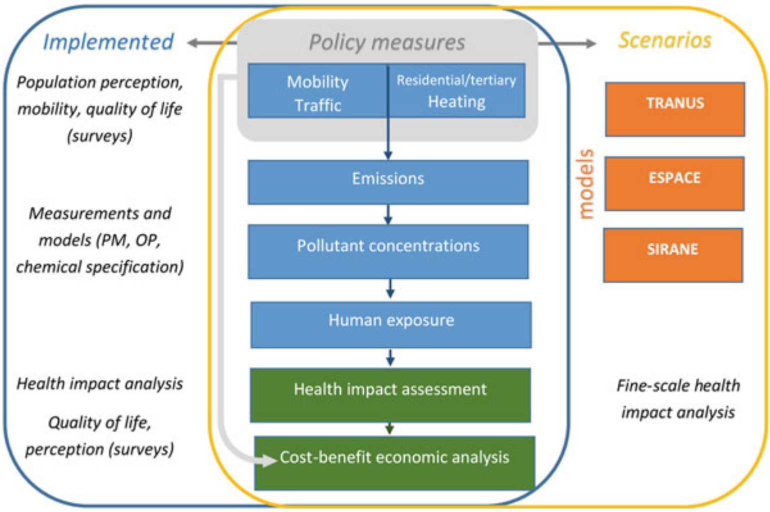

Fig. 5 Overview of the approach for the interdisciplinary and multidimensional assessment of pollution mitigation measures

The dimensions evaluated are the following:

1. Traffic and mobility
2. Wood heating: uses and old stove renewal
3. Greenhouse gas emissions
4. Air quality assessment
5. Health impacts (non-accidental mortality, lung cancer incidence and low birth-weight incidence). As done in the previous study from Morelli et al. (2016), results will be stratified on the European Deprivation Index, a measure of socioeconomic deprivation, available at the IRIS scale, the finest spatial scale for France.
6. Cost–benefit analyses will include (1) *the direct costs of implementation* of measures, (2) *the indirect economic costs/gains* induced by the measures on each category of agent: local authorities, households, economic activities, (3) *external costs*, corresponding to the economic assessment of the decrease of health impacts of pollution and (4) *other external costs* (time spent for mobility, road safety, noise, greenhouse gases emissions, health benefits of the development of active transportation modes).
7. Inequalities related to pollution exposure and to the impact of policies on social inequalities.

4.2 Evaluation of Measures Already Implemented or Planned

The assessment of measures actually implemented during the study period will rely on measurements done by the regional air quality-monitoring network, and dispersion modelling based on actual emission data. The parameters assessed include $PM_{2.5}$ and PM_{10} mass concentration, NO_2, ozone, as well as, for the first and last years of the study period, PM_{10} chemical speciation, including the levoglucosan (a marker of biomass burning) content. The latter parameter, which will only be assessed during the first and last years of the study period (and not continuously throughout the study period), will allow providing an evaluation of changes in the composition of particulate matter, reflecting possible changes in the nature of the main pollution sources, such as a decrease in the role of wood burning facilities.

Then, more theoretical and contrasted scenarios of measures will be assessed. They will include already planned measures (*wood heater replacement* incentive), hypothesized (e.g. ban of Euro 1-2-3 vehicles in the city centre) or possible measures (taken, e.g. from examples implemented in other cities). This approach will rely on the modelling chain described in Fig. 5. TRANUS is an integrated land use and transport model. In addition to allow short-term traffic simulation, TRANUS can simulate the long-term mutual interactions between the location of firms and households and transport offering.

Pollutant emissions are estimated by ESPACE developed by ATMO AuRA, which relies on comprehensive database of activities (vehicles number, ratio of heavy duty vehicles, speed ...). Emission data generated are then used as inputs in the SIRANE model (Soulhac et al. 2011, 2012) developed by ATMO AuRA to estimate the concentration of atmospheric pollutants (PM concentration, nitrogen oxides). This will allow assessing specific prospective evolution scenarios of the configuration of Grenoble area in the 2050 horizon (Fiore et al. 2015; Morton et al. 2008). Other emission drivers (technological evolutions of a fleet of vehicles, energy efficiency of buildings, energy mix of the residential and service sectors, decrease of old diesel vehicles and low-quality wood heating stoves) will also be investigated.

4.3 Identification of Measures Aiming to Reach Given Air Quality and Public Health Targets

Here, we will first investigate the impact of given reductions in $PM_{2.5}$ mass concentration of various amplitudes on health. The considered scenarios are described in Table 1. This approach will be implemented in parallel for Grenoble and Lyon urban areas. For each scenario, the expected change in life expectancy, all-cause mortality, lung cancer incidence as well as the associated economic costs, will be assessed.

Scenarios S1 to S5 are also graphically summarized in Fig. 6.

The estimates of health impact will rely on a health impact assessment approach described by Morelli et al. (2016). They imply in particular to consider the dose-response function between $PM_{2.5}$ concentration and each of the health outcomes considered, which are given in Table 2.

In a further step, we will take a reverse approach starting from the formulation of targeted benefits relevant to public health (a 20% decrease in PM-related mortality or a 2-month improvement in life expectancy for example). These targets will be formulated by the local authorities. These objectives will be then translated into an average change in atmospheric pollution (PM) concentration, using a reverse health impact assessment approach (implemented through iterative forward health impact assessment studies assuming various decreases in PM levels). We will then identify urban measures allowing to reach such a target PM concentration distribution in the urban area using inverse modelling techniques; these measures will be chosen among options concerning both traffic and wood heating based on an available inventory of highly polluting wood burning heaters in the area.

