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Abstract

Introduction

One third of the European population meets the minimum recommended levels of physical activity (PA). Physical inactivity is a major risk factor for non-communicable diseases. Walking and cycling for transport (active mobility, AM) are well suited to provide regular PA.

Aims and methods

The European research project Physical Activity through Sustainable Transport Approaches (PASTA) pursues the following aims:

1. To investigate correlates and interrelations of AM, PA, air pollution, crash risk;
2. To evaluate the effectiveness of selected interventions to promote AM;
3. To improve health impact assessment (HIA) of AM;
4. To foster the exchange between the disciplines of public health and transport planning, between research and practice.

Determinants of AM and the evaluation of measures to increase AM are investigated through a large scale longitudinal survey, with 14,000 respondents conducted in seven cities (Antwerp, Barcelona, London, Oerebro, Rome, Vienna, Zurich). Contextual factors are systematically gathered in each city. PASTA generates empirical findings to improve HIA for AM, e.g. with estimates of crash risks, factors on AM-PA substitution and carbon emissions savings from shifts towards AM. Findings from PASTA will inform the WHO's Health Economic Assessment Tools (HEAT) for walking and cycling.

Main innovative part

PASTA pursues a multi-method and multi-level approach that is consistently applied in seven case study cities throughout Europe. Its wide scope and the combination of qualitative and quantitative methods as well as health and transport methods, the innovative survey design and data collection efforts, the general as well as city-specific reviews and analyses and the transdisciplinary composition of the consortium and the wider network of partners all promise highly-relevant insights for research and practice.

Conclusions

PASTA contributes to the in-depth understanding of AM and PA and to the improvement of HIA. Gained insights can support efforts to facilitate PA through AM more efficiently.

'Strengths and limitations of this study

- The study Physical Activity through Sustainable Transport Approaches (PASTA) pursues a multi-method approach combining qualitative and quantitative methods from public health and transport research developed and implemented by academics and practitioners in a transdisciplinary setting.
- A large-scale quantitative survey on active mobility, physical activity, air pollution exposure and crash risk is carried out with overall 14,000, respondents in the PASTA case study cities Antwerp, Barcelona, London, Oerebro, Rome, Vienna, Zurich.
- Longitudinal data is collected for behaviour analysis and the evaluation of selected policy measures in each PASTA case study city.
- The collected data directly feeds into the advancement of health impact assessment models and HEAT.
- Data might be biased because of the opportunistic sampling and the web-based approach although the multiple recruitment approaches will minimise the bias, and analyses will account for recruitment method.

1 INTRODUCTION

Reducing sedentary behaviour and increasing the level of physical activity (PA) in the population is a key goal of the EU Strategy on nutrition, overweight and obesity-related health issues [1]. In contrast to this policy goal, levels of PA are decreasing [2, 3]. One third of the European population is estimated to meet the minimum recommended levels of PA, which for adults correspond to at least 150 minutes of moderate-intensity aerobic PA throughout the week [3–5]. Globally, physical inactivity is the fourth leading risk factor for mortality and a major cause of non-communicable diseases [6, 5].

Walking and cycling for transport solely or in combination with public transport, also referred to as active mobility (AM), are well suited to provide regular PA. In contrast to sports or exercise, AM requires less time and motivation; it is convenient as a mode of transport and as a form of exercise; and it is economically affordable. Hence, AM has the potential to reach parts of the population which may be less receptive to appeals of sports and exercise, or cannot afford them in terms of finance or time [7]. Especially for people with low PA such as sedentary, obese and elderly people it is easier to begin with AM as a moderate form of regular PA than with sports or other types of vigorous PA [8].

Increasing AM not only supports public health objectives but also serves goals in transport planning. The balanced and integrated development of all transport modes is a main characteristic of Sustainable Urban Mobility Plans (SUMP) [9] and a key goal in the strategic EU policy documents [10–12]. Increasing AM reduces the consumption of space for transport infrastructure, energy use, air pollution and noise and improves overall quality of urban life [13–16]. However, to date, health aspects of AM are rarely considered in SUMPs. Practitioners in both public health and transport planning departments pursue opportunities to increase AM; however, they usually work in isolation, thus not benefiting from the large potential for synergy. Similarly, researchers in health and transport fields work on a better understanding of AM and its interrelation with PA, but again, systematic collaboration is rare.

There is a lack of detailed studies on the interrelation between AM and PA [7], and most studies are either conducted with methods from public health resulting in an incomplete picture of AM, or with methods from transport research resulting in an incomplete picture of PA. Existing studies mainly apply cross-sectional designs which are neither suited to capture the variability in walking and cycling nor to identify causal chains.

Factors determining AM behaviour include socio-demographic characteristics such as income or car ownership [17–20], socio-psychological factors such as preferences, attitudes, habits or norms [19], and socio-geographic factors such as climate and topography, the built environment or the transport system [20–22, 17, 23, 24]. Cities with walking shares higher than 50% of all the trips such as Bilbao in Spain, and with cycling shares of up to 44% such as the Dutch cities Eindhoven or Groningen show that high shares of AM are feasible [25]. Parkin and Koorey [26, 27] summarised the requirements for AM-friendly spatial settings with the principles density, destination accessibility, design, distance to public transport and diversity (see also [28, 27]). The perceived lack of traffic safety is an important deterrent for AM [29–31]. Despite a rapidly growing body of research, determinants of AM behaviour remain poorly understood, in particular with regards to their interrelation with PA.

Good practice collections for AM measures exist (see e.g. http://www.eltis.org/) but few rigorous evaluation studies are available [32, 33] and public health aspects are rarely included in the evaluation of transport policies. Research projects, such as TAPAS [30], SHAPES [34] or iConnect [32, 33, 35] have addressed questions around AM and PA, as well

as exposures to air pollution and crash risks resulting from AM. These provide important input but more evaluation studies are needed.

In recent years, AM health impact assessments (HIA) and health impact modelling studies [36, 37], have received increasing attention in benefit-cost analysis and policy debates. Clear health effects have been demonstrated not only for overall PA but also for PA from walking and cycling for transport [31, 38, 39]. Public health impacts of AM are dominated by benefits from PA, while health risks from air pollution and crashes are found to be relatively small [31, 36]. Health risks from increased air pollution exposure are mainly studied in small sample sizes, with a limited geographical scope and scripted routes [40, 41]. The empirical evidence on minor crashes and near misses and on the risk exposure is limited [42].

Many studies assessing health impacts of AM policies have applied the WHOs' Health Economic Assessment Tool (HEAT) for walking and cycling [43–46, 30, 36, 47, 48]. HEAT is a simple online tool that enables transport planners to value health benefits from regular walking or cycling [49]. While there has been a recent surge in the development of AM HIAs, overall they are characterised by inconsistent methodologies, selective impact domains assessed, and the lack of robust input data [37, 31, 36].

Against this background, the European research project Physical Activity through Sustainable Transport Approaches (PASTA) carried out from 2013-2017 pursues the following four main aims:

1. To investigate correlates and interrelations of AM, PA, air pollution and crash risk;
2. To evaluate the effectiveness of selected interventions and measures to promote AM with regards to increasing AM and PA;
3. To improve comprehensive HIA of AM; and,
4. To foster the exchange between the disciplines of public health and transport planning, as well as between research and practice.

Determinants of AM and the evaluation of measures to increase AM (thereafter referred to as AM measures) are investigated through a large scale longitudinal survey conducted in seven PASTA case study cities with overall 14,000 respondents (Antwerp, Barcelona, London, Oerebro, Rome, Vienna, Zurich). Contextual factors are systematically gathered in each city. PASTA generates empirical findings to inform quantitative HIA models, e.g. with estimates of crash risks, factors on AM-PA substitution and carbon emissions savings from shifts towards AM modes. Selected findings from PASTA will feed into the further development of HEAT.

As such, PASTA is a broadband research project on AM which spans disciplines, research and practice, determinants and impacts, qualitative and quantitative methods, and other dimensions of relevance in a comprehensive approach towards a better understanding of the interrelation between travel behaviour and health. In a unique design, PASTA addresses the complexity of AM promotion by tackling comprehensively its determinants and impacts.

2 STUDY DESIGN

2.1 Overview

Figure 1 summarises the parts of the PASTA project and its workflow. The project starts with a systematic review of the state-of-the-art on AM, which subsequent work builds upon, including:

- an in-depth assessment of AM enablers, planning practice and demand at the city level in the seven PASTA cities;
- a web-based longitudinal study investigating determinants of AM, the interrelation between AM and PA, safety and air pollution exposure of AM, the effectiveness of selected AM measures; and,
- the advancement of HIA for AM.

Insights gained in these steps will feed into a compendium of good practice examples and recommendations for policies promoting PA through AM.

A unique feature of PASTA is its interdisciplinary and transdisciplinary approach [50]. PASTA addresses scientific questions at the interface of different disciplines with researchers from these disciplines jointly working in an interdisciplinary approach. Beyond this, PASTA also works at the interface of scientific questions and societal problems. PASTA addresses the societal challenge of finding ways to effectively increase PA through AM and the scientific challenge of enhancing the knowledge on AM and PA. The research approach to address these challenges is developed in PASTA jointly by academic and non-academic partners in a transdisciplinary setting. This collaboration throughout the study ensures that the identified research questions and methods are relevant for research and practice. It also ensures that innovations from research and practice feed into the PASTA project and that project results are fed back into the academic and non-academic professional communities. PASTA strives to create impact beyond the scientific community not only through the involvement of stakeholders at every stage, but also by feeding into the continuous development process of HEAT. This tool, together with a compendium on good practices for AM measures, will be made available for free online and specifically distributed to local/regional/national governments, health and transport authorities at all levels, relevant experts, and NGOs.

In the subsequent sections we will elaborate on each of the above mentioned parts.

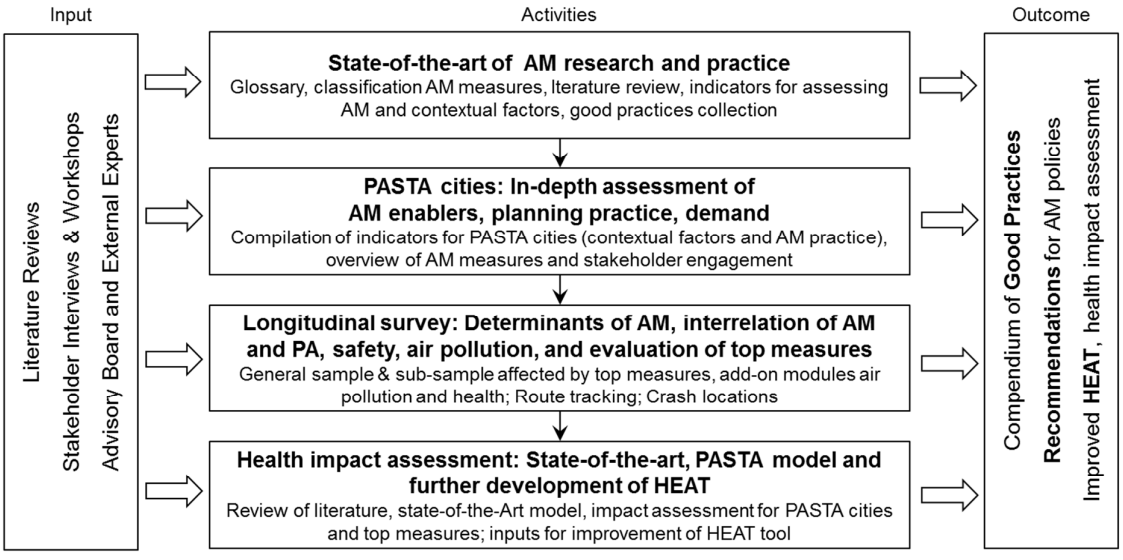

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Figure 1: The PASTA approach, AM Active Mobility, PA Physical Activity.

2.2 State-of-the-art of AM research and practice

This first part of the PASTA project establishes the groundwork for all subsequent steps.

A common glossary is developed that ensures mutual understanding throughout the project by harmonising terms of different disciplines. AM measures are classified in PASTA along two dimensions: first, four transport mode characterisations - walking, cycling, public transport, multi-modal trips - and second, four categories of policy measures - social environment, physical environment, regulation and strategic policies [28]. This scheme provides the basis for comprehensively covering all relevant transport modes and measures in the review, analysis and good practice compilation.

Academic and grey literature on determinants of AM and PA, policies and evaluation studies are reviewed in a Rapid Evidence Assessment (REA) [51, 52]. Based on the literature review, a set of qualitative and quantitative indicators is developed for the assessment of the state of AM demand, the state of practice of AM planning, and the contextual factors at the city level.

A list of contacts in various institutions (referred to as Friends of PASTA) is compiled both for dissemination purposes as well as to seek stakeholder inputs throughout the project, e.g. on good practices.

Aside from the critical review of published work, the methods used for these tasks include discussions with experts in the consortium and with members of the PASTA Advisory Board (AB), and interviews and workshops with external stakeholders. The insights gained support all subsequent steps of the PASTA project but specifically feed into the work done in the PASTA cities: The developed indicator system serves as the framework for the in-depth assessment of AM enablers, planning practice and demand at the city level as well as for the longitudinal study described in Section 2.4.

2.3 PASTA case study cities: In-depth assessment of AM enablers, planning practice, and demand

The insights gained from the literature review are complemented through in-depth analysis in the PASTA case study cities. Figure 2 gives an overview of the research questions (RQ) and the analysis framework for the PASTA cities. Contextual factors such as land use, the transport system, governance schemes or sociodemographic characteristics of the population are referred to as “enablers”. Enablers directly influence AM on the city level but also facilitate the implementation of specific AM measures which again affect AM demand. PASTA analyses the effects of both the general city-specific contextual factors (enablers) and AM measures on AM demand.

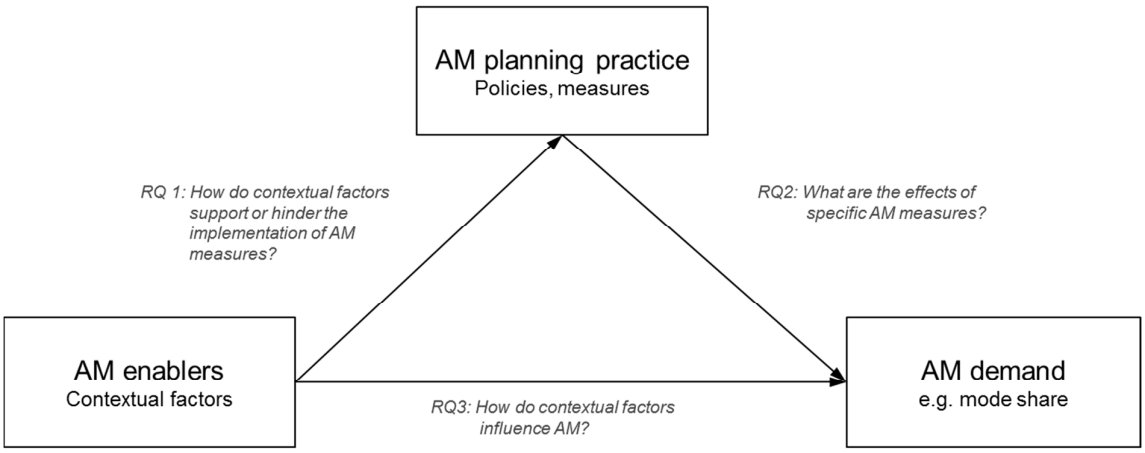

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Figure 2: Research framework for the in-depth assessment of AM and the contextual factors on the city-level for the PASTA case study cities; AM = Active Mobility, RQ = Research Question.

