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Urban and transport planning pathways to carbon neutral, liveable and healthy cities; A review of the current evidence

Mark J. Nieuwenhuijsen*

ISGlobal, Barcelona, Spain
Universitat Pompeu Fabra (UPF), Barcelona, Spain
CIBER Epidemiología y Salud Pública (CIBERESP), Madrid, Spain
Mary MacKillop Institute for Health Research, Melbourne, Australia

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ABSTRACT

Introduction: Half the world population lives in cities and this is likely to increase to 70% over the next 20 years. Suboptimal urban and transport planning has led to e.g. high levels of air pollution and noise, heat island effects and lack of green space and physical activity and thereby an increase in morbidity and premature mortality. How can better urban and transport planning improve public health?

Methods: A narrative meta-review around a number of cutting edge and visionary studies and practices on how to improve public health through better urban and transport planning reported in the literature and from meetings over the past few years.

Results: We describe the latest quantitative evidence of how cities can become healthier through better urban and transport planning. It focuses and provides evidence for important interventions, policies and actions that can improve public health, including the need for land use changes, reduce car dependency and move towards public and active transportation, greening of cities, visioning, citizen involvement, collaboration, leadership and investment and systemic approaches. Health impact assessment studies have recently provided new powerful quantitative evidence on how to make cities healthier and will be used as examples. At the same time these measures make also our cities more sustainable (i.e. carbon neutral) and liveable creating multiple benefits.

Conclusion: Better urban and transport planning can lead to carbon neutral, more liveable and healthier cities, particularly through land use changes, a move from private motorised transportation to public and active transportation and greening of cities.

1. Introduction

Half the world population lives in cities and this is likely to increase to 70% over the next 20 years (United nations, 2014, Rydin et al., 2012). Cities provide jobs, are centres of innovation and wealth creation, but also often are hotspots of air pollution (e.g. particulate matter, NO_2), noise, heat and disease (Bettencourt et al., 2007, Nieuwenhuijsen, 2016). Already in 1973, Oke (1973) described that the high density of buildings and roads can cause so-called urban heat islands, defined as built up areas that are hotter than nearby rural areas. Furthermore, cities often lack accessible green space and physical activity levels of people are below recommended guidelines (Nieuwenhuijsen, 2016, Mueller et al., 2017a, 2017b). They also generate a large proportion of CO_2 emissions, and contribute significantly to the climate crisis (GEA, 2012, IEA, 2012). Recent estimates show that 60–80% of final energy use globally is consumed by urban areas (GEA, 2012) and more than 70% of global greenhouse gas emissions are produced within urban areas (IEA, 2012).

Further urbanization may make things worse, for example, for air pollution (Larkin et al., 2016). NO_2 concentrations increase proportional to the number of the people raised to an exponent in cities (Lamsal and colleagues, 2013) and there is a near-linear relationship between population size and carbon emissions (Fragkias and colleagues, 2013). Access to green space declines rapidly as cities grow, reducing the opportunities for people to experience nature and reducing climate mitigation capacity (Fuller and Gaston, 2009).

Around 4–9 million people die each year because of ambient air pollution levels (Cohen et al., 2017, Burnett et al., 2018), 3.2 million because of lack of physical activity and 1.2 million because of traffic accidents (GBD, 2017, 2018, Bhalla et al., 2014). Noise causes more than 1.8 million DALYs a year in Europe alone (WHO, 2011) and heat may cause as much as around 0.4% of premature mortality annually

* Address: ISGlobal, Dr. Aiguader 88, 08003 Barcelona, Spain.
E-mail address: mark.nieuwenhuijsen@isglobal.org.

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worldwide (Gasparrini et al., 2015). A large part of the burden falls on cities as that is where people live and where higher exposure levels are. Population growth, ageing and the climate crisis put a further burden on cities in many aspects, including health (Rydin et al., 2012, Nieuwenhuijsen, 2016, Watts et al., 2018).

From an urban and transport planning and health view, current urban developments have not been a great success. Many cities follow 2 dominant urban forms; (1) being either dense with large concrete structures such as high rises and road infrastructure for motorised traffic (e.g. Shenzen) or (2) being of low density with lots of sprawl and extensive road infrastructure (e.g. Atlanta, Los Angeles, Melbourne). Both are not great from a sustainability, liveability and health point of view, particularly for the latter urban form as, for example, distances between destinations are large and there is little land use mix and public transportation. Of course, there are also many cities that have a mix of the 2 forms. Finally, rapid urbanization has often led to uncontrolled growth with minimum attention to public health implications beyond infectious disease.

One of factors that is apparent in all cities is the often large presence of the car that has led to high air pollution and noise levels, CO_2 emissions, heat island effects and lack of physical activity and green space in cities (Khreis et al., 2016, Nieuwenhuijsen, 2016, Nieuwenhuijsen, 2018). Public space in many cities is often to a large extent dedicated to motorized traffic (e.g. 60% in a city like Barcelona), even though in many cities it is not the predominant mode of travel (e.g. 25% in a place like Barcelona). Cars either driven or parked (they are parked on average 96% of the time) use space that is now detrimental to health because of e.g. air pollution, noise etc, while it could be used to promote healt, if, for example, it was a green space. At times it appears as if that cities are designed for cars rather than for people, while we need cities for people.

