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Active Mobility: Bringing Together Transport Planning, Urban Planning, and Public Health

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Abstract

Active mobility is related to various positive effects and is promoted in urban planning, transport planning, and in public health. The goals of these three disciplines differ in many respects but have a strong overlap in the ambition to foster active mobility. Until now, efforts for strengthening active mobility have typically not been combined, but rather promoted separately within each discipline. This paper presents a review of research on determinants and impacts of active mobility and of policy measures for supporting active mobility, including the three disciplines of transport planning, urban planning, and public health. The paper further shows the different perspectives and ambitions of the three disciplines and, simultaneously, the substantial synergies that can be gained from an interdisciplinary collaboration in research and practice.

Key words

Active mobility, walking, cycling, public health, planning

Introduction

As a core objective in public health strategies, the promotion of active mobility aids in increasing physical activity levels within the daily routine. Active mobility is defined as utilizing walking and cycling for single trips or within a trip in combination with public transport [1]. The World Health Organization [2] recommends at least 150 minutes of moderate-intensity physical activity per week for adults and at least 60 minutes of daily moderate to vigorous physical activity for children. In 2010, 20 percent of adult men, 27 percent of adult women, and 78 percent of boys and 84 percent of girls (between 11 and 17 years of age) did not fulfil these recommendations globally [2]. This results in the increased risk for non-communicable diseases and reduces life-expectancy [3]. The WHO [3] lists the promotion of active mobility as one core strategy to overcome these problems of insufficient physical activity.

Active mobility also supports transport planning ambitions. Walking and cycling are space efficient; these modes of transport are flexible; they cause low individual and societal costs; and, in combination with public transport, they can cover almost all mobility needs. Increased active mobility can thus help to mitigate the adverse effects caused by motorized private vehicles, especially in urban areas. Common transport-related and environmental problems include safety, congestion, climate change, air-pollution, noise and land consumption. In 2013, 22 percent of all fatalities in EU road transport were pedestrians and 8 percent were cyclists [4]. Compared to their share of overall traffic volume these numbers are high, and in recent years their decrease in fatalities is slower than the total fatality development.

The transport sector is responsible for major parts of the overall greenhouse gas emissions with no substantial reductions thus far [5]. Reductions of greenhouse gas emissions in transport might be more expensive as compared to other sectors, but effective climate protection will not be possible without this sector. Emissions from transport need to lower by around two thirds by 2050 (base year 1990) in order to meet the long-term 60 percent greenhouse gas emission reduction target set in the 2011 White Paper on transport of the European Commission [5].

In 2010, around 420,000 people died prematurely from air pollution in the European Union [6], and significant proportions of the urban population in the EU-28 are exposed to air pollutant concentrations above the EU limit or target values and even more in relation to the more stringent WHO air quality values set for the protection of human health. The critical pollutants are particulate matter ($PM_{2.5}$, PM_{10}), ozone (O_3), nitrogen dioxide (NO_2), and benzo[*a*]pyrene (BaP) [7]. More than 100 million people in the 33 member countries of the European Environment Agency (EEA) are affected by harmful noise levels above 55 decibels [dB]. Out of these, 32 million people are exposed to very high noise levels above 65 dB [8].

Additionally, from the urban and city planning perspective, increased levels of active mobility provide a promising outlook, as this increase allows for less space-consuming transport systems with lower speeds. This opens various opportunities for designing more attractive, inclusive, and livable cities. Some shopkeepers and representatives of local industries insist on having parking spaces nearby in order to increase their accessibility and attractiveness for customers; however, many examples worldwide show that destinations in areas with attractive public spaces are very successful and that success even increases when space is re-allocated from the car to active modes [9]. Gehl [9] demonstrates the reinforcing cycle of attractive public spaces: People are drawn to the area; this calls on political support for assistance in increasing and improving the space for these individuals, consequently leading to the presence of even more people in the streets and public spaces.

The ministers responsible for urban development in the member states of the European Union have committed to “create attractive, user-oriented public spaces and [to] achieve a high standard in terms of the living environment” [10]. In 2016, the EU Ministers agreed on the “Pact of Amsterdam” which establishes the so-called Urban Agenda for the EU [11]. This agenda focusses on an operational framework to encourage improved involvement of urban authorities within the EU policy processes. It presents an initial list of priority themes including the general topic “Urban Mobility” and, more specifically, “Soft Mobility”, referring to walking, cycling, and public spaces. More and more cities recognize the importance of people in public realms for developing attractive, economically successful, democratic and inclusive cities. There is a growing understanding that cities must be designed to invite pedestrian traffic and city life in order to be successful.