The following tasks are completed for each of the PASTA cities in this part of the project:

1. AM indicators: Data are collected and analysed for the indicator set that has been developed in the first part of the project. Appendix 1 shows an overview of the indicators. {see "Gerike et al PASTA study protocol supplementary file appendix 1.docx"}
2. AM measures: Information is gathered about planned and implemented measures, about successes and failures, about success factors and barriers and about the institutional contexts. The individual measures cover all four categories, namely strategic policies such as SUMPs, changes to the physical environment (e.g. specific infrastructure or services for walking and cycling), regulation (e.g. speed limits, access restrictions) and interventions targeting the social environment (e.g. AM campaigns).
3. Top measures: At least one so-called “top measure” is selected for each PASTA city. These measures are evaluated with regards to potential changes in AM behaviour within the longitudinal survey described in Section 2.4. The following top measures will be evaluated:
    - Physical environment: walking and cycling oriented re-development of the 2012 Olympic park area in London; a cycle bridge on a bicycle commuter highway in Antwerp; installation of bicycle racks in Rome; implementation of car-free “super islands” in Barcelona
    - Regulation: access restrictions for motorised vehicles to super islands in Barcelona
    - Social environment: personalised travel planning in Vienna; workplace campaigns accompanied by infrastructure upgrades (e.g. leasing of electric-assist bicycles, installation bicycle racks) in Oerebro
    - Sub-populations: in Zurich, users of electric-assist bicycles and car-sharing members are studied to better understand the potential of such measures to promote sustainable transport.
4. Networking: PASTA approaches local stakeholders from public health, transport and urban planning by means of joint workshops to identify current institutional settings,

funding schemes, policies and activities in both fields and to systematically search for opportunities to strengthen the collaboration and to bundle the efforts to increase AM.

5. Stakeholder needs for HIA: Local stakeholders are asked about their interest in and experience with HEAT and for suggestions to further develop this tool. This information feeds into the advancement of HEAT and provides the basis for the application of the PASTA final HIA in the PASTA cities (see Section 2.5).

Expert interviews and workshops are the main methods used for completing these tasks. Subsequent parts of PASTA benefit in several ways from this work with the PASTA cities: Local stakeholders support recruitment for the longitudinal survey and give valuable inputs for the development of the HIA. Collected data and information is used to inform the data analysis of the longitudinal survey and to properly interpret those results. In addition, PASTA hopes to spark long-term collaboration of the involved local stakeholders.

2.4 Longitudinal survey: Interrelation of AM and PA, safety, air pollution, and evaluation of top-measures

A major longitudinal survey of a targeted overall sample of 14,000 participants is carried out in the seven PASTA cities. The survey platform was launched in November 2014; it is planned to be online until October 2016. Figure 3 gives an overview of the survey design which builds on the successful designs of the SHAPES [34], TAPAS [30] and iConnect [32, 33] projects.

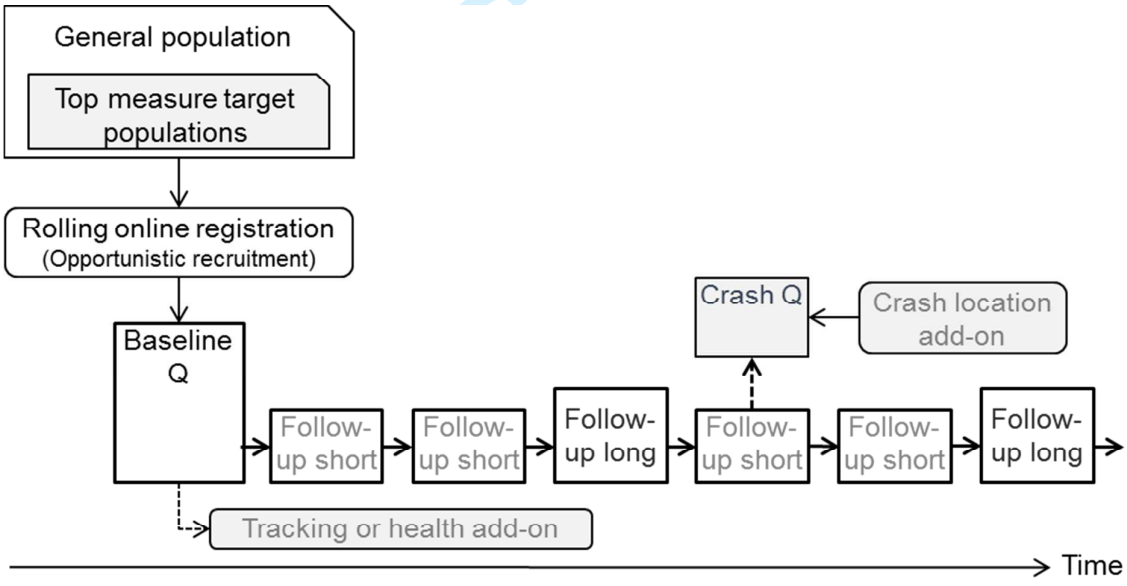

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Figure 3: The PASTA longitudinal survey design.

Study population

The study targets the general population in the PASTA cities and aspires to represent a balance of all transport modes (private {car or motorcycle}, public transport, walking, cycling). Participation in the study is open to people older than 16 or 18 (depending on the local ethical approval) who either live, work, study or otherwise regularly spend time in these cities. Within the general sample, a sub-group of participants affected by the respective top measure and a corresponding control group are identified.

Recruitment

The main recruitment strategies are opportunistic (except Oerebro) by disseminating information of online registration through as many channels as possible (city stakeholders, NGOs, print and online media, various websites, social media, events, active 'on-street' recruitment, etc.). Registration progress is continuously monitored through a dashboard which monitors participation by key variables which are compared against predefined sample composition targets, namely by gender, age groups and travel mode distribution.

Survey design and implementation

A longitudinal study design was chosen for the PASTA study for the following main reasons:

1. Repeated measures of AM and PA are warranted to derive robust estimates of long term average behaviour, since both AM and PA show substantial temporal variability.
2. To investigate how AM contributes to overall PA, or how subjects may substitute increases in PA from AM with decreases in PA from other domains (e.g. sports), repeated simultaneous assessments of AM and PA within subjects are necessary.
3. To assess crash risks of AM, longitudinal data is needed.
4. To evaluate how top measures affect AM (and overall PA), 'pre/ post-implementation assessments' are necessary.

To minimise the burden to participants and to limit logistic complexity, a web-based survey approach was chosen for the longitudinal study. Filter questions expose participants only to relevant questions. Map and routing tools support the identification of locations e.g. for home or the workplace. An attractive questionnaire design ensures high data quality and minimises response burden. The entire survey procedure is automated, from the registration to reminders and the assignments of participants to the general sample or the top measure groups.

Overview of the survey components

To accommodate the broad scope of topics relevant for the PASTA research objectives, and at the same time to keep participant burden bearable, a balance of contents for the individual questionnaires (minimising duration) and the follow-up frequency was chosen: The survey consists of a "core module" that is filled out by all participants. The core module is complemented by so-called "add-on modules". These are separate studies on 'time-activity and route tracking', 'air pollution exposure and health', and crash location audits. We aim to recruit 120 or more participants from the core-module for these „add-on modules".

Core module

Questionnaire sequence: Figure 3 shows the sequence of questionnaires for the core module. Upon online registration, participants are invited immediately to fill out the baseline questionnaire (BLQ). Regular follow-up questionnaires succeed every 13 days after the last questionnaire has been filled out. The sequence of follow-up questionnaires is a combination of 2 short follow-ups (FUS) and then one longer follow-up (FUL).

BLQ: All individual factors which are not expected to vary over time are collected in a fairly substantial baseline questionnaire (approx. 30 minutes to complete). Contents have been identified based on a conceptual model specifically developed for the PASTA project. The baseline questionnaire asks for socio-demographics, general AM and PA behaviour as well as perceptions, barriers and attitudes. AM and PA are measured in parallel with the single item PA-question [53], a slightly modified version of the Global Physical Activity Questionnaire separating walking and cycling (GPAQ, www.who.int/chp/steps/GPAQ/),

questions about the frequency of use for all transport modes and a 1-day travel diary adapted from the KONTIV© design [54, 55].

FUS only contain a single question about mobility and PA in the last week, respectively, as well as a question about whether subjects experienced a crash (i.e. collision or fall) or "near miss": i.e. an unexpected event while walking or cycling which forces someone to take sudden evasive action, without which a crash would have occurred.

FUL are similar to the FUS and include additionally a 1-day travel diary and the GPAQ.

Crash questionnaire: Questions about "near misses" and crashes are included in each core module questionnaire. If participants report an crash or a near miss, the questionnaire opens and asks for detailed information along the five categories of factors identified by [56]: human factors (e.g. rider or pedestrian behaviour), vehicle-related factors (e.g. type of bicycle, lights), infrastructure factors (e.g. crossroad design), traffic conditions (e.g. traffic density) and environmental factors (e.g. weather).

Evaluation of top measures: For the evaluation of top measures a subsample of participants in each city is divided into an affected and a control group. For these participants, the above described sequence of questionnaires is interrupted after two FUS by a hibernation period, resuming only after implementation of the measure.

Add-on modules

Tracking add-on: Data on active and motorised travel behaviour and PA will be collected with the help of the MOVES app (see https://www.moves-app.com/) and sent directly to the PASTA server. The combined analysis of data coming from the app and from the core questionnaires will allow for validating the core survey data.

Health add-on: Detailed data on AM and PA will be complemented in this add-on module by the assessment of health effects of travel behaviours. This assessment includes measurements of cardiovascular parameters such as heart rate variability, blood pressure and retinal vessel diameter (fundus photography), and respiratory parameters such as lung function (spirometry) and inflammation (exhaled nitrogene oxide).

Crash location add-on: Attributes of crash locations are reported in the crash questionnaire and will be compared to control locations randomly selected from trips on which crashes occurred, as done previously by [57].

2.5 Health impact assessment: state-of-the-art, PASTA model and further development of HEAT

A main objective of PASTA is the improvement of HIA of AM, based on the expertise within the PASTA consortium, existing research from projects such as SHAPES [34], TAPAS [47], iConnect [32, 33, 58], ITHIM [48] and HEAT [49, 59], stakeholders from each PASTA city, and data collected in the longitudinal survey and its add-on modules.

To start with, a systematic review of HIA of AM was performed (see Figure 1) [36]. This review revealed the main health pathways and methods existing in HIA of AM (see Figure 4). This review also highlighted the weight of each health pathway associated with AM, showing that PA is the main pathway to produce health benefits, outweighing any risks of air pollution exposure and crashes. Not only the active traveller is directly affected by a mode shift to AM, but also the general population profits from such a mode shift by overall motorised traffic volume reductions and associated exposure reductions of energy consumption, air pollution and noise emissions from (displaced) motorised travel [16, 60]. The review also identified the

main outcomes used to summarise and quantify the health impacts of AM (i.e. mortality, morbidity, injuries, life expectancy, disabilities, work and school absences and monetisation).

The workshops and interviews with stakeholders in the PASTA cities described in Section 2.3 served to identify the needs for assessment, the usefulness and feasibility of a HIA in the local context, and the availability of input data.

The longitudinal surveys and add-on modules described in Section 2.4 were designed to improve the quality and specificity of the input data necessary for quantitative HIA of AM. Examples of these data are 1) the levels and distributions of PA from walking and cycling; 2) the association between AM and total PA, with special interest in the PA substitution effect; 3) the AM associated crash risk, and; 4) varying air pollution exposure levels of different modes of transport.

The enhanced HIA model for AM will update methods and dose response functions for PA (non-linear, with greatest health benefits occurring for sedentary people becoming moderately active [61]) and AP; include an assessment for travellers (PA, air pollution and crashes) in combination to general population exposure (AP and noise); and integrate new health outcomes.

The PASTA HIA model will be applied prospectively to the top measures proposed by each city to assess and quantify expected health impacts and to inform policy makers on overall effectiveness of the top measure.

Finally, this work will feed into updates of HEAT, i.e. include additional health outcomes (morbidities), consideration of possible substitution effects between AM and PA, considerations of crash risk, air pollution exposure, fuel savings and carbon emissions reductions and alternative economic valuations. New modules and functionalities of HEAT will be designed with the specific aim of being user-friendly and tailored to the target audience of users (e.g. urban and transport planners) who do not necessarily possess advanced expertise in epidemiology, modelling and/or economics.

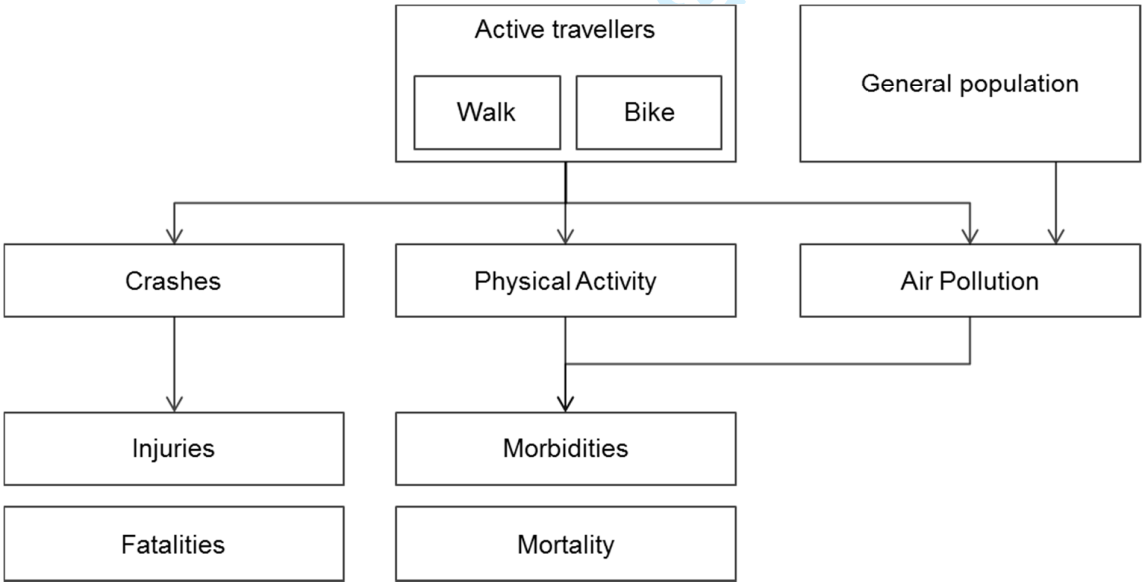

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Figure 4: Framework for health impact assessment of AM.