There is good evidence that there is a direct relationship between urban design, how people get around, and how this affects environmental exposure and life style factors and thereby morbidity and mortality (Nieuwenhuijsen, 2016, Nieuwenhuijsen, 2018). In a city designed for and with large investment in infrastructure for cars, you will get many people using the car. This will lead to e.g. high air pollution, noise and stress levels, heat island effects, lack of physical activity, social contacts and green space and to increased e.g. cardiovascular and respiratory morbidity, reduced cognitive functioning and cancer and thereby premature mortality (Nieuwenhuijsen, 2016, Nieuwenhuijsen, 2018). On the other hand, in a city designed for and with investment in infrastructure for active transportation such as cycling, you will get more people cycling. This will lead to e.g. lower air pollution, noise and stress levels, less heat island effects, more physical activity, social contacts and green space and to e.g. decreased cardiovascular and respiratory morbidity, better cognitive functioning and less cancer and thereby less premature mortality (Fig. 1) (Nieuwenhuijsen, 2016, Nieuwenhuijsen, 2018).

In an authoritative review Giles-Corti and colleagues (2016) identified eight fairly specific interventions for improving cities, including increasing destination accessibility, equitable distribution of employment across cities, managing demand by reducing the availability and increasing the cost of parking, designing pedestrian-friendly and cycling-friendly movement networks, achieving optimum levels of residential density, reducing distance to public transport, and enhancing the desirability of active travel modes (for example, creating safe, attractive neighbourhoods and safe, affordable, and convenient public transport) to encourage walking, cycling, and public transport use, while reducing private motor vehicle use. They suggested that together, these interventions will create healthier and more sustainable, compact cities that reduce the environmental, social, and behavioural risk factors that affect lifestyle choices, levels of traffic, environmental pollution, noise, and crime.

Barcelona is a city that ticks many boxes, but a recent health impact assessment study in Barcelona found that still nearly 3000 premature deaths (20% of total death) and 50,000 DALYs annually were due to poor urban and transport planning in the city because of not reaching international guidelines for air pollution, noise, physical activity and green space and due to health island effects (Mueller et al., 2017a, 2017b). This raises the question why is there still such a large health impact? The impacts of suboptimal or lack of urban and transport planning on health are preventable. Also, as much as cities may be the problem, they could also be the solution. Well planned and managed cities could provide an excellent and efficient habitat for the large human population and could not only be sustainable and liveable, but also healthy.

Here we describe the latest quantitative evidence of how cities can become healthier through better urban and transport planning. It focuses on important interventions, policies and actions that can improve public health, including the need for land use changes, reduce car dependency and move towards public and active transportation, greening of cities, visioning, citizen involvement, collaboration, leadership and investment and systemic approaches. Health impact assessment studies have recently provided new powerful quantitative evidence on how to make cities healthier and will be used as examples. At the same time these measures make also our cities more climate resilient, sustainable and liveable and thereby creating multiple benefits.

2. Methods

The paper is not a systematic, but a narrative meta-review around a number of cutting edge and visionary studies on urban and transport planning and health reported in the literature over the past few years. It will focus on important areas of change that can improve public health through urban and transport planning, including the need for land use changes, reduce car dependency and move towards public and active transportation, greening of cities, visioning, citizen involvement, collaboration, leadership and investment and systematic approaches. The areas were chosen because of recent published evidence (Nieuwenhuijsen, 2016, Nieuwenhuijsen, 2018) and a number of presentations, projects meetings, and (participatory) workshops where these themes came up.

3. Results

3.1. Land use changes

Land use often is described in terms of the five Ds: density, diversity, design, destination accessibility, and distance to transit (Ewing and Cervero, 2010). Higher population and development density lead often to shorter travel distances because destinations become closer to origins. Shorter distances are easier and more convenient to walk or cycle and reduce car use (Grasser et al., 2013, Wang et al., 2016). Destination accessibility is a measure of how accessible places are, whereas distance to transit expresses the shortest distance to a bus stop or railway station. Both encourage the use of public and active transportation when the destination accessibility is higher and the distance to public transport shorter (Wang et al., 2016). Design describes the overall infrastructure and connectivity, and a good design encourages public and active transportation and discourages the use of cars. Diversity is a measure of the land use mix, which is characterised by a mix homes, shops, schools, and work places in an area; greater diversity encourages walking and cycling (Grasser et al., 2013, Wang et al., 2016).

Greater density, diversity, and destination accessibility, better design, and shorter distance to public transport are characteristics of so-called compact cities, an example of which is Barcelona, Spain, where the density, diversity, and destination accessibility are high and distance to public transport is short. Conversely, a city like Atlanta, GA, USA, is a sprawling city, where the opposite is true. Compact cities have great (potential) benefits in terms of increased (potential for) walking, cycling and public transport use, reduced residential energy