The ambitions as well as the strategies for increasing active mobility differ substantially between the disciplines of transport planning, urban planning and public health, but, at the same time, they have a strong overlap in the objective to foster active mobility. However, despite this common interest in active mobility, efforts thus far have been primarily individual rather than collaborative. Substantial synergies could be harnessed by better coordinating activities, as well as by combining approaches for promoting active mobility from the various disciplines, and by pooling financial and personnel resources. Increased walking and cycling volumes yield various environmental, social, and economic benefits. These key factors contribute to the functioning of cities and support sustainable urban development [12].

This paper presents an overview of determinants and impacts of active mobility, as well as of policy measures for supporting active mobility, including the three disciplines of transport planning, urban planning, and public health. The paper is composed of three main parts: First, determinants of active mobility are presented based on a conceptual framework that combines findings from the literature in all three disciplines. Second, the impacts of active mobility and physical activity are introduced in order to show the substantial societal gains that result from high levels of active mobility. Third, key strategies for promoting active mobility are outlined.

The different foci of each discipline become apparent. This shows again the great potential that exists in combining the efforts in all the disciplines for promoting active mobility more efficiently and successfully. In the last section, the findings are summarized, and an outlook is given on perspectives for active mobility.

Conceptual Framework of Active Mobility

Research on active mobility has been exponentially growing in the last years, and, as a part of this research, various conceptual frameworks of active mobility have been developed (see [13] for a systematic review). Frameworks exist separately for walking and cycling as well as for overall active mobility. They are rooted more firmly in transport and public health and less in urban planning. Frameworks from transport research often put active mobility into the context of the overall travel behavior and do not consider non-transport physical activity; frameworks from public health often put active mobility into the context of the overall physical activity and do not consider travel with motorized modes. Few approaches include the overall picture of determinants, behavior, and impacts of active mobility; most focus on specific parts of the whole system. The built environment and transport systems, as well as the psychological, socio-demographic, and socio-economic characteristics as important determinants of active mobility obtain about equal attention. Most frameworks describe active mobility in generic terms and only a few offer a more detailed perspective, including, for example, modes and purposes of the individual trips. Some address the impacts of active travel; these cover health, safety, and environmental outcomes (e.g., carbon emissions). Most of the frameworks are static, only a few include feedback loops, policies or changes over time. Ogilvie et al. [14, 15] provide a framework that allows for the qualification and evaluation of changes in active mobility and physical activity resulting from measures which promote active mobility.

Socio-ecological frameworks are often used in public health related research [16, 17, 18], distinguishing the layers of environmental (ecological) and individual (socio-demographic, socio-economic, socio-psychological) determinants of active mobility and physical activity. The theory of planned behavior developed by Aizen [19, see also 20, 21] has been widely applied. It states that socio-psychological variables such as attitudes and norms influence the intention to choose a specific (travel) activity as a mediator variable, which, in turn, influences the actual behavior. Frameworks from the transport literature mainly focus on mode choice [See 22 for a comprehensive review.]. Schneider [23] propose a five-step mode choice process, covering (1) awareness and availability of choice options, (2) safety and security, (3) costs and convenience, (4) enjoyment, and (5) habits. Socio-demographic variables are included as moderators in these steps.

Singleton & Clifton [24, See also 25] conceptualize travel decisions based on a hierarchy of travel needs which was developed using Maslow's theory of human motivation [26]. The bottom of the hierarchy assesses feasibility, followed by accessibility of relevant destinations, safety, comfort and delight. The distinction between reasoned influences on behavior (such as perceptions, preferences, and attitudes) and unreasoned influences (such as habits and impulsiveness) as important determinants of active mobility are stressed by van Acker et al. [27]. Kroesen et al. [28] study the relationship between attitudes and travel behavior; they demonstrate that this relationship is bidirectional, however, the influence of travel behavior on attitudes is more dominant. Persons with dissonant (i.e., non-aligned) attitude-behavior patterns are less stable compared to persons with well aligned attitudes and behavior. These persons tend to rather adjust their attitudes to their behavior than vice versa. Pikora et al. [29] examine particular physical environmental factors as part of the social ecological model by reviewing studies from public health research, urban planning, and transport-related research. Their frameworks include the influencing factors for physical activity in the context of transport and recreation. Götschi et al. [13], based on their literature review as part of the PASTA-Project (Physical Activity through Sustainable Transport Approaches, See 1), develop a comprehensive and holistic framework of active mobility behavior. They use a detailed, multi-layered model to differentiate the socio-spatial levels, where socially, physically, and individually related factors are located. The interaction of these elements leads to the choice of travel and, thus, behavior.