Table 1 Description of the ten hypothetical scenarios of fine particulate matter ($PM_{2.5}$) exposure reduction considered (from Morelli et al. 2019)

Scenario number	Scenario description	Scenario name	$PM_{2.5}$ yearly level reduction
S1	Spatially homogeneous target value in the whole area	"WHO guideline"	Down to WHO yearly guideline (10 μg/m^3)
S2		"No anthropogenic $PM_{2.5}$ emissions"	Down to lowest nationwide levels (4.9 μg/m^3)[a]
S3		"Quiet neighbourhood"	Down to lowest study area district levels (tenth percentile of exposure)[b]
S4	Homogeneous $PM_{2.5}$ decreases in the whole area	"−1 μg/m^3"	Baseline[c] −1 μg/m^3
S5		"−2 μg/m^3"	Baseline[c] −2 μg/m^3
S6	Targeted reduction in $PM_{2.5}$-related mortality in the whole area[d]	"−1/3 of mortality"	Equivalent to decreasing homogeneously and sufficiently the baseline[c] exposure to achieve the indicated health objective[e]
S7		"−1/2 of mortality"	
S8		"−2/3 of mortality"	
S9	2008/50/EU Directive[f] "2020 target"	In the whole study area"	Baseline[c]—15%
S10		Restricted to $PM_{2.5}$ exposure hotspots"	Baseline[c]—15%, only if baseline ≥90th centile of $PM_{2.5}$ levels[g]

[a]Corresponding to the fifth percentile of $PM_{2.5}$ concentration distribution among French rural towns (Pascal et al. 2016)
[b]The tenth percentile of $PM_{2.5}$ exposure by Housing Block Regrouped for Statistical Information (IRIS) in the study area (corresponding to 10.3 and 12.4 μg/m^3 in Grenoble and Lyon conurbations, respectively)
[c]Baseline corresponds to the $PM_{2.5}$ exposure average for the 2015–2017 period, taken as a reference in the present study
[d]Mortality reduction targets expressed as a proportion of the non-accidental death cases attributable to $PM_{2.5}$ exposure that can be prevented under the scenario S2: "No anthropogenic $PM_{2.5}$ emissions"
[e]S6: −2.9 and −3.3 μg/m^3 in Grenoble and Lyon conurbations, respectively; S7: −4.4 and −5.1 μg/m^3; S8: −6.0 and −6.9 μg/m^3
[f]Inspired by the 2008/50/EU Directive, which targets relative $PM_{2.5}$ yearly average decreases to obtain by 2020. The decrease value depends on the exposure average for the last three years (2015–2017): −15% in the case of Grenoble and Lyon conurbations
[g]The 90th percentile corresponded to 16.0 and 17.4 μg/m^3 in Grenoble and Lyon conurbations, respectively

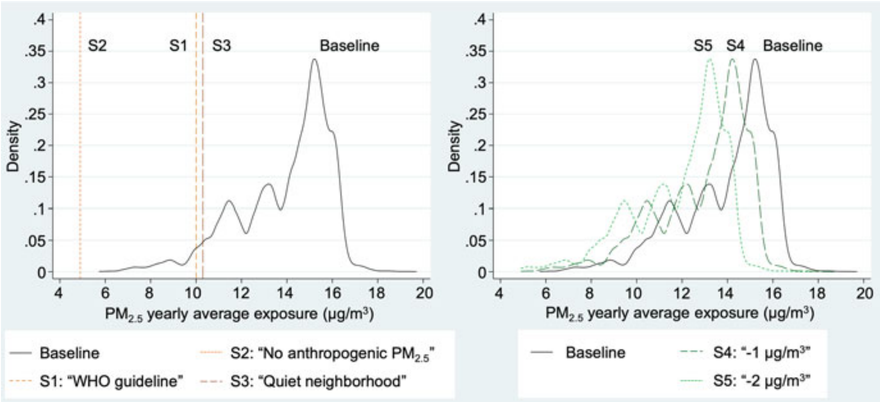

Fig. 6 Expected fine particulate matter ($PM_{2.5}$) exposure levels for the Grenoble conurbation population (yearly average exposure, in µg/m^3) under each $PM_{2.5}$ level reduction scenario: (1) scenarios targeting a spatially homogeneous value in the whole area (S1 to S3) and (2) scenarios decreasing homogeneously $PM_{2.5}$ in the whole study area (S4 and S5)

Table 2 Dose-response functions used to estimate the long-term effects of air pollution exposure to fine particulate matter ($PM_{2.5}$) on health

Health event	Study	Relative risk (95% CI) for a 10 µg/m^3 increase in $PM_{2.5}$ exposure
Non-accidental mortality	World Health Organization (2014)[a]	1.066 (1.040–1.093)
Lung cancer incidence	Hamra et al. (2014)[a]	1.09 (1.04–1.14)
Term low birth weight[b]	Pedersen et al. (2013)	1.392 (1.124–1.769)[c]

[a]Meta-analysis-based relative risk
[b]Occurrence of low birth weight birth cases (<2500 g) among term births (those occurring after the end of the 37th gestational week)
[c]The original odds ratio was reported for a 5 µg/m^3 increase in exposure and was 1.18 (1.06–1.33)

5 Conclusion

Atmospheric pollution in cities is a major challenge for public health in both developed and developing countries. This project aims to show the synergies between short-term public health issues related to pollution and the reduction of greenhouse gas emissions. Adopting a thoroughly interdisciplinary approach, the MobilAir project aims to identify precise measures to reduce significantly atmospheric pollution in cities and their impacts. Drawing on the considerable pluridisciplinary diversity of the Grenoble campus, MobilAir will develop an integrated approach in the urban area of Grenoble, which is a relevant pilot area. MobilAir will seek to develop methods and instruments, which can be copied in other cities in France and in other countries.

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