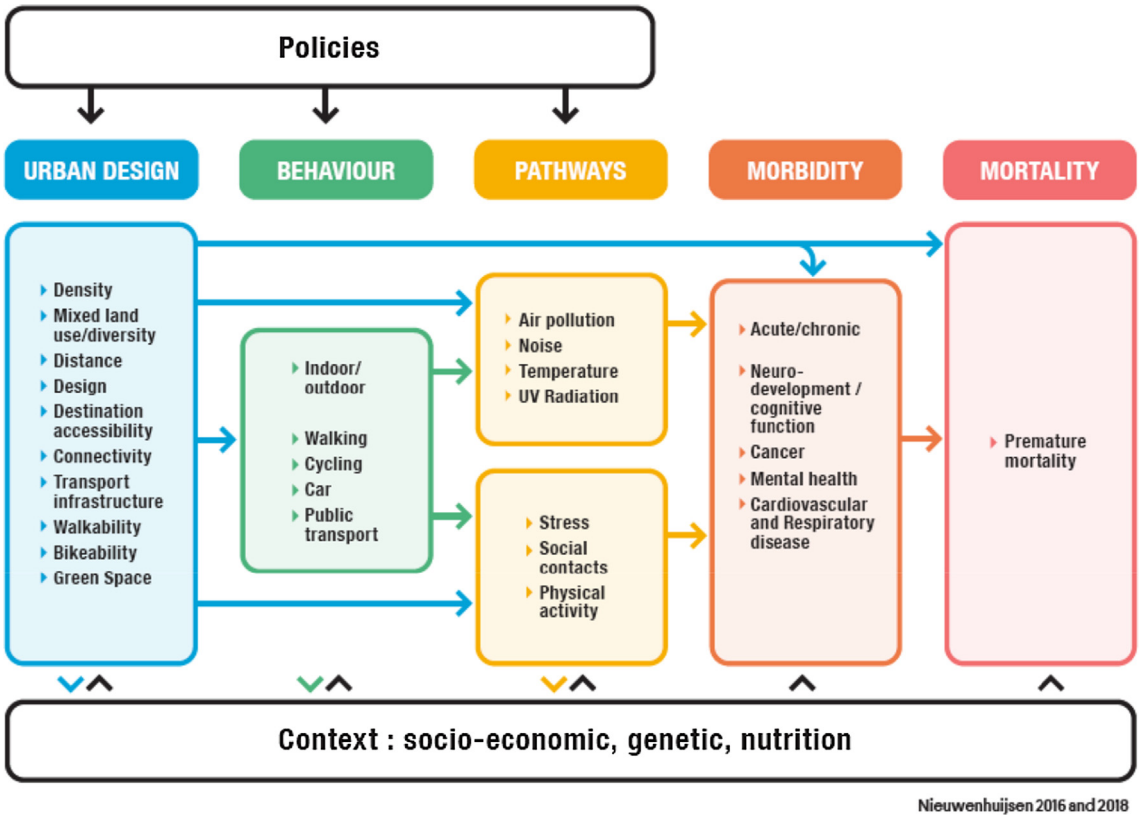

Fig. 1. The relationship between urban and transport planning, environment and health.

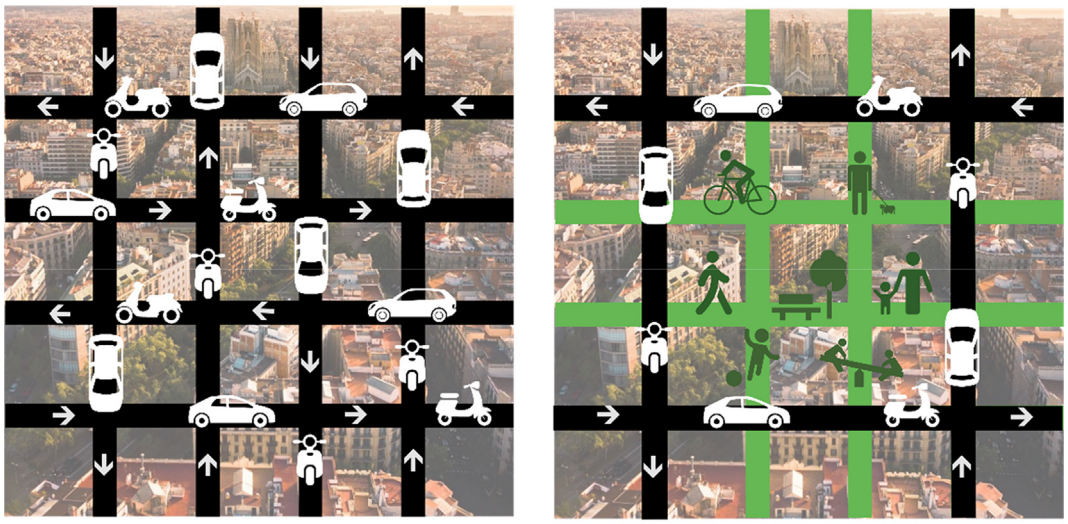

Fig. 2. Traffic flows before and after the Superblock implementation in Barcelona.

consumption, reduced pedestrian and vehicle fatalities, increased physical activity and reduced obesity, reduced household transportation cost, increased traffic safety, increased sense of community, and increased social interaction and capital (Ewing and Cervero, 2017; Malambo et al., 2016).

Stevenson et al. (2016), estimated the population health impacts arising from alternative land-use and transport policy initiatives in six quite different cities (Boston, Copenhagen, Delhi, London, Melbourne, São Paulo). Land-use changes were modelled to reflect a more compact city in which land-use density and diversity were increased and distances to public transport were reduced to produce low motorised mobility, namely a modal shift from private motor vehicles to walking, cycling, and public transport (around 30% change). The modelled compact city scenario resulted in health gains for all cities (for diabetes, cardiovascular disease, and respiratory disease) with overall health gains of 420–826 disability-adjusted life-years (DALYs) per 100,000 people. However, for moderate to highly motorised cities, such as Melbourne, London, and Boston, the compact city scenario predicted a small increase in road trauma for cyclists and pedestrians (health loss of between 34 and 41 DALYs per 100 000 population). The authors suggested that government policies need to actively pursue land-use elements—particularly a focus towards compact cities—that support a

Fig. 3. Benefits of cycling.

modal shift away from private motor vehicles towards walking, cycling, and low-emission public transport. At the same time, these policies need to ensure the provision of safe walking and cycling infrastructure.