Figure 1 presents the framework developed specifically for this contribution which is based on Götschi et al. [13]. The built environment in Figure 1 is distinguished by the type of area as well as by the characteristics of public space and the transport system. The whole transport system, including all modes and all components as active mobility, can only be understood in the context of overall travel behavior. For example, when commuting distances are too long, walking or cycling are not attractive options for these trips. Public space comprises not only the density and connectivity of networks for active mobility but also the design of each individual part of these networks (e.g., the design of intersections, streets, or squares). The type of area includes the spatial structure as, for example, the type, size, density, and spatial arrangement of buildings and additionally land-use as the specific usage of buildings and open spaces (e.g., for dwellings or work places). Most aspects of these three parts of the built environment can be characterized by their quality, attractiveness, availability, and accessibility. In Figure 1, the built environment spreads across the city/regional and neighborhood layers and represents, together with the natural factors such as climate and topography, the supply side of the framework.

The social context of active mobility is conceptualized by a multi-layer approach which considers the (neighborhood) community, the peers, the household, and finally the individual itself. Objective characteristics of each individual such as socio-demographic variables, the accessibility of destinations, and the availability of mobility tools (e.g., car ownership, membership in a carsharing scheme, possession of a public transport pass) are interpreted by each individual into their subjective perception of their mobility options. These, together with the socio-psychological variables shape the intention to choose specific travel activities and, finally, the behavior itself. The causal relationship between these different determinants is a two-way process, as shown by Kroesen et al. [28]: Attitudes and objective determinants affect travel behavior but travel behavior, in turn, also affects attitudes, the choice of residential location, mobility tools, etc.

The outer box "Policies, Strategies" brings temporal dynamics into the static framework. Policies might directly influence travel behavior when, for example, new walking and cycling infrastructure is developed. Policies might also indirectly influence travel behavior when these change attitudes and mindsets that then in a second step change travel behavior. Policies include all aspects of activities for promoting active mobility as described below but also the governance structures, institutions, processes, finance issues, etc.

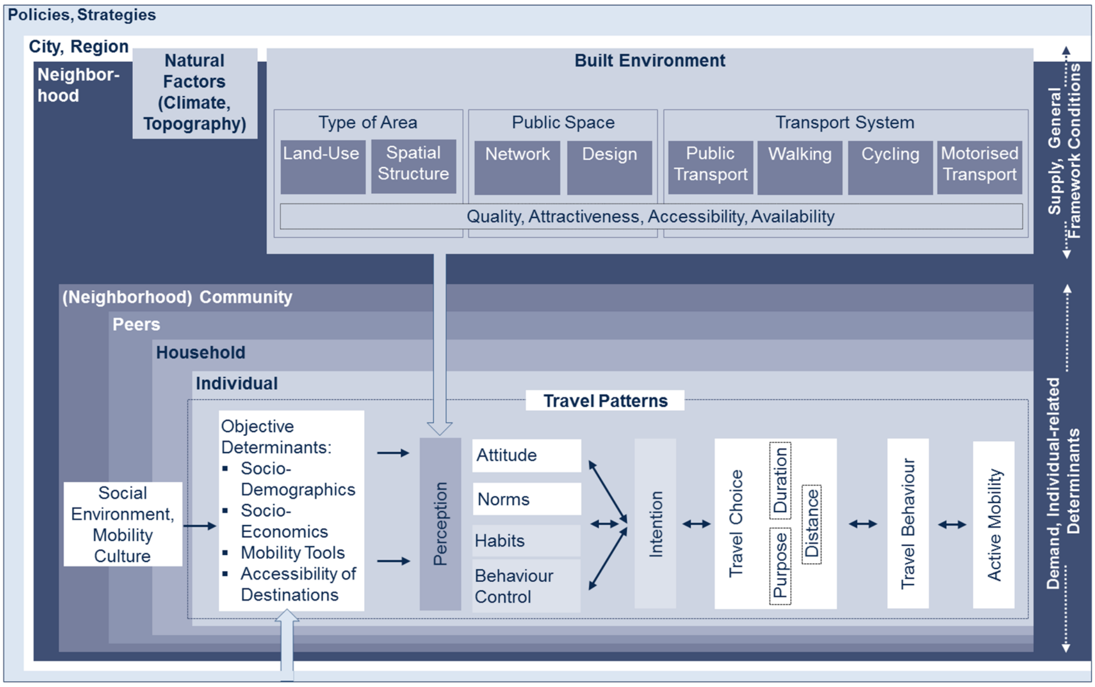

Figure 1: Conceptual Framework of Active Mobility

Determinants of Active Mobility

In this section, we review the most pertinent determinants of active mobility behavior as identified by research in the past years, in the context of the conceptual domains described above.