3 SUMMARY OF LIMITATIONS OF CURRENT WORK ON AM AND PA AND OF THE PASTA STUDY'S CONTRIBUTIONS

Table 1 summarises the main contributions that PASTA adds to previous work. The study pursues an innovative transdisciplinary approach by combining cutting edge methods from public health and transport research. Qualitative and quantitative methods from both disciplines are systematically combined in order to gain insights on the determinants of AM and PA, their interrelation, and on the effectiveness of AM measures. Based on the empirical work in PASTA, HIA are advanced including updating HEAT. PASTA involves stakeholders from research and practice and from public health and transport planning to inform the project's research efforts. Perhaps the most important and unique contribution of PASTA is the combination of these various approaches, thus addressing the real world complexities of AM promotion in a unified framework.

Table 1 Limitations of current work on AM and PA and work undertaken by PASTA to address these

Limitation current work on AM and PA	Contribution PASTA project
AM enablers, planning practice and demand on city level	
Few multi-method and multi-level studies	Systematic combination of qualitative and quantitative methods for the PASTA case study cities, with major longitudinal web-based survey, expert interviews, desktop research about city specific material, stakeholder workshops, compilation of city indicators on AM, PA, contextual factors
Determinants of AM behaviour on the individual level	
The relative importance of various determinants of individual AM behaviour is poorly understood, few studies comprehensively assess the wide range of factors which affect AM and PA,	Data collection and analysis based on a broad conceptual framework reflecting geographical, utilitarian and psychological factors, as well as data hierarchies (aggregation levels)
Predominantly cross-sectional approaches	Longitudinal approach, online survey with long baseline questionnaire and a frequent short follow-ups, continuous recruitment over two years
Often small sample sizes	Targeted sample size of 14,000 respondents across seven cities, number of submitted questionnaires per city > 5,000
Few studies investigate AM consistently across different settings with varying mode shares of AM, resulting in insufficient insights on the role of cultural differences and values	Comparable study design in the seven PASTA cities: Antwerp, Barcelona, London, Oerebro, Rom, Vienna, Zurich
Interrelation between AM and PA behaviour on the individual level	
Current studies are conducted either with methods from public health (over-simplified picture of travel behaviour, no motorised trips) or from transport research (no non-travel PA, proportion of recreational PA in leisure trips unclear)	Interdisciplinary approach, systematic combination of methods from public health (modified GPAQ) and transport research (travel diary) for comprehensive data collection on AM and PA, innovative web-based data collection
Few validation efforts for self-reported estimates	Validation of data from the PASTA core survey for sub-samples by accelerometers, smartphone tracking apps, GPS loggers
Substitution behaviour is poorly understood	Multiple, repeated parallel assessments of AM and PA allow for quantification of substitution behaviour in the short and longer term.
Contextual factors often not considered in quantitative studies	Systematic compilation of indicators of AM and PA, of information on the contextual factors through stakeholder workshops and expert interviews for the PASTA cities

Limitation current work on AM and PA	Contribution PASTA project
Evidence on effectiveness of AM measures	
Few systematic collection of measures supporting AM and PA	Systematic review of state-of-the-art AM measures and their assessments in the literature, the PASTA cities and additional cities (e.g. friends of PASTA network)
Few studies exist on the evaluation of AM measures	Evaluation of top measures in PASTA cities: infrastructure enhancements (e.g. cycle bridge, cycle super highways, leeways, bicycle racks), traffic organisation (ban of vehicles in selected areas), campaigning (workplace mobility management, personalised travel planning)
Few evaluation studies with control group designs	Control groups for all top-measures, using innovative approaches for the assignment of respondents to the affected or control group with the help of GIS-buffers or questions in the baseline questionnaire
High variability in AM leads to failure in evaluation studies	Longitudinal design with repeated measures, large sample sizes
Insufficient knowledge on the contribution of changes in perceived versus objectively measured environment attributes on behaviour change, on pathways and relative influence	Comprehensive measurement of perceived and objectively measured determinants of AM
Determinants of crash risks	
Underreporting of (minor) AM crashes and near misses	Integration of questions about AM crashes and near misses into the core module of the PASTA longitudinal survey
Few reliable numbers exist on the relative crash and crash risks of walking and cycling	Major longitudinal study collecting data about crashes and near misses expressed per kilometre or time cycled or walked, for different person groups and contextual measures
Few on-site visits of crash locations	Locations of reported crashes and near misses are examined in order to collect detailed information as the basis for computing crash risks for AM
Air pollution exposure	
Lack of real-life studies on combined health effects of air pollution and PA – especially multi-centre studies are missing	In three cities, exposure to air pollution and PA is assessed under real-life conditions. A multitude of non-invasive health biomarkers are repeatedly measured in 120 volunteers.
Air pollution exposure while traveling is largely unknown or ignored by using fixed monitoring stations.	Mobile sensors are used for air pollution, PA and travel behaviour. Not only exposure, but also inhaled dose is taken into account (especially relevant for AM).

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Limitation current work on AM and PA	Contribution PASTA project
Health Impact Assessment	
Lack of stakeholder involvement in studies quantifying health impacts of AM	Perform workshops and interviews with stakeholders in each of the seven PASTA cities.
Inconsistent use of methodologies and outcomes.	Develop a systematic review of the state-of-the-art on the HIA of AM, and integrate the good practices on risk assessment and HIA for multiple pathways and health outcomes.
Lack of local and specific input data for model the health impacts. In special data on PA levels and distribution for walking and cycling, substitution effect, air pollution exposure, and crash risk in each city.	Design of a longitudinal survey and add-on modules to collect data on PA, air pollution exposure, crashes.
Lack of translational science.	Update HEAT for cycling and walking, designed with the specific aim of being user-friendly and tailored to the target audience of users (i.e. urban and transport planners) who do not necessarily possess advanced expertise in epidemiology, modelling and/or economics, which is normally required for the conduction of comprehensive heath impact assessment. Apply the PASTA model in the local context to evaluate expected health impacts of top measures in order to inform policy makers on effectiveness of measures and provide recommendations on how to maximise health benefits.
Lack of understanding of co-benefits of AM beyond personal health, e.g. economic effects, reductions in carbon emissions	Extend economic and environmental co-benefit assessment, e.g. Incorporate empirical findings from PASTA on carbon emissions savings from (displaced) motorised traffic into HIA model
Transdisciplinary approach	
Few collaborations between public health and transport professionals	Systematic collaboration of professionals in public health and transport planning
Few exchanges between research and practice	Integration of stakeholders from research and practice in all steps of the project, beginning from the development of the research questions and methods to the broad dissemination of results through scientific and non-scientific communication channels
Few considerations of health arguments in transport policies for promoting AM	Compendium of good practices and recommendations for integrating public health aspects into urban planning and Sustainable Urban Mobility Plans (SUMPs)

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4 CONCLUSIONS

PASTA is a comprehensive research project that spans current research questions on AM ranging from understanding determinants and measures, to a more in-depth understanding of the interrelation between AM and overall PA, to the improvement of HIA. Its wide scope and the combination of qualitative and quantitative methods as well as health and transport contents, the innovative survey design and data collection efforts, the general as well as city-specific reviews and analyses and the transdisciplinary composition of the consortium and the wider network of partners all promise highly-relevant insights for research and practice. With HEAT and a compendium of good practices, significant PASTA findings will materialise in two products tailored to a broad audience of practitioners and beyond.

5 FUNDING STATEMENT

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6 ETHICS AND DISSEMINATION

Ethics approval was obtained for all aspects of the study by the local ethics committees in the countries where the work was conducted, and sent to the European Commission before the start of the survey/study. Various dissemination activities are carried out throughout the project, see www.pastaproject.eu.

7 AUTHORS' CONTRIBUTIONS

CB, AdN, TG, LIP, FR and MJN wrote the original grant proposal on which the study design and paper is based. TG, RG, and ED developed the conceptual framework, survey design and questionnaire contents for the longitudinal survey. ER, TU, SW and RG coordinate the overall work in PASTA. RG drafted this version of the paper and received input from all the authors. All authors read and commented on the paper and agree with the final version.

8 COMPETING INTERESTS

None

9 APPENDIX 1: SELECTED CITY-LEVEL INDICATORS FOR THE SEVEN CASE STUDY CITIES

See "Gerike et al PASTA study protocol supplementary file appendix 1.docx"

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Figure 1: The PASTA approach, AM Active Mobility, PA Physical Activity.

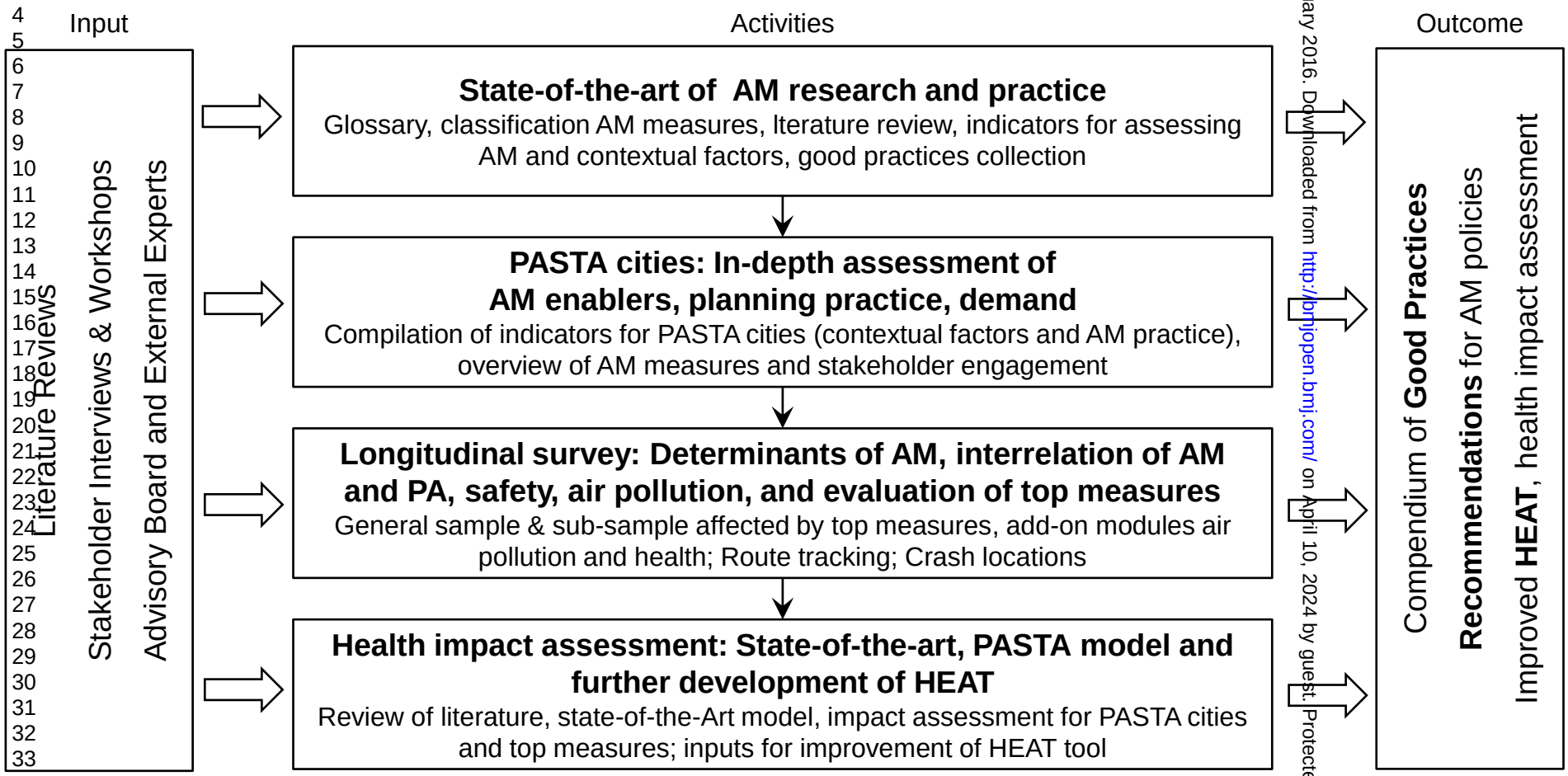


Figure 2: Research framework for the in-depth assessment of AM and the contextual factors on the city-level for the PASTA case study cities; AM = Active Mobility, RQ = Research Question.

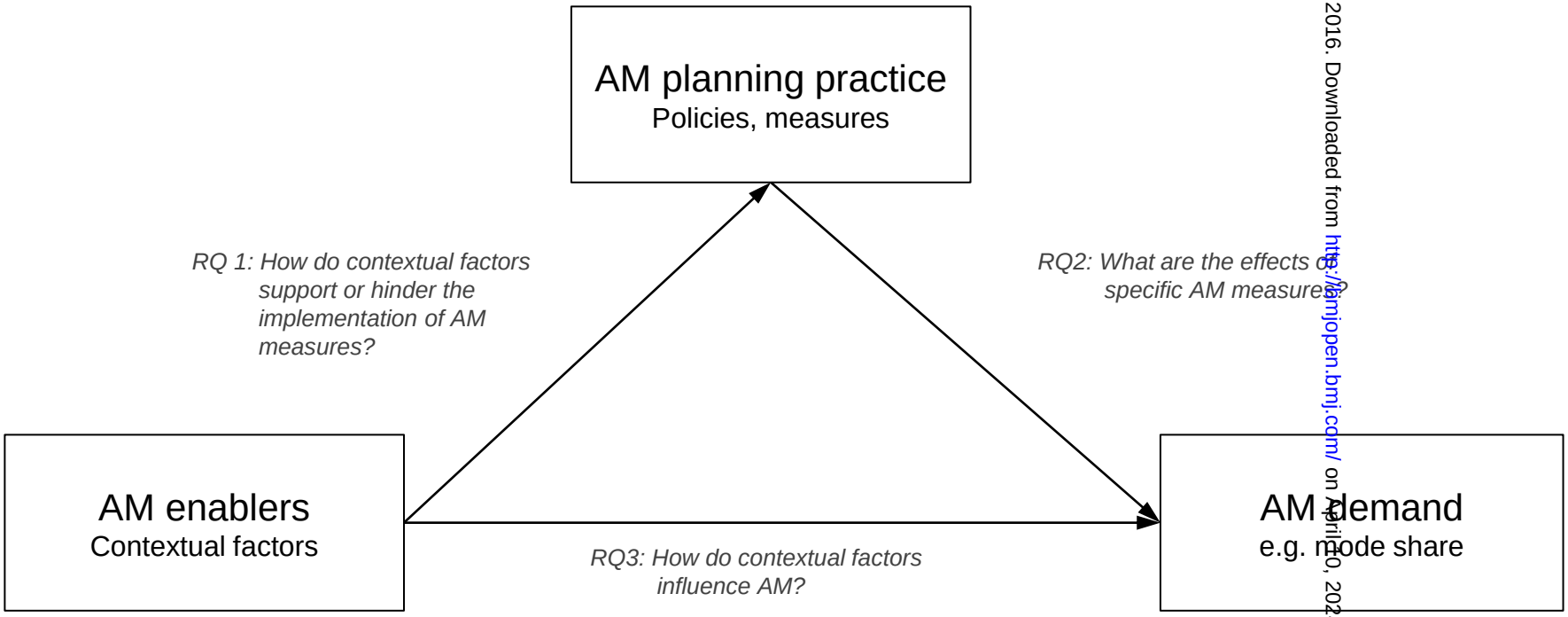


Figure 3: The PASTA longitudinal survey design.