But compactness may not be sufficient to for health as was recently shown in Barcelona, where the urban and transport related burden was estimated to be high, with up to 20% of premature mortality (Mueller et al., 2017a, 2017b). The actual design, use of space and traffic, air quality and green space management are also important. In Barcelona a new urban model is proposed, the so called Superblock (SuperIllas in Catalan) that aims to recover public space for people and thereby reduce car use, air pollution, noise and temperature levels and increase green space and physical activity (Rueda, 2018).

Mueller et al. (2019) conducted a health impact assessment (HIA) study for Barcelona residents ≥20 years (N = 1,301,827) on the projected Superblock area level (N = 503 Superblocks) (Fig. 2). They estimated health impacts for if the Superblocks were fully to be implemented with respect to expected changes in transport-related physical activity (PA), air pollution (NO_2), noise, green space, and reduction of the urban heat island (UHI) effect through heat reductions. They estimated that 681 premature deaths (95% CI: 245–1113) could be prevented annually with the implementation of the Superblocks. The greatest number of preventable deaths could be attributed to reductions in NO_2 (i.e. 291 deaths, 95% PI: 0–838), followed by noise (i.e. 163 deaths, 95% CI: 83–246), heat (i.e. 131 deaths, 95% CI: 114–153), green space development (i.e. 61 deaths, 95% CI: 0–123) and increased PA (36 deaths (95% CI: 26–50) annually. The Superblocks were estimated to prolong life for young adults by almost 300 days (95% CI: 133–400) and economic savings of 1.6 billion EUR (95% CI: 0.6–2.7) annually.

3.2. Reduce car dependency and move towards public and active transportation

Currently there are around 1 billion cars in the world and this number is likely to rise to 1.6 billion in 2040 (Bloomberg New Energy Finance (BNEF), 2017). An estimated 33% of cars in 2040 are expected to be electric (BNEF, 2017). Changes in technology have been proposed as solutions to our current problems in cities. For example, the electric car is often portrait as the solution to the current air pollution and climate change problems in our cities, but it provides only a partial solution. Electric cars reduce CO_2 emissions (depending on the source of the electricity used), tailpipe air pollutant emissions and engine noise, but there are still, for example, non-tailpipe particulate matter (PM) emissions from tear ware of brakes and tires, noise from tires, they take up the same amount of space as fossil fuel cars and they don't do anything to address physical activity (Requia et al., 2018).

Autonomous vehicles have also been suggested as a future solution and predictions suggest a quick and extensive market penetration (LexInnova, 2016), but it is currently unclear to what lifestyle and behavourial changes they may lead and how these impact on health, or whether a quick introduction is actually possible, particularly in complex city streets (Rojas-Rueda et al., 2020). Previous optimism about the speed of the introduction has been replaced with sober realism (English, 2020). However, they may reduce accidents, as 90% of accidents are due to human error. If they are shared, they could lead to a large reduction of vehicles on the road and being parked (if we would have the same transport patterns as now). However, people may choose to live further away from work, if e.g. they can work on their commute to work, which means that it may increase the total number of kilometers driving and urban sprawl. They may also pull people from active and public transport modes, if the cost of trips is low. On the other side, electric shared autonomous vehicles could be beneficial for public health, if the number and types of current vehicle trips would stay the same, but the number of vehicles reduced (Rojas-Rueda et al., 2020). However, there is some evidence that ride sharing may increase the number of vehicle kilometers driven, reducing the potentially beneficially effects (Hawkins, 2020).

A large number of car trips are less than 5 km (as high as 50%) and these could easily be replaced by other modes of transport such as cycling (Khreis et al., 2016). Cycling has many advantages as it reduces e.g. premature mortality, it combines transport with the gym (many people don't have time to go to the gym), it does not cause air and noise pollution, it emits zero CO2 (although some through the manufacturing and what the rider eats), it uses much less space than the car and cyclists tend to be happier than other transport users (Mueller et al., 2015, Gotchi et al., 2016, ISGlobal 2019) (Fig. 3). Countless studies have also