Built Environment

Density of Spatial Structures, Diversity of Land-Use

Land-use planning determines the shape of transport networks, the attractiveness of public space, and the distances between relevant generators and attractors of travel. It is therefore one core determinant of active mobility [30, 31, 32, 33]. The following requirements for spatial structures that support active mobility are listed in the literature (sometimes also called the "5 Ds"): density, destination accessibility, design, distance to public transport, and diversity [34, 35, 36]. Stead & Marshall [30] describe the relationship between density and diversity of spatial structures on mode choice as follows: A higher density of development and of population lead to (i) a higher amount of personal contacts and possible activities, (ii) a higher amount of commercial facilities and services in the neighborhood and, consequently, to (iii) a reduction of distances. Dense developments (iv) are thus beneficial for the supply of public transport as well as for active mobility. In addition to the density of spatial structures, the diversity or mix of land-uses contributes to the vitality of the public spaces and to a pedestrian- and cycling-friendly environment. Kang [36] has observed increased daily walking times in areas with mixed-use developments, whereas mono-functional residential and industrial land-uses show opposite effects [see also 37, 38].

Connectivity and Density of Transport Networks

The density and connectivity of transport networks are closely linked to the spatial structures since these determine the size of blocks and hence the transport grid meshes. Dense, well-connected, safe, and comfortable infrastructures are important determinants for mode choice in general, including all modes as alternatives; they are particularly important for walking and cycling. Pedestrians and cyclists are the most vulnerable road users; they cover all age groups from infants to elderly people. They require muscle power and are thus highly detour-sensitive modes.

The public transport infrastructure and services are also decisive determinants of active mobility. Most public transport trips include at least two walking legs (access to the first public transport leg, egress from the last public transport leg). Walking is not suitable for all travel needs on its own, but in combination with public transport it can serve almost all travel needs. The infrastructure for the motorized individual modes (mainly car and motorcycles) is also of high relevance for active mobility: Attractive infrastructures for the motorized modes encourage car use for all purposes and distances, even for very short distances, and thus hinders active mobility. Less attractive infrastructures for the motorized modes with, for example, lower speed and/or less parking spaces support active mobility—on its own or in combination with public transport.

Hooper et al. [39] measure the connectivity of the road network and the accessibility of centers within a specific radius of 1,600 meters in the neighborhood by using a Geographic Information System [GIS] with the following result: The higher the road connectivity and the higher the accessibility to commercial land-use within the neighborhood, the higher the odds of walking. In addition, Cervero et al. [40] find that inhabitants of neighborhoods with highly connected road networks tend to have higher active mobility levels of a minimum of 30 minutes per day on average. A high connectivity is mainly related to fine-grained road networks with many intersections [nodes] and requires many route options to get from each starting point to the respective destination. The smaller the distances are between the intersections, the higher the share of pedestrians and cyclists in the local modal split [41, 42, 43, 44].

For cycling specifically, various studies confirm the importance of the density and connectivity of the network of cycling paths [45, 46, 47, 48]. The accessibility of cycling paths particularly near to the residence and workplace as well as near to other destinations has a positive influence on cycling [49]. Lowry et al. [50] introduce aspects of infrastructure quality and traffic density into their connectivity measure, emphasizing the role of the weakest network links (i.e., highest stress) in limiting accessibility.

Accessibility

Land-use characteristics (density, diversity of spatial structures) and transport networks (density, connectivity, quality of transport networks) together determine the accessibility of destinations. For achieving high levels of active mobility, good accessibility is of special importance for the following destinations: workplaces [43], shopping facilities [39, 41, 51, 52, 53], gastronomy [43, 51, 52], public transport [51, 53, 54], residential buildings [36], and educational institutions [55]. Giles-Corti et al. [56, see also 39, 51] stress the importance of good accessibility to parks and other green spaces for fostering recreational active mobility.

Availability of Infrastructure, Design of Public Space

In addition to the quantity of destinations and the characteristics of the transport networks, the design and the quality of public spaces must be considered. Kang [36] and Kamargianni [57] find that the width of sidewalks and a higher share of wide sidewalks positively impact walking. Test persons accepted even longer distances because of wider sidewalks [58]. On the contrary, a poor sidewalk quality has a hindering effect. The violation of the "design for all"-principles (e.g., by shortcomings in the surface or in the street layout but also damages such as cracks or uplifts in the sidewalk surface) is directly related to lowered pedestrian activities and fewer minutes of physical activity—especially for recreational purposes [54, 56]. Findings regarding the qualitative design of the bicycle network are similar to those of walking: The higher the comfort of the bike paths and also of parking facilities, the higher the regular use of the bicycle for transport purposes [49, 59, 60, 61, 62].