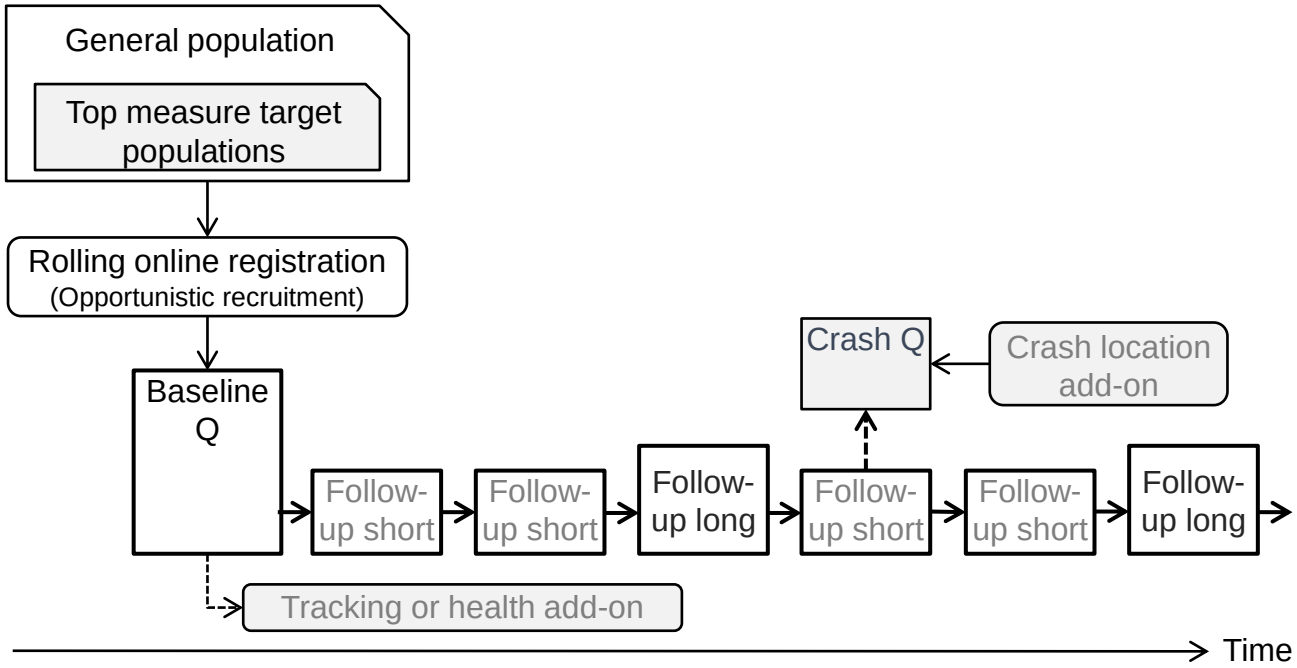
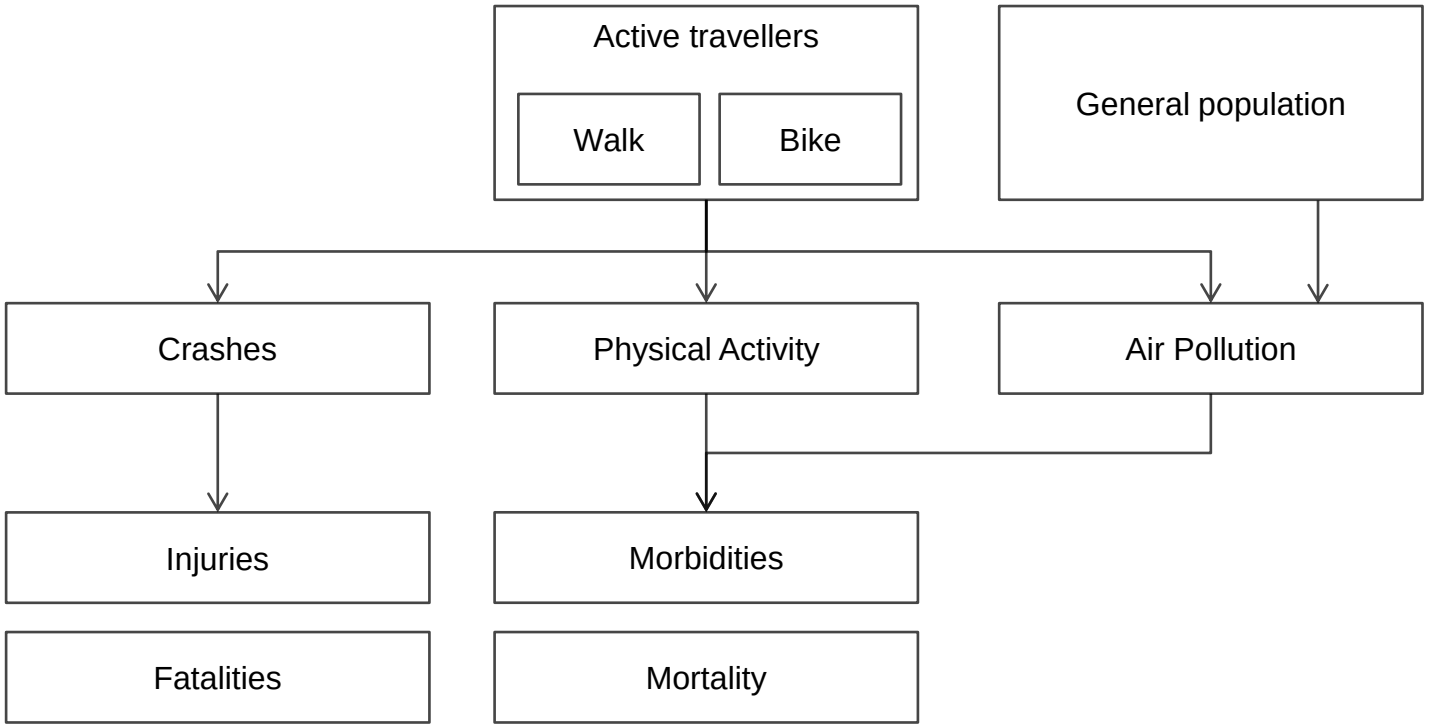


Figure 4: Framework for health impact assessment of AM.



Supplementary file

Physical Activity Trough Sustainable Transport Approaches (PASTA): A Study Protocol for a Multi-Centre Project

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APPENDIX 1: SELECTED CITY-LEVEL INDICATORS FOR THE SEVEN CASE STUDY CITIES

AM Enablers									
Category	Sub category	Unit	Antwerp	Barcelona	London	Orebro	Rome	Vienna	Zurich
City Information	Area	km²	204	102[1]	1.572	1.373	1.285	415	92[2]
	Green space	km²	38	5,9 [3]	786	n.s.	3,6	189	8,4
	Hilliness	y/n/p	n	y	n	n.s.	p	y	y
Population	Inhabitants	number	502.604	1.620.943	8.538.689[4]	138.952	2.683.842	1.741.246[5]	398.575 [6]
	Men	%	49,5	47,5	n.s.	49,1	47,1	48,0	50,0
	Women	%	50,5	52,5	n.s.	50,9	52,9	52,0	50,0
	Population density	Inh/km²	2.464	15.892	5.432	101	2.089	4.196	4.332
Climate	Average annual air temperature	°C	9,6	18,2 [7]	9,6 [8]	n.s.	17,8	11,3 [9]	9,7
	Average annual precipitation	mm	776	565	754	n.s.	648	609	1.133
Society needs	*Mobility survey*	*y/n/p*	n.s.	p	y	p	p	y[10]	y
	Knowledge PT user needs	*y/n/p*	n.s.	p	y	p	p	y	y [11]
	Knowledge pedestrian needs	*y/n/p*	n.s.	p	y	n.s.	p	y	p
	Knowledge cyclist needs	*y/n/p*	n.s.	p	y	n.s.	p	y.	p
Vision/Strategy	*AM support Strategies*	*y/n*	y	y [12]	y	n.s.	y	y	y [13]
	Policy for increasing PA	*y/n*	n.s.	y	y	y	n.s.	y	n
	Policy to improve air quality	*y/n*	y [14]	y[15]	y [16]	y	y	y	y [17]
	Municipal bicycle plan/strategy	*y/n*	y	y	y [18]	y	y	y [19]	y [20]
	Municipal walking plan/strategy	*y/n*	p	y [21]	y [22]	y	y	y [23]	y [24]
	Vision for traffic safety	*y/n/p*	y	y[25]	p	y	y	y [26]	y
Monitoring	*Public participation*	*y/n/p*	n.s.	n.s.	p	p	p	y	n.s.
	Usage HIA & HEAT	*y/n*	n.s.	n	y	y	n.s.	n.s.	n.s.

The indicators refer to the year 2012 and were generated from different sources as transports statistics or press releases as well as from interviews with experts. They are based on a city level except form Orebro where the municipality was chosen as focus area. This results in the wide spatial extent and the very low population density compared to the other cities. The highest population density can be found in Barcelona, the widest spatial

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[2] Dokument "Umweltdaten zur Stadt Zürich, 2012" http://www.zuerich.ch/gud/de/index/umwelt/umweltpolitik/umweltbericht.html
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[5] Magistrat der Stadt Wien MA 23 - Wirtschaft, Arbeit und Statistik (2013): Wien in Zahlen. Wien.
[6] Statistisches Jahrbuch der Stadt Zürich 2013, S. 30
[7] http://w1.bcn.cat/temps/docs/Can_Bruixa%201987-2010.pdf
[8] http://www.climatedata.eu/climate.php?loc=ukxx0085&lang=en
[9] http://www.zamg.ac.at/cms/en/news (11.03.2015)
[10] https://www.oesterreich-unterwegs.at/ (27.03.2015) https://www.wien.gv.at/stadtentwicklung/projekte/verkehrsplanung/fussgaenger/befragung-2013/index.html (27.03.2015)
[11] http://www.afv.zh.ch/internet/volkswirtschaftsdirektion/afv/de/verkehrsgrundlagen/instrumente_und_erhebungen/kundenzufriedenheit_zvv.html
[12] http://w110.bcn.cat/Mobilitat/Continguts/Documents/Fitxers/PMU2013-2018IntroDiagnosiEscenaris.pdf
[13] http://www.astra.admin.ch/themen/langsamverkehr/index.html
[14] http://www.antwerpen.be/eCache/ABE/84/21/537.Y29udGV4dD04MDMzOTAz.html
[15] https://w110.bcn.cat/MediAmbient/Continguts/Vectors_Ambientals/Energia_i_qualitat_ambiental/Documents/Traduccions/PECQ_english_def01.pdf
[16] https://www.london.gov.uk/priorities/environment/clearing-londons-air
[17] https://www.stadt-zuerich.ch/gud/de/index/umwelt/luft/massnahmenplan_luft.secure.html
[18] https://tfl.gov.uk/corporate/about-tfl/how-we-work/planning-for-the-future/vision-for-cycling
[19] https://www.wien.gv.at/verkehr/radfahren/ (27.03.2015) http://www.mobilitaetsagentur.at/ (27.03.2015)
[20] https://www.stadt-zuerich.ch/masterplanvelo
[21] http://w110.bcn.cat/Mobilitat/Continguts/Documents/Fitxers/PMU2013-2018IntroDiagnosiEscenaris.pdf
[22] https://www.london.gov.uk/priorities/transport/publications/mayors-transport-strategy
[23] https://www.wien.gv.at/verkehr/zufussgehen/ (27.03.2015) http://www.mobilitaetsagentur.at/ (27.03.2015)
[24] https://www.stadt-zuerich.ch/portal/de/index/politik_u_recht/stadtrat/strategien_zuerich_2025/wie_leben_wir_/mobilitaet.html
[25] http://w110.bcn.cat/Mobilitat/Continguts/Documents/Fitxers/PMU2013-2018IntroDiagnosiEscenaris.pdf
[26] https://www.wien.gv.at/verkehr/verkehrssicherheit/programm/index.html (27.03.2015)

extent in London. The high average annual air temperatures reflect the geographical position of Rome and Barcelona.

There is very good knowledge on the society and user needs in some of the cities (e.g. London, Vienna) while other cities only have information on some specific questions. All cities have policies for improving air quality and for increasing physical activeness and traffic safety. This is reflected in the existence of walking and bicycle plans. Public participation is a topic while the usage of HEAT differs.