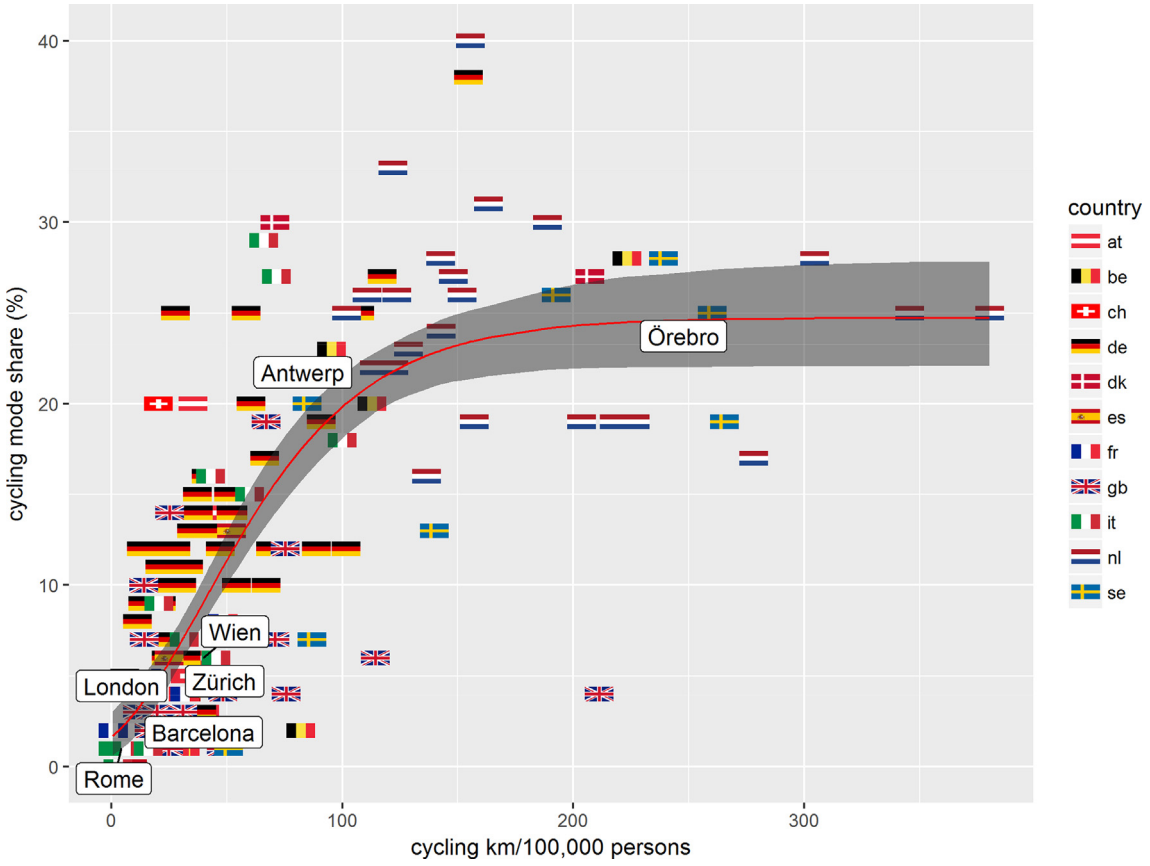

Fig. 4. The relationship between the availability of segregated cycling paths and the mode share of cycling in European cities.

shown that health benefits of physical activity well outweigh the risk of fatal accidents and of increased inhalation of air pollution due to increased physical activity (Mueller et al., 2015). Also, cost benefit analyses show that costs of cycling are general much lower than car use; for example, the cost of car driving is more than six times higher (Euro 0.50/km) than cycling (Euro 0.08/km) in Copenhagen (Gössling and Choi, 2015). New technologies such as bike sharing systems have greatly increased the number of cycling trips and health in cities, where they were introduced (Otero et al., 2018), and electric bikes allow for older people to cycle more and for people to make longer distance cycling rides and rides uphill, which otherwise would not have been possible (Bourne et al., 2018).

An important prerequisite for cycling though is e.g. the availability of safe cycling infrastructure including segregated cycling lanes. A recent large cross sectional European study in 168 European cities (75 million people) found that there was an almost linear relationship between the availability of segregated cycling infrastructure and the percentage cycling as total number trips made, up to 25% of transport mode share (Mueller et al., 2018a) (Fig. 4). This supports previous work on the relationship between cycling infrastructure and cycling (Kärmeniemi et al., 2018), but should be interpreted with caution as it is cross sectional. Over 25% of transport mode share there was no relationship anymore and other factors may become more important. They also estimated that just over 10,000 premature deaths could be prevented in these 168 cities, if they all had a 25% transport mode share of cycling.

Other studies have evaluated specific transport policy measures in cities (Mueller et al., 2015). For example, Woodcock et al (2009) estimated the health effects of alternative urban land transport scenarios for two settings London, UK, and Delhi, India and found that a combination of active travel and lower-emission motor vehicles would give the largest benefits (7439 DALYs in London, 12 995 in Delhi) and a reduction in CO_2 emissions.

Although less new technology is being introduced besides the ticketing, public transport also provides many environmental, climate change and health benefits and could cover longer journeys that cannot be covered by cycling (Kwan and Hashim, 2016). Therefore, a general shift away from car use towards active and public transportation can have significant environmental, climate change, health and economic benefits (Creutzig et al. 2012, Rojas-Rueda et al., 2012, Rojas-Rueda et al., 2013, He and Qiu, 2016).

3.3. Greening of cities

The health and ecosystem services benefits of green space are well known (Salmond et al., 2016, Nieuwenhuijsen et al., 2017a). Greening cities has many health benefits including longer life expectancy (Gascon et al., 2016; Rojas-Rueda et al., 2019), fewer mental health problems (Gascon et al., 2015), better cognitive functioning (Dadvand et al., 2015, de Keijzer et al., 2016), better mood and healthier babies (Nieuwenhuijsen et al., 2017a). The exactly amount, frequency and duration of green space needed to obtain health benefits is still not clear, but what is clear is that more green space provides more health benefits (Nieuwenhuijsen et al., 2017a). Furthermore, it mitigates air pollution, heat and noise levels, which have all health benefits (Salmond et al., 2016, Nieuwenhuijsen et al., 2017a). However, it is important to note that there may be also some risks to health such as increased risks for allergies due to pollen, some infectious disease (e.g. Lyme disease), falling trees and trees trapping or emitting air pollutants (Nieuwenhuijsen et al., 2017a).