Attractive public places are also decisive for active mobility. Gehl [9] emphasizes the importance of the following characteristics of public spaces for achieving high walking levels:

- Provision of opportunities to sit and stand/stay with high quantity and quality, [See also 63, 64]
- Good lighting and security [See also 53, 65]
- Active frontages in the buildings adjacent to the street as a linking element between public space and the insides of the buildings
- Attractive frontages, including, but not limited to, interesting and inviting eye-level facades
- Clearly defined areas for various activities on the sidewalks (e.g., walking, standing, resting, gastronomy, and other commercial facilities) [66]

Scale of Buildings

The scale of buildings is another important factor for active mobility [9, 67]. Neighborhoods with medium-high buildings and appropriate proportions within the public space are convenient for human scale and adequate for the horizontal sensory apparatus [9]. Gehl [9] stresses the importance for adequate proportions between buildings and public spaces: the so-called human dimension of the built environment. Spatial structures and the transport systems need to be built in a matter that attracts people and activities, including not only the necessary engagements but also optional, spontaneous, and social activities. Inviting buildings, historical elements, and local attractions also support active mobility as well as other outdoor activities [53, 63, 64, 68, 69].

Road Traffic, Traffic Safety

Road traffic and traffic safety are other aspects which influence active mobility; both are prerequisite and motivating factors [35, 70, 71]. Road sections with a major link function and high traffic volumes of motorized vehicles do not show high pedestrian volumes [69]; this which is due to a low objective and subjective [perceived] safety on these roads. Additionally, Kaplan et al. [44] state that an increased density of road traffic as well as a high share of heavy goods vehicles (HGV) decreases active mobility. In particular, the two variables “density of traffic” and “share of HGV” have a negative impact on children on their way to school [44]. For children, the choice of walking and cycling is negatively related with the exposure of main streets in their neighborhoods [72].

Traffic Calming

The presence of traffic calming elements as well as a high number of traffic-calmed roads have a positive influence on active mobility, particularly when there is a high amount of traffic-calmed roads within a radius of 500 meters for pedestrians and 1,500 meters for cyclists around the home location [44]. Again, regarding children as a part of the most vulnerable road users, traffic-calmed roads increase the odds of walking and cycling [73].

Socio-Demographic, Socio-Economic and Socio-Psychological Determinants

Socio-demographic and socio-economic characteristics are important indicators for the propensity to walk and cycle [35, 74, 75].

In Germany, the overall number of trips is nearly constant for men in almost all age groups across their life cycle [76]; however, for females, age is a key factor for explaining trip rates which vary substantially across their lifetime. Up to five trips per day are made between the ages of twenty and forty; afterwards trip rates decrease steadily [76]. This often refers to the phases of family formation and family living. Compared to females, males have a stronger preference for the bicycle, rather than walking [40, 68, 77]. Females have more walking trips when it comes to physical activity [78, 79].

The age distribution of cycling is more even in high-cycling countries, such as the Netherlands, than in low-cycling countries where cycling is dominated by the young (and male) [80]. Pupils generally have higher levels of active mobility compared to adult persons. In particular, in the age group of nine- to seventeen-year-olds, children and adolescents show a high affinity towards the active modes [81]. Harms et al. [81] especially find a reduction of cycling trips after the age of seventeen for both male and female adolescents. This decline in cycling trips could be associated with the obtainment of a driver´s license.

Parents have a special responsibility to shape their children’s travel behavior. The more parents travel by bicycle, the higher the odds of their children going by bicycle [82]. The mobility behavior of children is affected adversely by the car-oriented mobility culture of their parents [73, 83]. Furthermore, the early personal contact of children to the streetscape promotes active mobility. For example, this can be manifested by the permission to walk independently to school, to play outside or to cycle [78, 82, 84]. Other familiar persons and peers can have the same impact, as far as active mobility is concerned [85].

Seniors show an increase in walking trips as they get older and a concomitant decline of the overall trip rate per day and of the daily travel time by bicycle [86, 87]. The availability of commercial facilities in the neighborhood, physical fitness, and personal health are decisive factors for active mobility [87, 88]. Thus, healthy persons and persons with no functional limitations are more often active than persons with health restrictions [60].

Education is another important determinant of active mobility. The odds of walking [63] and cycling [46, 49, 89] rise with increasing levels of education. The impact of household size and structure on (active) mobility is evident as household members need to coordinate their travel activities as well as the usage of joint mobility tools, such as the car or a public transport season ticket. Guo et al. [41, see also 90] find a higher propensity to use motorized vehicles for utilitarian purposes as the size of the household increases.