AM planning practice									
Category	Sub category	Unit	Antwerp	Barcelona	London	Orebro	Rome	Vienna	Zurich
MM services	*Bike sharing system*	*number*	1	1 [27]	1	0	1	1 [28]	0
	Car sharing system	*number*	1	1	5	2	3	4 [29]	1 [30]
Individual traffic	*Road network*	*km*	1.649	1.362	n.s.	3.604	8.770	2.763[31]	n.s.
	Stock of motor vehicles - cars	*number*	192.707	584.848	2.600.000	62.584	1.867.520	679.492	136.789
	Stock of motor vehicles - motorcycles	*number*	13.505	296.618	n.s.	3.609	418.425	63.012	23.952
	Car ownership rate	*cars/1.000 inh.*	383	361	305	450	696	390	343
	Car free and low speed zones	*%*	n.s.	31	n.s.	60	n.s.	58[32]	44
Traffic restraints	*Parking regulations*	*y/n*	y.	y [33]	y [34]	y	y	y	y [35]
	Average parking costs per hour	*€/hour*	1,6 - 3,8	1,8 - 3	n.s.	1,67 - 2,82	1 - 1,5	2[36]	n.s.
	Road pricing	*y/n/p*	n	n	y [37]	n	p	p	p
Public Transport	*Length of PT network total*	*km*	n.s.	1.747	n.s.	n.s.	2.323	794	280
	Number of lines total	*number*	n.s.	115 [38]	n.s.	14	430	147	45 [39]
	Price for a PT day ticket	*€*	5,00	7,60 [40]	6,81[41]	n/a	6,00	7,60 [42]	4,83 [43]
	Price for a monthly PT ticket	*€*	32,00	52,75	174,81	181,05	35,00	48,20	49,17
	Price for a PT annual ticket	*€*	249,00	n.s.	1.820,00	n/a	250,00	365,00	442,50
	Real time information for PT	*y/n/p*	p	y	p	y	p	p	y
	Priority for PT	*y/n/p*	n.s.	p	p	n.s.	y	p	y
Walking	*Pedestrian zones*	*km²*	n.s.	0,8	n.s.	n.s.	n.s.	0,3	11
Cycling	*Cycling network*	*km*	n.s.	187[44]	n.s.	215	254	1.223	340
	Contraflow cycling	*y/n*	y	y	n.s.	n	n	y	y
	Bicycles permitted in PT	*y/n/p*	p	p	p	p	p	p	y
	Priority/green wave for cyclists	*y/n/p*	p	n	n.s.	n.s.	n	n	n
	Right turn at red light for cyclists	*y/n*	y	n	n	n.s.	n	n	n

Bike and Car sharing systems are available in most of the cities while the public transport supply and the ticket prices rise with the spatial extent and the number of inhabitants. The car ownership rate is characteristic for European cities except the high rate in Rome. Due to

[27] http://w110.bcn.cat/Mobilitat/Continguts/DB_2012_compr.pdf
[28] http://www.citybikewien.at/ (12.03.2015)
http://www.wien.gv.at/verkehr/radfahren/service/citybike.html (12.03.2015)
[29] http://carsharing-wien.net/ (12.03.2015)
[30] www.mobility.ch
[31] Magistrat der Stadt Wien MA 28-Straßenverwaltung und Straßenbau
https://www.wien.gv.at/verkehr/strassen/fakten.html (12.03.2015)
[32] Die Presse (2014): http://diepresse.com/home/panorama/wien/1579825/Tempo-30-in-Wien_Eine-Stadt-bremst-ab (25.03.2015)
[33] http://www.areaverda.cat/en/types-of-spaces/residents-only/
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[34] https://tfl.gov.uk/modes/driving/red-routes/rules-of-red-routes/parking
[35] https://www.stadt-zuerich.ch/pd/de/index/dav/parkkarten_bewilligungen.html
[36] https://www.wien.gv.at/amtshelfer/verkehr/parken/kurzparkzone/parkpickerl.html (27.4.2015)
[37] https://tfl.gov.uk/modes/driving/congestion-charge
[38] http://w110.bcn.cat/Mobilitat/Continguts/DB_2012_compr.pdf p 34
[39] https://www.stadt-zuerich.ch/vbz/de/index/die_vbz/portraet/zahlen_fakten/linien.html
[40] http://www.tmb.cat/en/bitllets-i-tarifes
[41] https://tfl.gov.uk/cdn/static/cms/documents/tube-dlr-lo-adult-fares.pdf
[42] Wiener Linien: http://www.wienerlinien.at/eportal2/ep/channelView.do/pageTypeId/66526/channelId/-46648 (11.03.2015)
[43] http://www.zvv.ch/de/tickets/tickets-und-preise/netzpass/index.html
[44] http://w110.bcn.cat/Mobilitat/Continguts/Documents/Fitxers/Dadesbasiquesmobilitat2011.pdf

the city profile and climate conditions the highest share of motorcycles can be found in Barcelona. Parking fees are standard in all cities, real time information and priority for public transport is widely spread. Priority measures for cycling differ between the cities while the knowledge of pedestrian zones is very low.

AM demand									
Category	Sub category	Unit	Antwerp	Barcelona	London	Orebro	Rome	Vienna	Zurich
Modal Split	*Motorised individual traffic*	%	41[45]	15[46]	38	55	55	27[47]	35[48]
	Public Transport	%	16	36	36	9	29	39	34
	Cycling	%	23	2	2	25	0	6	4
	Walking	%	20	47	24	11	16	28	26
Mobility	*Number of trips per day*	*number*	n.s.	4.9 Mio.	25.9 Mio.	n.s.	4.9 Mio.	n.s.	n.s.
	Average travel time per day	*minutes*	n.s.	85	68	n.s.	92	n.s.	111
	Total PT passengers per year	*number*	n.s.	890 Mio.	3.819 Mio.	n.s.	945 Mio.	907 Mio. [49]	304 Mio.
Road Safety	*Traffic accidents inv. personal injury*	*number/ y.*	2.357	8.419 [50]	n.s.	224	15.782	6.348	3.666
	Injured persons total	*number/ y.*	2.954	11.347	28.780	220	20.670	7.704	1.313
	Deaths in traffic accidents	*number/ y.*	24	30	134	4	154	24	12
CO_2 Emissions and Air Quality	*CO_2 emissions road traffic*	*tons/year*	n.s.	1.025.603[51]	7.959	230.287	4.356.000	3.336.000	n.s.
	Share of transport sector in total CO_2 emissions	%	n.s.	25,3	n.s.	51,2	31,7	36	n.s.
	NOx emissions road traffic	*tons/year*	n.s.	4.849	24.234	770	n.s.	4.390	878
	Share of transport sector in total NOx emissions	%	n.s.	65	n.s.	61,7	n.s.	51	47

The modal split as a result of city profile factors and planning practices and policies differ between the cities. In Rome the main traffic mode is motorised individual traffic, in Vienna public transport. The highest share of pedestrians can be found in Barcelona, cycling in Orebro.

[45] City of Antwerp (2010). Mobiliteitsonderzoek 2010. TEMS – The EPOMM Modal Split Tool. http://www.epomm.eu/tems/result_city.phtml

[46] http://w110.bcn.cat/Mobilitat/Continguts/DB_2012_compr.pdf p 23

[47] Stadt Wien, MA18 (2012). Modal Split Wien 2012.

[48] Stadt Zürich (2012). Umweltdaten der Stadt Zürich. https://www.stadt-zuerich.ch/gud/de/index/umwelt/umweltpolitik/umweltbericht.html

[49] Magistrat der Stadt Wien MA 23-Wirtschaft, Arbeit und Statistik (2014): Statistisches Jahrbuch der Stadt Wien-2014. Wien. p.: 45 http://www.wien.gv.at/statistik/pdf/leben.pdf (18.03.2015)

[50] http://w110.bcn.cat/Mobilitat/Continguts/DB_2012_compr.pdf p. 33

[51] https://w110.bcn.cat/MediAmbient/Continguts/Vectors_Ambientals/Energia_i_qualitat_ambiental/Documents/Traduccions/PECQ_english_def01.pdf

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Physical Activity Through Sustainable Transport Approaches (PASTA): A Study Protocol for a Multi-Centre Project

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Physical Activity Through Sustainable Transport Approaches (PASTA): A Study Protocol for a Multi-Centre Project

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Abstract

Introduction

Only one third of the European population meets the minimum recommended levels of physical activity (PA). Physical inactivity is a major risk factor for non-communicable diseases. Walking and cycling for transport (active mobility, AM) are well suited to provide regular PA. The European research project Physical Activity through Sustainable Transport Approaches (PASTA) pursues the following aims: (1) To investigate correlates and interrelations of AM, PA, air pollution, crash risk; (2) To evaluate the effectiveness of selected interventions to promote AM; (3) To improve health impact assessment (HIA) of AM; (4) To foster the exchange between the disciplines of public health and transport planning, and between research and practice.

Methods and analysis

PASTA pursues a mixed-method and multi-level approach that is consistently applied in seven case study cities. Determinants of AM and the evaluation of measures to increase AM are investigated through a large scale longitudinal survey, with overall 14,000 respondents participating in Antwerp, Barcelona, London, Oerebro, Rome, Vienna, Zurich. Contextual factors are systematically gathered in each city. PASTA generates empirical findings to improve HIA for AM, e.g. with estimates of crash risks, factors on AM-PA substitution and carbon emissions savings from mode shifts. Findings from PASTA will inform the WHO's Health Economic Assessment Tools (HEAT). The study's wide scope, the combination of qualitative and quantitative methods and health and transport methods, the innovative survey design, the general and city-specific analyses and the transdisciplinary composition of the consortium and the wider network of partners all promise highly-relevant insights for research and practice.

Ethics and dissemination

Ethics approval has been obtained by the local ethics committees in the countries where the work is being conducted, and sent to the European Commission before the start of the survey. The PASTA website (www.pastaproject.eu) is at the core of all communication and dissemination activities.

'Strengths and limitations of this study

- The study Physical Activity through Sustainable Transport Approaches (PASTA) pursues a mixed-method approach combining qualitative and quantitative methods from public health and transport research developed and implemented by academics and practitioners in a transdisciplinary setting.
- A large-scale quantitative survey on active mobility, physical activity, air pollution exposure and crash risk is carried out with overall 14,000 participants in the PASTA case study cities Antwerp, Barcelona, London, Oerebro, Rome, Vienna and Zurich.
- Longitudinal cohort data are collected for detailed activity analyses and the evaluation of selected policy measures and interventions in each PASTA case study city.
- The collected data directly feeds into the advancement of health impact assessment models and HEAT.
- The survey data may be biased due to opportunistic sampling and a web-based approach. Measures are in place to minimise any bias, including multiple recruitment approaches and analytical methods taking account of the recruitment methods.

1 INTRODUCTION

Reducing sedentary behaviour and increasing the level of physical activity (PA) in the population is a key goal of the EU Strategy on nutrition, overweight and obesity-related health issues [1]. In contrast to this policy goal, levels of PA are decreasing [2, 3]. Only one third of the European population is estimated to meet the minimum recommended levels of PA, which for adults correspond to at least 150 minutes of moderate-intensity aerobic PA throughout the week [3–5]. Globally, physical inactivity is the fourth leading risk factor for mortality and a major cause of non-communicable diseases [6, 5].

Walking and cycling for transport solely or in combination with public transport, also referred to as active mobility (AM), are well suited to provide regular PA. In contrast to sports or exercise, AM requires less time and motivation; it is convenient as a mode of transport and as a form of exercise; and it is economically affordable. Hence, AM has the potential to reach parts of the population which may be less receptive to appeals of sports and exercise, or cannot afford them in terms of finance or time [7]. Especially for people with low PA such as sedentary, obese and elderly people it is easier to begin with AM as a moderate form of regular PA than with sports or other types of vigorous PA [8].

Increasing AM not only supports public health objectives but also serves goals in transport planning. The balanced and integrated development of all transport modes is a main characteristic of Sustainable Urban Mobility Plans (SUMP) [9] and a key goal in the strategic EU policy documents [10–12]. Increasing AM reduces the consumption of space for transport infrastructure, energy use, air pollution and noise and improves overall quality of urban life [13–16]. However, to date, health aspects of AM are rarely considered in SUMPs. Practitioners in both public health and transport planning departments pursue opportunities to increase AM; however, they usually work in isolation, thus not benefiting from the large potential for synergy. Similarly, researchers in health and transport fields work on a better understanding of AM and its interrelation with PA, but again, systematic collaboration is rare.

There is a lack of detailed studies on the interrelation between AM and PA [7], and most studies are either conducted with methods from public health resulting in an incomplete picture of AM, or with methods from transport research resulting in an incomplete picture of PA. Existing studies mainly apply cross-sectional designs which are neither suited to capture the variability in walking and cycling nor to identify causal chains.

Factors determining AM behaviour include socio-demographic characteristics such as income or car ownership [17–20], socio-psychological factors such as preferences, attitudes, habits or norms [19], and socio-geographic factors such as climate and topography, the built environment or the transport system [20–22, 17, 23, 24]. Cities with walking shares higher than 50% of all the trips such as Bilbao in Spain, and with cycling shares of up to 44% such as the Dutch cities Eindhoven or Groningen show that high shares of AM are feasible [25]. Parkin and Koorey [26, 27] summarised the requirements for AM-friendly spatial settings with the principles density, destination accessibility, design, distance to public transport and diversity (see also [28, 27]). The perceived lack of traffic safety is an important deterrent for AM [29–31]. Despite a rapidly growing body of research, determinants of AM behaviour remain poorly understood, in particular with regards to their interrelation with PA.

Good practice collections for AM measures exist (see e.g. http://www.eltis.org/) but few rigorous evaluation studies are available [32, 33] and public health aspects are rarely included in the evaluation of transport policies. Research projects, such as TAPAS [30], SHAPES [34] or iConnect [32, 33, 35] have addressed questions around AM and PA, as well

as exposures to air pollution and crash risks resulting from AM. These provide important input but more evaluation studies are needed.

In recent years, AM health impact assessments (HIA) and health impact modelling studies [36, 37], have received increasing attention in benefit-cost analysis and policy debates. Clear health effects have been demonstrated not only for overall PA but also for PA from walking and cycling for transport [31, 38, 39]. Public health impacts of AM are dominated by benefits from PA, while health risks from air pollution and crashes are found to be relatively small [31, 36]. Health risks from increased air pollution exposure are mainly studied in small sample sizes, with a limited geographical scope and scripted routes [40, 41]. The empirical evidence on minor crashes and near misses and on the risk exposure is limited [42].

Many studies assessing health impacts of AM policies have applied the WHOs' Health Economic Assessment Tool (HEAT) for walking and cycling [43–46, 30, 36, 47, 48]. HEAT is a simple online tool that enables transport planners to value health benefits from regular walking or cycling [49]. While there has been a recent surge in the development of AM HIAs, overall they are characterised by inconsistent methodologies, selective impact domains assessed, and the lack of robust input data [37, 31, 36].

Against this background, the European research project Physical Activity through Sustainable Transport Approaches (PASTA) carried out from 2013-2017 pursues the following four main aims:

1. To investigate correlates and interrelations of AM, PA, air pollution and crash risk;
2. To evaluate the effectiveness of selected interventions and measures to promote AM with regards to increasing AM and PA;
3. To improve comprehensive HIA of AM; and,
4. To foster the exchange between the disciplines of public health and transport planning, as well as between research and practice.

Determinants of AM and the evaluation of measures to increase AM (thereafter referred to as AM measures) are investigated through a large scale longitudinal survey conducted in seven PASTA case study cities with overall 14,000 respondents (Antwerp, Barcelona, London, Oerebro, Rome, Vienna, Zurich). Contextual factors are systematically gathered in each city. PASTA generates empirical findings to inform quantitative HIA models, e.g. with estimates of crash risks, factors on AM-PA substitution and carbon emissions savings from shifts towards AM modes. Selected findings from PASTA will feed into the further development of HEAT.

As such, PASTA is a broadband research project on AM which spans disciplines, research and practice, determinants and impacts, qualitative and quantitative methods, and other dimensions of relevance in a comprehensive approach towards a better understanding of the interrelation between travel behaviour and health. In a unique design, PASTA addresses the complexity of AM promotion by tackling comprehensively its determinants and impacts.