(re)Forestation has great potential to combat rising CO_2 levels (Bastin et al., 2019). The contribution of trees in carbon sequestration and offsetting carbon emissions in cities is more limited and varies substantially by e.g. city and type of vegetation, but makes a

contribution (Chen, 2015, Velasco et al., 2016). Also the costs and benefits of trees in cities vary greatly (Ping Song et al., 2018). The benefits most frequently studied are those related to environmental regulation and property values, and the available data show that these usually outweigh the costs. Aesthetic, amenity, and shading benefits have also been shown to provide significant economic benefits, while benefits in terms of water regulation, carbon reduction and air quality are usually more modest. Variation in benefits and costs among studies is attributed largely to differences in the species composition and age structure of urban tree populations (Ping Song et al., 2018).

Replacing car infrastructure such as roads and parking with green infrastructure can be one way forward to change an environment from detrimental to beneficial to health (Nieuwenhuijsen et al., 2017a). So called nature based solutions (NBS) have shown great benefits to public health (van den Bosch and Ode, 2017) and there is no time to loose and we should green cities now (van den Bosch and Nieuwenhuijsen, 2017). A recent study estimated that more than 400 premature deaths overall, including more than 200 deaths in lower SES areas, could be prevented annually in Philadelphia, if the city is able to meet its goal of increasing tree canopy from its current 20% to up to 30% (Kondo et al., 2020). This predicted number translates to billions of dollars in averted costs. There are already some good examples in a number of cities where road infrastructure has been replaced by green and blue space e.g. in Seoul, South Korea, where a major road in the city was replaced by green space and water, improving sustainability, livability and health in the city (Gizmodo, 2016).

So if there is fairly good evidence that changes in land use, a move from cars to active and public transportation and greening of cities can not only improve public health, but also address climate concerns, sustainability and liveability, why is this not happening? Economic arguments are likely to be a significant factor, but there may be others too such as lack of healthy city vision, citizen involvement and leadership.

3.4. Visioning

What may be lacking in many cities is perhaps a vision of what is a sustainable, liveable and healthy city, and how to put this vision into standard operating procedures. There is no cook book out there on what are the ingredients of such a city and how to prepare it. What are the specific elements of such a city? The Sustainable Development goals also include health (goal 3) and sustainable cities communities (goal 11) (United Nations, 2015). Furthermore the New Urban Agenda includes commitments that address urban and transport planning such as to promote safe, inclusive, accessible green and quality public spaces (commitment 37), clean environment taking into account air quality guidelines (commitment 35), promote access to affordable, accessible and sustainable mobility with sustainable infrastructure for public transport, walking and cycling and prioritizing them over private motorized transportations /commitment 114) (UN Habitat, 2016). WHO reports such as Health as the pulse of the New Urban Agenda expand on the New Urban Agenda and provide some more concrete examples (WHO, 2016). However, these proposed measures together may make a city healthier, but they still lack a more coherent and holistic vision.

But visions are being developed. The Visions 2030 Walking and Cycling project, (Visions 2030 http://www.visions2030.org.uk/) considered alternative scenarios for the UK for the year 2030 in which walking and cycling play a central role in urban transportation. Woodcock et al. (2013) quantified scenarios for urban areas (population greater than 10,000) in England and Wales outside London based on Visions 2030 and modelled their impact on population health and greenhouse gas emissions. Three scenarios with increased walking and cycling and lower car use were generated based upon the Visions 2030 Walking and Cycling project. The study found considerable reductions in disease burden under all three scenarios (3500–8500 DALYs per million people), with the largest health benefits attributed to reductions in ischemic heart disease. The pathways that produced the largest benefits were, in order, physical activity, road traffic injuries, and air pollution. CO_2 emissions from passenger transport by people who live in urban areas fell by 16 megatonnes Mt) (26%), to 50 Mt (83%) (Vision 3)

A number of cities have a vision to become car free e.g. Hamburg envisages to be car free by 2034 (Nieuwenhuijsen and Khreis, 2016). The main driver is climate action, but it may have also many health benefits. Car free cities can have a considerable benefit on health through potential reduction in air pollution, noise, and heat island effects and increase in physical activity and green space and thereby improving health (Nieuwenhuijsen and Khreis, 2016). The move towards public and active transportation in this is crucial, as physical activity is one of the main drivers for health and lack of time has been repeatedly listed as a reason for the lack of physical activity. Urban and transport planning practices such as making cities denser, providing mixed land-use (e.g. home, work, shops), street furniture, safe urban environments and pedestrian and cyclist-friendly amenities could promote positive physical activity patterns and build them into daily routines. An example of a car free neighbourhood is Vauban in Freiburg (Nieuwenhuijsen and Khreis, 2016). No cars are allowed in the neighbourhood and there is a good transport link to the centre of the city by tram (Vauban, 2020).

3.5. Citizens involvement

But there is also a need to involve more the citizens. As where in the past many larger developments were bottom down, nowadays there is a large need to involve the community and citizens in any urban and transport planning development (Nieuwenhuijsen et al., 2017, Verlinghieri, 2018). An interesting and novel approach has been taken by the Ringland project in Antwerp, Belgium (Ringland, 2020). The Ringland project is a 6 billion euro investment, which proposes a large-scale sustainable urban development focusing on a complete redesign of the highway system in the city of Antwerp. The research underlying this complex infrastructure project has been entirely organized by local citizens in bottom-up fashion. Detailed research studies, executed by external academics, were financed through crowdfunding and subsequently presented to the government. The Ringland project hence pioneers a new kind of societal interaction between citizens, scientists and policy makers (Ringland, 2020).