The relation between the income at the person or at the household level in regards to active mobility is often investigated with inconclusive findings:

- Low-income neighborhoods have the highest amount of short walking trips [91]. Pucher et al. [92] find that people with low income use the bicycle for work trips or other utilitarian purposes more often than for recreation.
- There are two opposite findings about the effect of high income on cycling [81]. High-income person-groups are able to spend more money on bicycles. This has a positive effect on the usage frequencies of bicycles. Mainly this group of persons cycle for recreation purposes. In opposite, the same group has a higher car ownership rate, which decreases the bicycle usage mainly for utilitarian purposes [81, 92, 93].
- The higher the parental income, the less pupils walk to school [44, 94]. In contrast, McDonald [95] reports higher odds of walking for pupils from high income families.

There is a clear consensus in the literature regarding both the ownership of a driving license and the availability of motorized vehicles. Both factors inhibit active mobility and encourage people to adopt a car-oriented travel behavior. The higher the number of motorized vehicles in one household, the higher the share of inactive mobility [45, 48, 61, 77, 84, 96]. The same effect has been shown for the ownership of driving licenses [97, 98]. Accordingly, the steady usage of bicycles is related to the availability of bicycles in the household [37, 41, 61, 62, 99].

Socio-cultural indicators (e.g., origin and cultural background) are influencing factors. For instance, Cervero & Duncan [37] find in their study for the San Francisco Bay Area (USA) that African Americans are undertaking more walking trips (for all trip purposes) than Caucasian or Asian Americans. Also, the cycling rates increased the fastest among African Americans, Hispanics, and Asian Americans in the United States during the 2000s [81, 92]. In contrast, Harms et al. [81] describe a lower propensity toward bicycle usage for people with a migrant background in countries with already high cycling rates, such as in the Netherlands. Instead, they use public transport and private motorized vehicles.

Factors such as perceptions, preferences, attitudes, habits, perceived controls on behavior (e.g., linked with the ability to carry luggage or to ride a bicycle), and social and personal norms are found to determine individual mode choice in general and active mode shares specifically. The theory of planned behavior [19] is often applied in this context: This theory states that attitudes, habits, perceived behavioral control, and social and personal norms influence the intention to use certain transport modes; consequently, this intention influences the actual behavior. Affirmative opinions about active mobility are positively correlated with active mobility levels in a bidirectional, causal relationship [28]. Motivating factors for cycling include status and lifestyle promotion, mental and physical relaxation, comfort, time savings, privacy and security [100]. Heinen [101] lists the following individually perceived barriers for cycling: time loss compared to motorized transport modes, too-long distances to relevant destinations, bad weather, lack of parking facilities for bicycles, physical overload (e.g., caused by differences in altitude or insufficient fitness and sweating). Inhibiting aspects also refer to perceived security such as crime and fear of strangers [42, 102]. Factors like flexibility and environmental awareness [48, 60, 99, 100, 103] are identified only in a few studies. In all cases they have a positive influence on cycling trips.

Furthermore, “pleasant” neighborly relations in addition to participation in neighborly events set within a kind and trustful neighborhood increase the odds of walking [64, 98, 102]. Much less subjective motivational factors are identified for walking as compared to cycling. Ball et al. [85] describe emotions such as fun and joy while walking as motivational factors. In particular, the purpose of each trip influences the decision for active mobility; the share of active mobility for leisure and for shopping purposes are higher than for others [104, 105].

Impacts of Active Mobility

The main positive impacts of active mobility are improved health and enhanced quality of life as a consequence of the physical activity inherent to walking and cycling. Mueller et al. [106] show, in their meta-analysis of health-impact assessments from Europe, North America, Australia, and New Zealand, the dominance of these effects. Improved health and quality of life generate 50 to 98 percent of the health effects from more frequent or prolonged walking and cycling trips resulting from measures for promoting active mobility.

Consistent moderate to vigorous physical activity reduces the risks of several non-communicable diseases such as cardiovascular diseases, type 2 diabetes, cancer, dementia, depression, and reduced life-expectancy [3]. Insufficient physical activity is responsible for 25 percent of breast and colorectal cancer, 27 percent of diabetes and about 30 percent of ischemic heart disease [107]. The most substantial health improvements are achieved for persons who are currently physically inactive and begin physical activities. Behavioral changes from increased walking and cycling for transport are more stable compared to sports activities—the latter of which are more often abandoned after a short time [108].