2 STUDY DESIGN

2.1 Overview

Figure 1 summarises the parts of the PASTA project and its workflow. The project starts with a systematic review of the state-of-the-art on AM, which subsequent work builds upon, including:

- an in-depth assessment of AM enablers, planning practice and demand at the city level in the seven PASTA cities;
- a web-based longitudinal study investigating determinants of AM, the interrelation between AM and PA, safety and air pollution exposure of AM, the effectiveness of selected AM measures; and,
- the advancement of HIA for AM.

Insights gained in these steps will feed into a compendium of good practice examples and recommendations for policies promoting PA through AM.

A unique feature of PASTA is its interdisciplinary and transdisciplinary approach [50]. PASTA addresses scientific questions at the interface of different disciplines with researchers from these disciplines jointly working in an interdisciplinary approach. Beyond this, PASTA also works at the interface of scientific questions and societal problems. PASTA addresses the societal challenge of finding ways to effectively increase PA through AM and the scientific challenge of enhancing the knowledge on AM and PA. The research approach to address these challenges is developed in PASTA jointly by academic and non-academic partners in a transdisciplinary setting. This collaboration throughout the study ensures that the identified research questions and methods are relevant for research and practice. It also ensures that innovations from research and practice feed into the PASTA project and that project results are fed back into the academic and non-academic professional communities. PASTA strives to create impact beyond the scientific community not only through the involvement of stakeholders at every stage, but also by feeding into the continuous development process of HEAT

In the subsequent sections we will elaborate on each of the above mentioned parts.

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Figure 1: The PASTA approach, AM Active Mobility, PA Physical Activity.

2.2 State-of-the-art of AM research and practice

This first part of the PASTA project establishes the groundwork for all subsequent steps.

Academic and grey literature on determinants of AM and PA, policies and evaluation studies and on the usage of relevant terms in the public health and transport planning communities are reviewed in a Rapid Evidence Assessment (REA) [51, 52]. REA, in contrast to systematic reviews (as applied for HIA, see Section 2.5), commonly involves targeted searches of the key literature without lengthy meta-analyses, and thus allows for rigorous reviews in a condensed timescale (3-6 months, not 1-2 years). The following steps were taken for the REA in this study: (1) definition of the research questions and search terms, (2) choice of key databases and sources by partners, (3) systematic literature search based on (1), (4) screening and selecting of relevant studies, (5) narrative synthesis of included studies, (6) report production [51]. Clear research questions are paramount for successfully carrying out a REA. This REA aimed at understanding the usage of relevant terms and at getting to know the state of the art for classifying AM measures and for AM and PA determinants.

Based on the REA review, a common glossary was developed that ensures mutual understanding throughout the project by harmonising terms of different disciplines. AM measures were classified along two dimensions: first, four transport mode characterisations -

walking, cycling, public transport, multi-modal trips - and second, four categories of policy measures - social environment, physical environment, regulation and strategic policies [28]. This scheme provides the basis for comprehensively covering all relevant transport modes and measures in the review, analysis and good practice compilation. A set of qualitative and quantitative indicators was developed for the assessment of the state of AM demand, the state of practice of AM planning, and the contextual factors at the city level. A list of contacts in various institutions (referred to as Friends of PASTA) was compiled both for dissemination purposes as well as to seek stakeholder inputs throughout the project, e.g. on good practices. The contacts originated from consortium partners' networks (e.g. Polis, ICLEI, WHO) but also from the Advisory Board (AB) and external stakeholders e.g. from the PASTA cities.

Aside from the critical review of published work, the methods used for these tasks include discussions with experts in the consortium and with members of the PASTA AB, and interviews and workshops with external stakeholders. The insights gained support all subsequent steps of the PASTA project but specifically feed into the work done in the PASTA cities: The developed indicator system serves as the framework for the in-depth assessment of AM enablers, planning practice and demand at the city level as well as for the longitudinal study described in Section 2.4.

2.3 PASTA case study cities: In-depth assessment of AM enablers, planning practice, and demand

The insights gained from the above evidence review are complemented through in-depth analysis in the PASTA case study cities. Figure 2 gives an overview of the research questions (RQ) and the analysis framework for the PASTA cities. Contextual factors such as land use, the transport system, governance schemes or sociodemographic characteristics of the population are referred to as "enablers". Enablers directly influence AM on the city level but also facilitate the implementation of specific AM measures which again affect AM demand. PASTA analyses the effects of both the general city-specific contextual factors (enablers) and AM measures on AM demand.

{Insert figure 2 about here, " Image Gerike et al PASTA study protocol Figure 2.TIF" }

Figure 2: Research framework for the in-depth assessment of AM and the contextual factors on the city-level for the PASTA case study cities; AM = Active Mobility, RQ = Research Question.

The following tasks are completed for each of the PASTA cities in this part of the project:

1. AM indicators: Data are collected and analysed for the indicator set that has been developed in the first part of the project. Appendix 1 shows an overview of the indicators. {see "Gerike et al PASTA study protocol supplementary file appendix 1.docx"}
2. AM measures: Information is gathered about planned and implemented measures, about successes and failures, about success factors and barriers and about the institutional contexts. The individual measures cover all four categories, namely strategic policies such as SUMPs, changes to the physical environment (e.g. specific infrastructure or services for walking and cycling), regulation (e.g. speed limits, access restrictions) and interventions targeting the social environment (e.g. AM campaigns).

3. Top measures: At least one so-called “top measure” is selected for each PASTA city. These measures are evaluated with regards to potential changes in AM behaviour within the longitudinal survey described in Section 2.4. The following top measures will be evaluated:
    - Physical environment: walking and cycling oriented re-development of the 2012 Olympic park area in London; a cycle bridge on a bicycle commuter highway in Antwerp; installation of bicycle racks in Rome; implementation of car-free “super islands” in Barcelona
    - Regulation: access restrictions for motorised vehicles to super islands in Barcelona
    - Social environment: personalised travel planning in Vienna; workplace campaigns accompanied by infrastructure upgrades (e.g. leasing of electric-assist bicycles, installation bicycle racks) in Oerebro
    - Sub-populations: in Zurich, users of electric-assist bicycles and car-sharing members are studied to better understand the potential of such measures to promote sustainable transport.
4. Networking: PASTA approaches local stakeholders from public health, transport and urban planning by means of joint workshops to identify current institutional settings, funding schemes, policies and activities in both fields and to systematically search for opportunities to strengthen the collaboration and to bundle the efforts to increase AM.
5. Stakeholder needs for HIA: Local stakeholders are asked about their interest in and experience with HEAT and for suggestions to further develop this tool. This information feeds into the advancement of HEAT and provides the basis for the application of the PASTA final HIA in the PASTA cities (see Section 2.5).

Expert interviews and workshops are the main methods used for completing these tasks. Subsequent parts of PASTA benefit in several ways from this work with the PASTA cities: Local stakeholders support recruitment for the longitudinal survey and give valuable inputs for the development of the HIA. Collected data and information is used to inform the data analysis of the longitudinal survey and to properly interpret those results. In addition, PASTA hopes to spark long-term collaboration of the involved local stakeholders.

2.4 Longitudinal survey: Interrelation of AM and PA, safety, air pollution, and evaluation of top-measures

A major longitudinal survey of a targeted overall sample of 14,000 participants is carried out in the seven PASTA cities. The survey platform was launched in November 2014; it is planned to be online until October 2016. Figure 3 gives an overview of the survey design which builds on the successful designs of the SHAPES [34], TAPAS [30] and iConnect [32, 33] projects.

{Insert figure 3 about here, " Image Gerike et al PASTA study protocol Figure 3.TIF" }

Figure 3: The PASTA longitudinal survey design.

Study population

The study targets the general population in the PASTA cities and aspires to represent a balance of all transport modes (private {car or motorcycle}, public transport, walking, cycling).

Participation in the study is open to people older than 16 or 18 (depending on the local ethical approval) who either live, work, study or otherwise regularly spend time in these cities. Within the general sample, a sub-group of participants affected by the respective top measure and a corresponding control group are identified.

Recruitment

A standardised recruitment strategy was developed for all cities based on an opportunistic approach (except Oerebro). Recruitment began with a press release directly after launching the platform. Common promotional materials including postcards and leaflets are distributed, local stakeholders and target groups are contacted directly, social media is extensively used throughout the rolling recruitment process that runs over the whole survey period. Registration progress is continuously monitored through a dashboard which monitors participation by key variables which are compared against predefined sample composition targets, namely by gender, age groups and travel mode distribution.

Survey design and implementation

A longitudinal study design was chosen for the PASTA study for the following main reasons:

1. Repeated measures of AM and PA are warranted to derive robust estimates of long term average behaviour, since both AM and PA show substantial temporal variability.
2. To investigate how AM contributes to overall PA, or how subjects may substitute increases in PA from AM with decreases in PA from other domains (e.g. sports), repeated simultaneous assessments of AM and PA within subjects are necessary.
3. To assess crash risks of AM, longitudinal data is needed.
4. To evaluate how top measures affect AM (and overall PA), 'pre/ post-implementation assessments' are necessary.

To minimise the burden to participants and to limit logistic complexity, a web-based survey approach was chosen for the longitudinal study. Filter questions expose participants only to relevant questions. Map and routing tools support the identification of locations e.g. for home or the workplace. An attractive questionnaire design ensures high data quality and minimises response burden. The entire survey procedure is automated, from the registration to reminders and the assignments of participants to the general sample or the top measure groups.

Overview of the survey components

To accommodate the broad scope of topics relevant for the PASTA research objectives, and at the same time to keep participant burden bearable, a balance of contents for the individual questionnaires (minimising duration) and the follow-up frequency was chosen: The survey consists of a "core module" that is filled out by all participants. The core module is complemented by so-called "add-on modules". These are separate studies on 'time-activity and route tracking', 'air pollution exposure and health', and crash location audits. We aim to recruit 120 or more participants from the core-module for these „add-on modules".

Core module

Questionnaire sequence: Figure 3 shows the sequence of questionnaires for the core module. Upon online registration, participants are invited immediately to fill out the baseline questionnaire (BLQ). Regular follow-up questionnaires succeed every 13 days after the last questionnaire has been filled out. The sequence of follow-up questionnaires is a combination of 2 short follow-ups (FUS) and then one longer follow-up (FUL).

BLQ: All individual factors which are not expected to vary over time are collected in a fairly substantial baseline questionnaire (approx. 30 minutes to complete). Contents have been identified based on a conceptual model specifically developed for the PASTA project. The baseline questionnaire asks for socio-demographics, general AM and PA behaviour as well as perceptions, barriers and attitudes. AM and PA are measured in parallel with the single item PA-question [53], a slightly modified version of the Global Physical Activity Questionnaire separating walking and cycling (GPAQ, www.who.int/chp/steps/GPAQ/), questions about the frequency of use for all transport modes and a 1-day travel diary adapted from the KONTIV© design [54, 55].

FUS only contain a single question about mobility and PA in the last week, respectively, as well as a question about whether subjects experienced a crash (i.e. collision or fall) or “near miss”: i.e. an unexpected event while walking or cycling which forces someone to take sudden evasive action, without which a crash would have occurred.

FUL are similar to the FUS and include additionally a 1-day travel diary and the GPAQ.

Crash questionnaire: Questions about “near misses” and crashes are included in each core module questionnaire. If participants report an crash or a near miss, the questionnaire opens and asks for detailed information along the five categories of factors identified by [56]: human factors (e.g. rider or pedestrian behaviour), vehicle-related factors (e.g. type of bicycle, lights), infrastructure factors (e.g. crossroad design), traffic conditions (e.g. traffic density) and environmental factors (e.g. weather).

Evaluation of top measures: For the evaluation of top measures a subsample of participants in each city is divided into an affected and a control group. For these participants, the above described sequence of questionnaires is interrupted after two FUS by a hibernation period, resuming only after implementation of the measure.

Add-on modules

Tracking add-on: Data on active and motorised travel behaviour and PA will be collected with the help of the MOVES app (see https://www.moves-app.com/) and sent directly to the PASTA server. The combined analysis of data coming from the app and from the core questionnaires will allow for validating the core survey data.

Health add-on: Detailed data on AM and PA will be complemented in this add-on module by the assessment of health effects of travel behaviours. This assessment includes measurements of cardiovascular parameters such as heart rate variability, blood pressure and retinal vessel diameter (fundus photography), and respiratory parameters such as lung function (spirometry) and inflammation (exhaled nitrogene oxide).

Crash location add-on: Attributes of crash locations are reported in the crash questionnaire and will be compared to control locations randomly selected from trips on which crashes occurred, as done previously by [57].

2.5 Health impact assessment: state-of-the-art, PASTA model and further development of HEAT

A main objective of PASTA is the improvement of HIA of AM, based on the expertise within the PASTA consortium, existing research from projects such as SHAPES [34], TAPAS [47], iConnect [32, 33, 58], ITHIM [48] and HEAT [49, 59], stakeholders from each PASTA city, and data collected in the longitudinal survey and its add-on modules.

To start with, a systematic review of HIA of AM was performed (see Figure 1) [36]. This review revealed the main health pathways and methods existing in HIA of AM (see Figure 4). This review also highlighted the weight of each health pathway associated with AM, showing that PA is the main pathway to produce health benefits, outweighing any risks of air pollution exposure and crashes. Not only the active traveller is directly affected by a mode shift to AM, but also the general population profits from such a mode shift by overall motorised traffic volume reductions and associated exposure reductions of energy consumption, air pollution and noise emissions from (displaced) motorised travel [16, 60]. The review also identified the main outcomes used to summarise and quantify the health impacts of AM (i.e. mortality, morbidity, injuries, life expectancy, disabilities, work and school absences and monetisation).

The workshops and interviews with stakeholders in the PASTA cities described in Section 2.3 served to identify the needs for assessment, the usefulness and feasibility of a HIA in the local context, and the availability of input data.

The longitudinal surveys and add-on modules described in Section 2.4 were designed to improve the quality and specificity of the input data necessary for quantitative HIA of AM. Examples of these data are 1) the levels and distributions of PA from walking and cycling; 2) the association between AM and total PA, with special interest in the PA substitution effect; 3) the AM associated crash risk, and; 4) varying air pollution exposure levels of different modes of transport.

The enhanced HIA model for AM will update methods and dose response functions for PA (non-linear, with greatest health benefits occurring for sedentary people becoming moderately active [61]) and AP; include an assessment for travellers (PA, air pollution and crashes) in combination to general population exposure (AP and noise); and integrate new health outcomes.

The PASTA HIA model will be applied prospectively to the top measures proposed by each city to assess and quantify expected health impacts and to inform policy makers on overall effectiveness of the top measure.