Currently a highway system (300,000 vehicles/day) runs through densely populated areas within Antwerp (~500,000 inhabitants), which has a major impact on pollution, living conditions and health (Ringland, 2020). Moreover, the city has an urgent need for additional green areas (e.g. to combat the heat island effect), as well as housing development opportunities, as the city expects a population increase of 70,000 inhabitants by 2050.

The Ringland project brought together the different stakeholders and, amongst other things, conducted citizen science air pollution monitoring project in the city with 2000 NO2 diffusion tubes distributed in the city (Ringland, 2020), it administered a health impact assessment showing the health benefits of the project (Van Brusselen et al., 2016) and it held public sessions to discuss the plans, implications and results of the work. Although not implemented yet, the work shows how citizen action can initiative action and make a city more sustainable, liveable and healthy.

3.6. Collaboration, leadership and investment

There is a large need for collaboration to improve current cities. It is important to tackle air pollution, noise, heat islands, and lack of green space and physical activity at the same time as they have common sources and determinants (Nieuwenhuijsen, 2016). This requires collaboration between urban and transport planners, architects, the education section and health professionals, to name a few. It is important

that we have a more holistic approach to our cities, addressing, health, livability, sustainability, climate change and equity simultaneously. Good leadership and the right investment is essential and mayors and their teams need to take the lead and direct investments that benefit these different aspects in cities. Unfortunately, too often we find a lack of leadership and focus and too many silos in cities. Also, there is no clear vision for a sustainable, liveable and healthy city, no joint policies which lead to fragmented efforts and too little collaboration between departments. Cities have taken the lead in sustainability and climate crisis and are more networked than ever. They have enhanced their capabilities by working together, sharing experiences and forging public–private partnerships across health, governance, democracy, infrastructure and security. Formal networks include C40 Cities Climate Leadership Group, the Rockefeller Foundation's 100 Resilient Cities, United Cities and Local Governments (UCLG), ICLEI Local Governments for Sustainability and the World Health Organization's (WHO) Healthy Cities (Acuto, 2016). But there is still an increasing need to become more organised and share best practices to address the big challenges we have in the world, and particularly in cities.

3.7. Systemic approaches

Cities are complex systems and to address the challenges in cities we need system approaches taking into many different factors (Bai et al., 2016, Nieuwenhuijsen, 2016). For example, when Bogotá, Colombia introduced advanced bus rapid transit system (BRT), bicycle paths and pedestrian zones in the late 1990s. These changes provided a lot of benefits including greenhouse gas reductions and reduced commuting times and traffic fatalities to decreases in crime, higher land values, and a perception of greater social justice (Bai et al., 2016). Urban planning influences the amount of green space in a city, and thereby altering urban heat island effects and consequently energy demands from buildings. Measures that tend to mitigate climate change in cities also tend to reduce air pollution levels and both improve liveability and health (Gao et al., 2018, Khreis and Sudmant, 2018). These are only a few examples, but the list is endless, but is requires an effort to install this type of thinking and action that ticks many boxes, but also take into account feedback loops.

4. Discussion

Here we described a number of pathways to improve public health in our cities, including land use changes, reduction of car dependency and move towards public and active transportation, greening of cities, and the need for visioning, citizen involvement, collaboration, leadership and investment and system approaches (Table 1). Besides public health, these pathways also address the climate crisis, and sustainability and liveable of cities creating multiple benefits. The literature is growing rapidly on the quantification of the potential climate, environmental and health impacts of the potential pathways and provide better evidence what some of the benefits could be, and the extent. This will strengthen the hand of policy and decision makers that want to introduce policies to make our cities more sustainable, liveable and healthier.

We have provided here a number of pathways, but did not go into detail into the exact measures that should be implemented to support these pathways as it is beyond the scope of this paper. There is a substantial urban and transport literature out there on what kind of indicators to include in the planning process (Mueller et al., 2020) and how to implement e.g. specific transport measures and what the likely effects will be on health. For example, Khreis et al., 2017 qualitatively reviewed 64 different transport policy measures indexed in the Knowledgebase on Sustainable Urban Land use and Transport (KonSULT), and provided an indication of their potential health impacts, based on expert judgment. via pathways of motor vehicle crashes, traffic-related air pollution, noise, heat islands, lack of green space, physical inactivity, climate change and social exclusion and community severance. Further reviews provide the effect of e.g. vehicle technologies, emission reduction, and low emission zones on health (Glazener and Khreis, 2019). An aspect addressed less above, but what has been successful, is the use of legal instruments to make changes. For example to reduce air pollution in European cities, the introduction of euro emission standards was critical (Kuklinska et al., 2015, Glazener and Khreis, 2019).

Table 1
Requisites for carbon neutral, liveable and healthy cities.