Negative impacts of active mobility result from increased collision risks and from higher exposure to air pollution. Some studies also consider potential harms from increased noise exposure [109]. Pedestrians and cyclists have a raised risk per travelled distance of getting involved in an accident compared to car users, and, in addition, the accident consequences are on average more severe [110]. Crash risks are lower where levels of active mobility are higher—a phenomenon often attributed to the so-called "safety in numbers" effect: This effect implies increased safety from the more prominent visibility of cyclists (or pedestrians) and resulting effects on driver awareness and behavior [111]. While the non-linear relationship of crash risk and volumes has been confirmed by many, the term "safety-in-numbers" has been criticized for the implied direction of causality. It is very likely that safer infrastructure and traffic conditions (i.e., "safety") play the dominant role in increasing active mobility volumes (i.e., "numbers), rather than vice-versa [110, 112, 71]. The number of underreported cases is high for collisions involving pedestrians and cyclists. Von Below [113] has observed, for single collisions with only cyclists, a share of unrecorded cases up to 96 percent. For collisions involving cyclists and cars, this share is up to 47 percent. This means that half of these collisions are not reported to the police and do not show up at all in the official collision statistics.

Panis et al. [114] find five to nine times higher inhalation rates of air pollutants for cyclists while cycling compared to car occupants on the same routes. This leads to a significantly higher exposure to air pollution for cyclists than for car occupants. The resulting negative health effects from this exposure are, however, low compared to the abovementioned positive effects from improved health and quality of life resulting from the physical activity [106]. Tainio et al. [115] show that cycling and walking are beneficial for the individual health even if engaged in excessively.

Environmental noise is, following air pollution, the second most significant environmental health risk in Europe [3]. However, there is a lack of scientific evidence linking potentially increased exposure to noise while walking or cycling to negative health effects. Noise mapping is required every five years for all cities with more than 100,000 residents [116, 117]. Unfortunately, these noise maps are not specifically focused on active mobility and not detailed enough to learn more about the noise exposure during walking or cycling compared to other transport modes.

The Health Economic Assessment Tool (HEAT, www.heatwalkingcycling.org) provided by the WHO is a user-friendly tool that allows for the quantification and monetization of the effects from measures for promoting active mobility including physical activity benefits, air pollution risks, crash risks and carbon emissions from modal shifts between active mobility and the motorized modes. Municipalities and other interested stakeholders can compute the expected impacts of planned measures for promoting active mobility (ex-ante) or evaluate the results from already implemented measures (ex-post) with the help of this tool.

Policies and Strategies for Promoting Active Mobility

Figure 2 visualizes how the three disciplines of urban planning, transport planning, and public health could and should collaborate for fostering active mobility. Each of these three disciplines pursue different specific objectives, but they all have a strong interest in achieving higher active mobility levels. This common objective is represented in the center of the figure in the middle triangle (See Figure 2). The three disciplines are arranged at each triangle-apex in order to show that these are individual disciplines with substantial differences in their objectives, power, resources, competencies, and governance structures as well as in their policies for achieving the objectives. Acknowledging these differences is one core success factor for a fruitful collaboration.