Finally, this work will feed into updates of HEAT, i.e. include additional health outcomes (morbidities), consideration of possible substitution effects between AM and PA, considerations of crash risk, air pollution exposure, fuel savings and carbon emissions reductions and alternative economic valuations. New modules and functionalities of HEAT will be designed with the specific aim of being user-friendly and tailored to the target audience of users (e.g. urban and transport planners) who do not necessarily possess advanced expertise in epidemiology, modelling and/or economics.

{Insert figure 4 about here, "Image Gerike et al PASTA study protocol Figure 4.TIF" }

Figure 4: Framework for health impact assessment of AM.

2.6 Dissemination

The core element of all communication and dissemination activities within this study is the website where information about all activities is constantly updated, see www.pastaproject.eu. The dissemination strategy aims at getting relevant stakeholders involved; disseminating good practices and recommendations for promoting AM; facilitating the take up of the developed HIA tools and HEAT; stimulating behavioural changes among end-users; supporting recruitment for the longitudinal survey. Dissemination activities are carried out by all partners. They range from leaflets, press releases, activities in social media to the organisation of and participation in various events such as the Transport & Health Conference 2015 (see http://www.tphlink.com/2015-transport--health-conference.html), the IATBR conference 2015 (see http://www.iatbr2015.org.uk/), the Walk21 conference 2015 (see http://walk21vienna.com/) and the Polis annual conference 2015 (see http://www.pastaproject.eu/news-items/events/). The advanced HEAT, together with a compendium on good practices for AM measures, will be made available for free online and specifically distributed to local/regional/national governments, health and transport authorities at all levels, relevant experts, and NGOs.

3 SUMMARY OF LIMITATIONS OF CURRENT WORK ON AM AND PA AND OF THE PASTA STUDY'S CONTRIBUTIONS

Table 1 summarises the main contributions that PASTA adds to previous work. The study pursues an innovative transdisciplinary approach by combining cutting edge methods from public health and transport research. Qualitative and quantitative methods from both disciplines are systematically combined in order to gain insights on the determinants of AM and PA, their interrelation, and on the effectiveness of AM measures. Based on the empirical work in PASTA, HIA are advanced including updating HEAT. PASTA involves stakeholders from research and practice and from public health and transport planning to inform the project's research efforts. Perhaps the most important and unique contribution of PASTA is the combination of these various approaches, thus addressing the real world complexities of AM promotion in a unified framework.

Table 1 Limitations of current work on AM and PA and work undertaken by PASTA to address these

Limitation current work on AM and PA	Contribution PASTA project
AM enablers, planning practice and demand on city level	
Few multi-method and multi-level studies	Systematic combination of qualitative and quantitative methods for the PASTA case study cities, with major longitudinal web-based survey, expert interviews, desktop research about city specific material, stakeholder workshops, compilation of city indicators on AM, PA, contextual factors
Determinants of AM behaviour on the individual level	
The relative importance of various determinants of individual AM behaviour is poorly understood, few studies comprehensively assess the wide range of factors which affect AM and PA,	Data collection and analysis based on a broad conceptual framework reflecting geographical, utilitarian and psychological factors, as well as data hierarchies (aggregation levels)
Predominantly cross-sectional approaches	Longitudinal approach, online survey with long baseline questionnaire and a frequent short follow-ups, continuous recruitment over two years
Often small sample sizes	Targeted sample size of 14,000 respondents across seven cities, number of submitted questionnaires per city > 5,000
Few studies investigate AM consistently across different settings with varying mode shares of AM, resulting in insufficient insights on the role of cultural differences and values	Comparable study design in the seven PASTA cities: Antwerp, Barcelona, London, Oerebro, Rom, Vienna, Zurich
Interrelation between AM and PA behaviour on the individual level	
Current studies are conducted either with methods from public health (over-simplified picture of travel behaviour, no motorised trips) or from transport research (no non-travel PA, proportion of recreational PA in leisure trips unclear)	Interdisciplinary approach, systematic combination of methods from public health (modified GPAQ) and transport research (travel diary) for comprehensive data collection on AM and PA, innovative web-based data collection
Few validation efforts for self-reported estimates	Validation of data from the PASTA core survey for sub-samples by accelerometers, smartphone tracking apps, GPS loggers
Substitution behaviour is poorly understood	Multiple, repeated parallel assessments of AM and PA allow for quantification of substitution behaviour in the short and longer term.
Contextual factors often not considered in quantitative studies	Systematic compilation of indicators of AM and PA, of information on the contextual factors through stakeholder workshops and expert interviews for the PASTA cities

Limitation current work on AM and PA	Contribution PASTA project
Evidence on effectiveness of AM measures	
Few systematic collection of measures supporting AM and PA	Systematic review of state-of-the-art AM measures and their assessments in the literature, the PASTA cities and additional cities (e.g. friends of PASTA network)
Few studies exist on the evaluation of AM measures	Evaluation of top measures in PASTA cities: infrastructure enhancements (e.g. cycle bridge, cycle super highways, leeways, bicycle racks), traffic organisation (ban of vehicles in selected areas), campaigning (workplace mobility management, personalised travel planning)
Few evaluation studies with control group designs	Control groups for all top-measures, using innovative approaches for the assignment of respondents to the affected or control group with the help of GIS-buffers or questions in the baseline questionnaire
High variability in AM leads to failure in evaluation studies	Longitudinal design with repeated measures, large sample sizes
Insufficient knowledge on the contribution of changes in perceived versus objectively measured environment attributes on behaviour change, on pathways and relative influence	Comprehensive measurement of perceived and objectively measured determinants of AM
Determinants of crash risks	
Underreporting of (minor) AM crashes and near misses	Integration of questions about AM crashes and near misses into the core module of the PASTA longitudinal survey
Few reliable numbers exist on the relative crash and crash risks of walking and cycling	Major longitudinal study collecting data about crashes and near misses expressed per kilometre or time cycled or walked, for different person groups and contextual measures
Few on-site visits of crash locations	Locations of reported crashes and near misses are examined in order to collect detailed information as the basis for computing crash risks for AM
Air pollution exposure	
Lack of real-life studies on combined health effects of air pollution and PA – especially multi-centre studies are missing	In three cities, exposure to air pollution and PA is assessed under real-life conditions. A multitude of non-invasive health biomarkers are repeatedly measured in 120 volunteers.
Air pollution exposure while traveling is largely unknown or ignored by using fixed monitoring stations.	Mobile sensors are used for air pollution, PA and travel behaviour. Not only exposure, but also inhaled dose is taken into account (especially relevant for AM).

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Limitation current work on AM and PA	Contribution PASTA project
Health Impact Assessment	
Lack of stakeholder involvement in studies quantifying health impacts of AM	Perform workshops and interviews with stakeholders in each of the seven PASTA cities.
Inconsistent use of methodologies and outcomes.	Develop a systematic review of the state-of-the-art on the HIA of AM, and integrate the good practices on risk assessment and HIA for multiple pathways and health outcomes.
Lack of local and specific input data for model the health impacts. In special data on PA levels and distribution for walking and cycling, substitution effect, air pollution exposure, and crash risk in each city.	Design of a longitudinal survey and add-on modules to collect data on PA, air pollution exposure, crashes.
Lack of translational science.	Update HEAT for cycling and walking, designed with the specific aim of being user-friendly and tailored to the target audience of users (i.e. urban and transport planners) who do not necessarily possess advanced expertise in epidemiology, modelling and/or economics, which is normally required for the conduction of comprehensive heath impact assessment. Apply the PASTA model in the local context to evaluate expected health impacts of top measures in order to inform policy makers on effectiveness of measures and provide recommendations on how to maximise health benefits.
Lack of understanding of co-benefits of AM beyond personal health, e.g. economic effects, reductions in carbon emissions	Extend economic and environmental co-benefit assessment, e.g. Incorporate empirical findings from PASTA on carbon emissions savings from (displaced) motorised traffic into HIA model
Transdisciplinary approach	
Few collaborations between public health and transport professionals	Systematic collaboration of professionals in public health and transport planning
Few exchanges between research and practice	Integration of stakeholders from research and practice in all steps of the project, beginning from the development of the research questions and methods to the broad dissemination of results through scientific and non-scientific communication channels
Few considerations of health arguments in transport policies for promoting AM	Compendium of good practices and recommendations for integrating public health aspects into urban planning and Sustainable Urban Mobility Plans (SUMPs)

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4 CONCLUSIONS

PASTA is a comprehensive research project that spans current research questions on AM ranging from understanding determinants and measures, to a more in-depth understanding of the interrelation between AM and overall PA, to the improvement of HIA. Its wide scope and the combination of qualitative and quantitative methods as well as health and transport contents, the innovative survey design and data collection efforts, the general as well as city-specific reviews and analyses and the transdisciplinary composition of the consortium and the wider network of partners all promise highly-relevant insights for research and practice. With HEAT and a compendium of good practices, significant PASTA findings will materialise in two products tailored to a broad audience of practitioners and beyond.

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6 ETHICS AND DISSEMINATION

Ethics approval was obtained for all aspects of the study by the local ethics committees in the countries where the work was conducted, and sent to the European Commission before the start of the survey/study. In what follows, the local ethics committees are listed:

- Ethics board of the University hospital of Antwerp (Belgium) on October 20, 2014
- Clinical Research Ethics Committee of the Municipal Health Care (Barcelona – Spain) on October 1, 2014
- Imperial College Research Ethics Committee (London – UK) on November 20, 2014
- Regional ethical board, situated at the University of Lund (Örebro – Sweden) on April 9, 2015
- RSM - Roma Servizi per la Mobilità and the Air quality Commission of Roma Capitale Administration (Rome – Italy) on November 24, 2014
- The Austrian Data Processing Register (Vienna – Austria) on September 26, 2014
- Kantonale Ethikkommission Zürich (Switzerland) on October 28, 2014

Various dissemination activities are carried out throughout the project, see www.pastaproject.eu.

7 AUTHORS' CONTRIBUTIONS

CB, AdN, TG, LIP, FR, TU and MJN wrote the original grant proposal on which the study design and paper is based. TG, RG and ED led on the development of the conceptual framework, survey design and questionnaire contents for the longitudinal survey. ER, TU, SW and RG coordinate the overall work in PASTA. RG drafted this version of the paper and

received input from all the authors. All authors read and commented on the paper and agree with the final version.

8 COMPETING INTERESTS

No, there are no competing interests.

9 APPENDIX 1: SELECTED CITY-LEVEL INDICATORS FOR THE SEVEN CASE STUDY CITIES

See "Gerike et al PASTA study protocol supplementary file appendix 1.docx"

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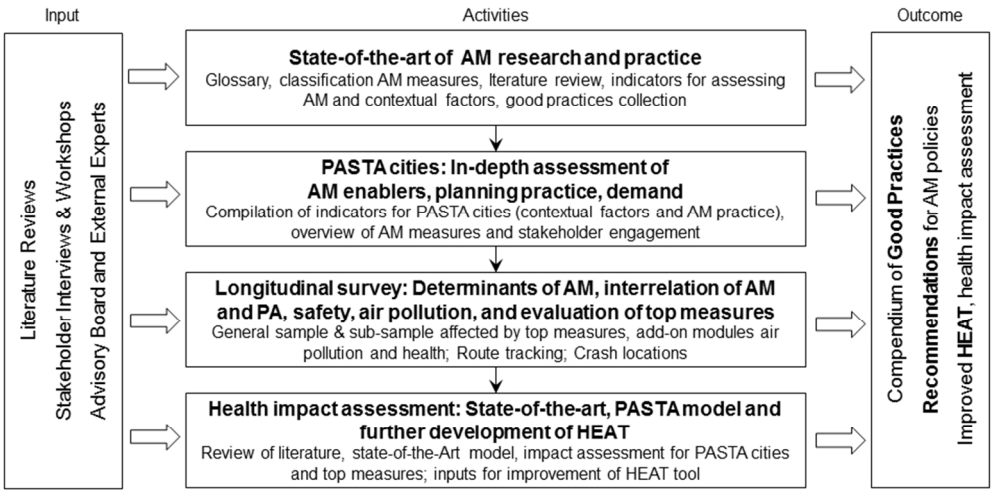

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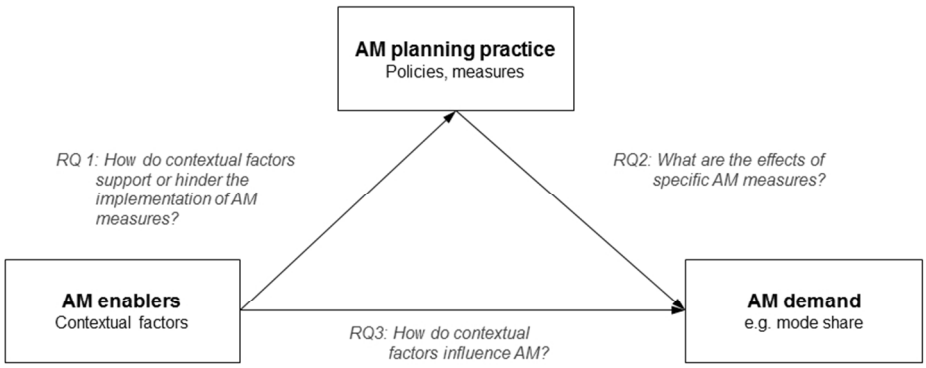

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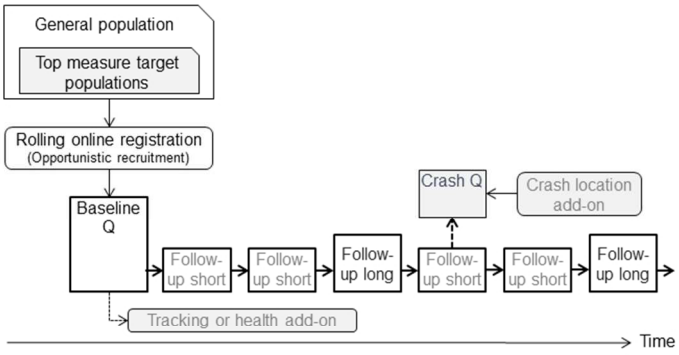

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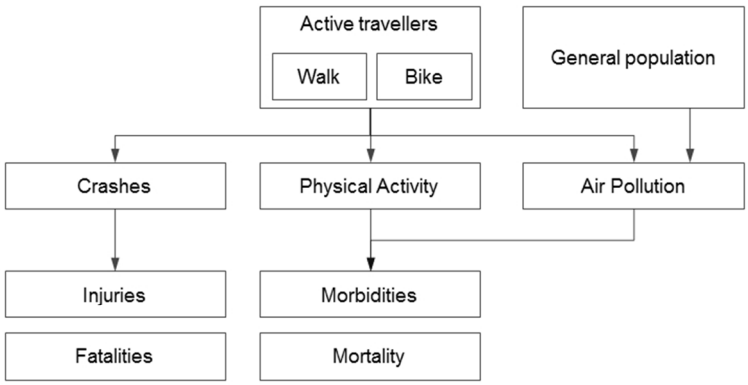