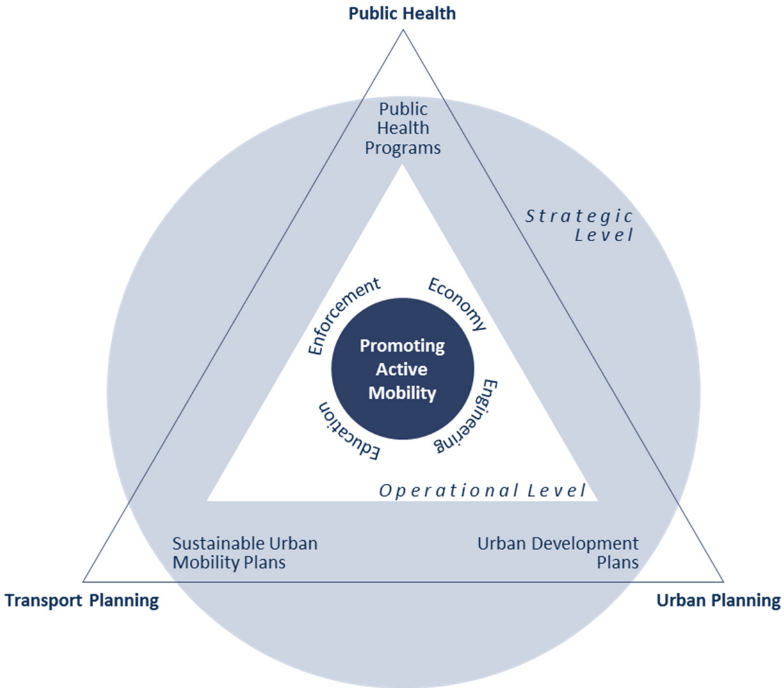

Figure 2: Policies and Strategies for Fostering Active Mobility

In the figure, measures for promoting active mobility are highlighted in the outer circle representing the strategic level which encompasses an operative level in the form of a white triangle. On the strategic level, mid- and long-term strategic plans and concepts are developed. This is for urban planning the urban development plan that coordinates activities for all spatial elements including all land-use types. Urban development plans are highly important for transport planning since they determine the location, quantity, and quality of origins and destinations that need to be subsequently connected by transport planning. In addition, urban planning determines the location and widths of roads and, at times, can also contain prepared specifications of the street layout. Sustainable Transport Mobility Plans (SUMPs) are produced in transport planning. Following the distinction of the strategic and operational levels, these plans provide the strategies for developing future transport systems including all modes [118]. Public health programs formulate health objectives and develop concepts and strategies for achieving those objectives. These strategic plans are each located at a triangle-apex and are specifically developed within the respective disciplines—this development should remain individual since each of the attributed strategic plans includes many objectives and strategies beyond active mobility. These are important for reaching the objectives of each discipline. The sections on active mobility provide for the coordination between the disciplines; this would create substantial synergies and improve the opportunities for fostering active mobility as a joint effort.

The operative level of measures for promoting active mobility is put into the white triangle based on the so-called "4 Es" as a proven classification of measures for promoting active mobility and also for transport planning in general [see e.g. 35, 119]:

E1 Engineering: Measures in this category address the built environment in urban planning and the transport supply in transport planning. They are supported by the processes of transport planning and traffic engineering. Examples are the strategic development of spatial structures, infrastructure networks, traffic signalization, layout of streets and intersections, (bicycle) parking facilities and the integration of transport modes.

E2 Enforcement: This category includes all legal issues such as land-use classifications, speed limits and rights-of-way. There is need for improvement in a number of jurisdictions, especially those which appear to "blame the victim" rather than "protect the vulnerable".

E3 Economy: Measures in this category use monetary instruments for incentivizing or discouraging specific behaviors. For example, some cities and companies implement parking management schemes, or subsidize pedelecs or bike-sharing systems. More economic incentives are possible that would indirectly encourage active mobility by directly discouraging car use: for example, pricing parking or congestion charging schemes. Economic measures are effective but often lack public or political acceptance and support.

E4 Education: This category includes all measures related to knowledge and understanding provided through information, campaigning, personalized travel planning, training and social marketing. For maximum effect, these measures will usually target specific user groups such as speeding offenders, school children learning to navigate the public realm, company staff, the elderly or new residents moving into a city.

In Figure 2, the "4 Es" are not assigned to specific disciplines as all three disciplines are applied by all of the "Es". However, the importance of each of the "4 Es" differs between the disciplines. Transport planning and urban planning efforts are dominated by engineering and enforcement measures; the English-speaking countries Anglo-Saxon countries also have a high affinity for economic measures. Education measures are applied but with fewer resources and engagement than the other categories. Public health measures, on the contrary, are often focused on education. This difference in the importance of the different types of measures can be illustrated with the help of a "3 L" classification of physical activity measures used in the public health field [120]. This classification distinguishes three domains as follows:

L1: Campaigns and informational approaches: This category comprises community-wide campaigns, mass media campaigns, and decision prompts encouraging the use of stairs versus lifts and escalators.

L2: Behavioral and social approaches: These measures are meant to increase social support for physical activity within communities, specific neighborhoods, and worksites. The main difference to the first category is that measures in this second category target specific institutions that are classified in five different settings: school, workplace, community, clinical or health care, and other. Strategies for schools can encompass, for example, physical education, classroom activities or after-school sports, and the promotion of active transport.

L3: Policy and environmental approaches: These interventions create or enhance access to places for physical activity with outreach activities and include mainly measures from the "Engineering" category as described above.

The "3 Ls" thus put more weight into campaigning compared to the "4 Es". They assign the first two out of the three categories to community-wide versus institution-specific measures, classified altogether as "Education" in the "4 Es".

Packages of measures are needed for successfully achieving and maintaining high active mobility levels [119]. Certain measures are highly effective but not well received; other measures are well received but are not very effective. Combining both into packages allows for their successful implementation while at the same time actually achieving behavioral changes and progress according to the specific circumstances and objectives.

Perspectives for Active Mobility

The above review of determinants and impacts of active mobility as well as of strategies for its promotion shows the substantial societal benefits that can be derived from high active mobility levels. Three disciplines are of particular importance for promoting active mobility: First, public health activities aim at increasing physical activity—this does not include, for example, traffic management or road safety improvements; second, transport planning efforts focus on providing efficient transport systems and leave, for example, the WHO standards of physical activity mainly unaddressed; third, the goals of urban planning are directed toward economically successful and attractive cities—urban planners focus less on the public health levels in the population. Thus, each of the three disciplines differ substantially in their ambitions and also in the policies used to achieve their respective goals while simultaneously promoting active mobility. Combining their expertise, resources, and policies has an enormous potential for fostering active mobility which would inevitably result in numerous societal benefits.

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