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Supplementary file

Physical Activity Trough Sustainable Transport Approaches (PASTA): A Study Protocol for a Multi-Centre Project

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APPENDIX 1: SELECTED CITY-LEVEL INDICATORS FOR THE SEVEN CASE STUDY CITIES

AM Enablers									
Category	Sub category	Unit	Antwerp	Barcelona	London	Orebro	Rome	Vienna	Zurich
City Information	Area	km²	204	102[1]	1.572	1.373	1.285	415	92[2]
	Green space	km²	38	5,9 [3]	786	n.s.	3,6	189	8,4
	Hilliness	y/n/p	n	y	n	n.s.	p	y	y
Population	Inhabitants	number	502.604	1.620.943	8.538.689[4]	138.952	2.683.842	1.741.246[5]	398.575 [6]
	Men	%	49,5	47,5	n.s.	49,1	47,1	48,0	50,0
	Women	%	50,5	52,5	n.s.	50,9	52,9	52,0	50,0
	Population density	Inh/km²	2.464	15.892	5.432	101	2.089	4.196	4.332
Climate	Average annual air temperature	°C	9,6	18,2 [7]	9,6 [8]	n.s.	17,8	11,3 [9]	9,7
	Average annual precipitation	mm	776	565	754	n.s.	648	609	1.133
Society needs	*Mobility survey*	*y/n/p*	n.s.	p	y	p	p	y[10]	y
	Knowledge PT user needs	*y/n/p*	n.s.	p	y	p	p	y	y [11]
	Knowledge pedestrian needs	*y/n/p*	n.s.	p	y	n.s.	p	y	p
	Knowledge cyclist needs	*y/n/p*	n.s.	p	y	n.s.	p	y.	p
Vision/Strategy	*AM support Strategies*	*y/n*	y	y [12]	y	n.s.	y	y	y [13]
	Policy for increasing PA	*y/n*	n.s.	y	y	y	n.s.	y	n
	Policy to improve air quality	*y/n*	y [14]	y[15]	y [16]	y	y	y	y [17]
	Municipal bicycle plan/strategy	*y/n*	y	y	y [18]	y	y	y [19]	y [20]
	Municipal walking plan/strategy	*y/n*	p	y [21]	y [22]	y	y	y [23]	y [24]
	Vision for traffic safety	*y/n/p*	y	y[25]	p	y	y	y [26]	y
Monitoring	*Public participation*	*y/n/p*	n.s.	n.s.	p	p	p	y	n.s.
	Usage HIA & HEAT	*y/n*	n.s.	n	y	y	n.s.	n.s.	n.s.

The indicators refer to the year 2012 and were generated from different sources as transports statistics or press releases as well as from interviews with experts. They are based on a city level except form Orebro where the municipality was chosen as focus area. This results in the wide spatial extent and the very low population density compared to the other cities. The highest population density can be found in Barcelona, the widest spatial

[1] http://w110.bcn.cat/Mobilitat/Continguts/DB_2012_compr.pdf
[2] Dokument "Umweltdaten zur Stadt Zürich, 2012" http://www.zuerich.ch/gud/de/index/umwelt/umweltpolitik/umweltbericht.html
[3] http://w110.bcn.cat/MediAmbient/Continguts/Vectors_Ambientals/Energia_i_qualitat_ambiental/Documents/Fitxers/pla-soroll-web.pdf p 21
[4] Population Estimates for UK, England and Wales, Scotland and Northern Ireland, Mid-2014
[5] Magistrat der Stadt Wien MA 23 - Wirtschaft, Arbeit und Statistik (2013): Wien in Zahlen. Wien.
[6] Statistisches Jahrbuch der Stadt Zürich 2013, S. 30
[7] http://w1.bcn.cat/temps/docs/Can_Bruixa%201987-2010.pdf
[8] http://www.climatedata.eu/climate.php?loc=ukxx0085&lang=en
[9] http://www.zamg.ac.at/cms/en/news (11.03.2015)
[10] https://www.oesterreich-unterwegs.at/ (27.03.2015)
https://www.wien.gv.at/stadtentwicklung/projekte/verkehrsplanung/fussgaenger/befragung-2013/index.html (27.03.2015)
[11] http://www.afv.zh.ch/internet/volkswirtschaftsdirektion/afv/de/verkehrsgrundlagen/instrumente_und_erhebungen/kundenzufriedenheit_zvv.html
[12] http://w110.bcn.cat/Mobilitat/Continguts/Documents/Fitxers/PMU2013-2018IntroDiagnosiEscenaris.pdf
[13] http://www.astra.admin.ch/themen/langsamverkehr/index.html
[14] http://www.antwerpen.be/eCache/ABE/84/21/537.Y29udGV4dD04MDMzOTAz.html
[15] https://w110.bcn.cat/MediAmbient/Continguts/Vectors_Ambientals/Energia_i_qualitat_ambiental/Documents/Traduccions/PECQ_english_def01.pdf
[16] https://www.london.gov.uk/priorities/environment/clearing-londons-air
[17] https://www.stadt-zuerich.ch/gud/de/index/umwelt/luft/massnahmenplan_luft.secure.html
[18] https://tfl.gov.uk/corporate/about-tfl/how-we-work/planning-for-the-future/vision-for-cycling
[19] https://www.wien.gv.at/verkehr/radfahren/ (27.03.2015)
http://www.mobilitaetsagentur.at/ (27.03.2015)
[20] https://www.stadt-zuerich.ch/masterplanvelo
[21] http://w110.bcn.cat/Mobilitat/Continguts/Documents/Fitxers/PMU2013-2018IntroDiagnosiEscenaris.pdf
[22] https://www.london.gov.uk/priorities/transport/publications/mayors-transport-strategy
[23] https://www.wien.gv.at/verkehr/zufussgehen/ (27.03.2015)
http://www.mobilitaetsagentur.at/ (27.03.2015)
[24] https://www.stadt-zuerich.ch/portal/de/index/politik_u_recht/stadtrat/strategien_zuerich_2025/wie_leben_wir_/mobilitaet.html
[25] http://w110.bcn.cat/Mobilitat/Continguts/Documents/Fitxers/PMU2013-2018IntroDiagnosiEscenaris.pdf
[26] https://www.wien.gv.at/verkehr/verkehrssicherheit/programm/index.html (27.03.2015)

extent in London. The high average annual air temperatures reflect the geographical position of Rome and Barcelona.

There is very good knowledge on the society and user needs in some of the cities (e.g. London, Vienna) while other cities only have information on some specific questions. All cities have policies for improving air quality and for increasing physical activeness and traffic safety. This is reflected in the existence of walking and bicycle plans. Public participation is a topic while the usage of HEAT differs.

AM planning practice									
Category	Sub category	Unit	Antwerp	Barcelona	London	Orebro	Rome	Vienna	Zurich
MM services	*Bike sharing system*	*number*	1	1 [27]	1	0	1	1 [28]	0
	Car sharing system	*number*	1	1	5	2	3	4 [29]	1 [30]
Individual traffic	*Road network*	*km*	1.649	1.362	n.s.	3.604	8.770	2.763[31]	n.s.
	Stock of motor vehicles - cars	*number*	192.707	584.848	2.600.000	62.584	1.867.520	679.492	136.789
	Stock of motor vehicles - motorcycles	*number*	13.505	296.618	n.s.	3.609	418.425	63.012	23.952
	Car ownership rate	*cars/1.000 inh.*	383	361	305	450	696	390	343
	Car free and low speed zones	*%*	n.s.	31	n.s.	60	n.s.	58[32]	44
Traffic restraints	*Parking regulations*	*y/n*	y.	y [33]	y [34]	y	y	y	y [35]
	Average parking costs per hour	*€/hour*	1,6 - 3,8	1,8 - 3	n.s.	1,67 - 2,82	1 - 1,5	2[36]	n.s.
	Road pricing	*y/n/p*	n	n	y [37]	n	p	p	p
Public Transport	*Length of PT network total*	*km*	n.s.	1.747	n.s.	n.s.	2.323	794	280
	Number of lines total	*number*	n.s.	115 [38]	n.s.	14	430	147	45 [39]
	Price for a PT day ticket	*€*	5,00	7,60 [40]	6,81[41]	n/a	6,00	7,60 [42]	4,83 [43]
	Price for a monthly PT ticket	*€*	32,00	52,75	174,81	181,05	35,00	48,20	49,17
	Price for a PT annual ticket	*€*	249,00	n.s.	1.820,00	n/a	250,00	365,00	442,50
	Real time information for PT	*y/n/p*	p	y	p	y	p	p	y
	Priority for PT	*y/n/p*	n.s.	p	p	n.s.	y	p	y
Walking	*Pedestrian zones*	*km²*	n.s.	0,8	n.s.	n.s.	n.s.	0,3	11
Cycling	*Cycling network*	*km*	n.s.	187[44]	n.s.	215	254	1.223	340
	Contraflow cycling	*y/n*	y	y	n.s.	n	n	y	y
	Bicycles permitted in PT	*y/n/p*	p	p	p	p	p	p	y
	Priority/green wave for cyclists	*y/n/p*	p	n	n.s.	n.s.	n	n	n
	Right turn at red light for cyclists	*y/n*	y	n	n	n.s.	n	n	n

Bike and Car sharing systems are available in most of the cities while the public transport supply and the ticket prices rise with the spatial extent and the number of inhabitants. The car ownership rate is characteristic for European cities except the high rate in Rome. Due to

[27] http://w110.bcn.cat/Mobilitat/Continguts/DB_2012_compr.pdf
[28] http://www.citybikewien.at/ (12.03.2015)
http://www.wien.gv.at/verkehr/radfahren/service/citybike.html (12.03.2015)
[29] http://carsharing-wien.net/ (12.03.2015)
[30] www.mobility.ch
[31] Magistrat der Stadt Wien MA 28-Straßenverwaltung und Straßenbau
https://www.wien.gv.at/verkehr/strassen/fakten.html (12.03.2015)
[32] Die Presse (2014): http://diepresse.com/home/panorama/wien/1579825/Tempo-30-in-Wien_Eine-Stadt-bremst-ab (25.03.2015)
[33] http://www.areaverda.cat/en/types-of-spaces/residents-only/
http://www.areaverda.cat/en/types-of-spaces/green/
http://www.areaverda.cat/en/types-of-spaces/blue/
[34] https://tfl.gov.uk/modes/driving/red-routes/rules-of-red-routes/parking
[35] https://www.stadt-zuerich.ch/pd/de/index/dav/parkkarten_bewilligungen.html
[36] https://www.wien.gv.at/amtshelfer/verkehr/parken/kurzparkzone/parkpickerl.html (27.4.2015)
[37] https://tfl.gov.uk/modes/driving/congestion-charge
[38] http://w110.bcn.cat/Mobilitat/Continguts/DB_2012_compr.pdf p 34
[39] https://www.stadt-zuerich.ch/vbz/de/index/die_vbz/portraet/zahlen_fakten/linien.html
[40] http://www.tmb.cat/en/bitllets-i-tarifes
[41] https://tfl.gov.uk/cdn/static/cms/documents/tube-dlr-lo-adult-fares.pdf
[42] Wiener Linien: http://www.wienerlinien.at/eportal2/ep/channelView.do/pageTypeId/66526/channelId/-46648 (11.03.2015)
[43] http://www.zvv.ch/de/tickets/tickets-und-preise/netzpass/index.html
[44] http://w110.bcn.cat/Mobilitat/Continguts/Documents/Fitxers/Dadesbasiquesmobilitat2011.pdf

the city profile and climate conditions the highest share of motorcycles can be found in Barcelona. Parking fees are standard in all cities, real time information and priority for public transport is widely spread. Priority measures for cycling differ between the cities while the knowledge of pedestrian zones is very low.

AM demand									
Category	Sub category	Unit	Antwerp	Barcelona	London	Orebro	Rome	Vienna	Zurich
Modal Split	*Motorised individual traffic*	%	41[45]	15[46]	38	55	55	27[47]	35[48]
	Public Transport	%	16	36	36	9	29	39	34
	Cycling	%	23	2	2	25	0	6	4
	Walking	%	20	47	24	11	16	28	26
Mobility	*Number of trips per day*	*number*	n.s.	4.9 Mio.	25.9 Mio.	n.s.	4.9 Mio.	n.s.	n.s.
	Average travel time per day	*minutes*	n.s.	85	68	n.s.	92	n.s.	111
	Total PT passengers per year	*number*	n.s.	890 Mio.	3.819 Mio.	n.s.	945 Mio.	907 Mio. [49]	304 Mio.
Road Safety	*Traffic accidents inv. personal injury*	*number/ y.*	2.357	8.419 [50]	n.s.	224	15.782	6.348	3.666
	Injured persons total	*number/ y.*	2.954	11.347	28.780	220	20.670	7.704	1.313
	Deaths in traffic accidents	*number/ y.*	24	30	134	4	154	24	12
CO_2 Emissions and Air Quality	*CO_2 emissions road traffic*	*tons/year*	n.s.	1.025.603[51]	7.959	230.287	4.356.000	3.336.000	n.s.
	Share of transport sector in total CO_2 emissions	%	n.s.	25,3	n.s.	51,2	31,7	36	n.s.
	NOx emissions road traffic	*tons/year*	n.s.	4.849	24.234	770	n.s.	4.390	878
	Share of transport sector in total NOx emissions	%	n.s.	65	n.s.	61,7	n.s.	51	47

The modal split as a result of city profile factors and planning practices and policies differ between the cities. In Rome the main traffic mode is motorised individual traffic, in Vienna public transport. The highest share of pedestrians can be found in Barcelona, cycling in Orebro.

[45] City of Antwerp (2010). Mobiliteitsonderzoek 2010. TEMS – The EPOMM Modal Split Tool. http://www.epomm.eu/tems/result_city.phtml
[46] http://w110.bcn.cat/Mobilitat/Continguts/DB_2012_compr.pdf p 23
[47] Stadt Wien, MA18 (2012). Modal Split Wien 2012.
[48] Stadt Zürich (2012). Umweltdaten der Stadt Zürich. https://www.stadt-zuerich.ch/gud/de/index/umwelt/umweltpolitik/umweltbericht.html
[49] Magistrat der Stadt Wien MA 23-Wirtschaft, Arbeit und Statistik (2014): Statistisches Jahrbuch der Stadt Wien-2014. Wien. p.: 45 http://www.wien.gv.at/statistik/pdf/leben.pdf (18.03.2015)
[50] http://w110.bcn.cat/Mobilitat/Continguts/DB_2012_compr.pdf p. 33
[51] https://w110.bcn.cat/MediAmbient/Continguts/Vectors_Ambientals/Energia_i_qualitat_ambiental/Documents/Traduccions/PECQ_english_def01.pdf