Land use changes
Reduce car dependency and move towards public and active transportation
Greening of cities
Visioning
Citizen involvement
Collaboration, leadership and investment
Systemic approaches

The energy transition from a fossil fuel to a renewable energy based economy is without doubt one of the main drivers of the reduction of CO_2 emissions and air pollution from traffic, residential cooking and heating, industry and other sources, but may not deal sufficiently with other problems such as the lack of physical activity and green space and noise that have a large health impact. Therefore, we will need to go beyond the energy transition and look wider and use systemic approaches to tackle the other challenges in cities like liveability and lack of physical activity and green space, mental health and obesity. Only a systemic and multi-disciplinary approach will bring solutions that tackle a number of challenges at the same time, and should be included in policy development. Multiple indicators should be included and cross boundaries created by existing silos, where policy and decision makers only focus on their own territory.

And fortunately there are many measures that tend to mitigate climate change in cities also tend to reduce air pollution levels and both improve liveability (i.e. quality of life) and health (Gao et al., 2018, Khreis and Sudmant, 2018). Sustainability, liveability and health often go hand in hand in cities, but not always (Khomenko et al., 2020). For example, the reduction or elimination of cars in streets is not only a good climate mitigation action, but also makes streets more liveable and healthy. Also the greening of streets does not only address climate crisis issues, but also liveable and health. However, what we see though is that many cities now have indicators and targets for greenhouse emissions (including being carbon neutral in a given year), but these targets are often lacking for liveability and health. It is essential though to introduce them and monitor the progress towards them, and include for any policy, indicators and targets for all three areas.

A large part of the evidence in the paper is based on health impact assessment (HIA). HIA is an important tool to integrate evidence in the decision-making process, and introduce health in all policies (Ramirez-Rubio et al., 2019). In urban and transport planning, HIAs have been used generally to assess qualitatively urban interventions rather than offering more useful/powerful estimations to stakeholders through quantitative approaches (Nieuwenhuijsen et al., 2017b). HIAs could answer various pressing questions such as: what are the best and most feasible urban and transport planning policy measures to improve public health in cities? However, HIAs have also their limitations as their outcomes are only estimations and built on many assumptions. The data going into HIAs is getting better and more is becoming available, which means we can make better predictions. But we need more and better input data. We need more evidence on what are the actual effects on sustainability, liveability and health of actual interventions taking place in cities. In many cities large transformations are taking places e.g. trying to green them or trying to increase active transportation and we should evaluate these interventions in detail to obtain better evidence that we can use in our HIAs (Scheepers et al., 2014).

Cities are an important driving force to implement the Sustainable Development Goals (SDGs) and the New Urban Agenda (UN Habitat, 2016, UNSDSN, 2020, Ramirez-Rubio et al., 2019). The SDGs provide an operational framework to consider urbanization globally, while providing local mechanisms for action and careful attention to closing the gaps in the distribution of health gains. While health and well-being are explicitly addressed in SDG 3, health is also present as a pre-condition of SDG 11, that aims at inclusive, safe, resilient and sustainable cities. Health in All Policies (HiAP) is an approach to public policy across sectors that systematically takes into account the health implications of decisions, seeks synergies, and avoids harmful health impacts in order to improve population health and health equity. HiAP is key for local decision-making processes in the context of urban policies to promote public health interventions aimed at achieving SDG targets (Ramirez-Rubio et al., 2019) and should be integrated in city policy and decision making.

Finally, in this review we paid little attention to equity, partly because of space constraints. However, that makes the issue not less important, but it probably needs to have a whole paper by itself to address this properly. We know that environmental exposures and lifestyle factors, and thereby health, are often not equally distributed through cities. We see gradients of life expectancy in cities, and part of them can be explained by these different factors. Recent HIA studies showed that there is an equal distribution of exposures and health impacts by socio-economic and ethnic groups and geographical areas (Mueller et al., 2018b, Khomenko et al., 2020). Certainly this warrants further research and action to reduce the difference.

4.1. Future research needs

As described above, in the research community we have a fairly good idea in which direction we need to go to make cities more sustainable, liveable and healthy, but the part that needs more attention is the implementation, as this is far from straight forward. Of course, research on potential other measures to make cities more sustainable, liveable and healthy should not stop and will need to continue, as more innovations may be forthcoming. The need for research on implementation is strong though and requires multidisciplinary research bringing together researchers from all kind of backgrounds. And fortunately many cities are trying to make changes, which could be used for this, but unfortunately cities often do not include an evaluation component. It is beyond the scope of this paper to go into detail, but we know that actual change is hard to achieve, but that evaluating change can provide novel insights into what may or may not work. Often it starts with changing peoplés perceptions, believes and attitudes which is difficult and requires social science involvement and methodology. And many of the proposed measures require physical infrastructure changes, but the research on this is still limited and well conducted intervention studies are needed to assess the effectiveness and efficiency of such measures. One of the difficulties with intervention studies is that often not one or two things are changing, but many, as change comes as policy packages. Disentangling the effects of specific measures becomes almost impossible, and requires creative and novel methodology.

Finally, health impact assessment is an important tool, but also needs further research, particularly regarding participatory and systems approaches and dynamic modelling, including feedback loops (Nieuwenhuijsen et al., 2017b). Also, more HIA and burden of disease studies are needed where different cities are compared with each other (so that cities could learn from what others have done). There is especially need for such studies in low and middle income countries, where variations in sustainability tend to be larger than e.g. in Europe & N-America (Thondoo et al., 2019). Furthermore, HIAs tend to be technical tools that seldom engage with, or even acknowledge the existence of, values. Often we pretend our assessments are value-free, and the numbers that spill out of the models are self-evidently the best way to proceed. But of course all modelling and assessment is value driven. And decisions about how public money should be spent inevitably depend on trade-offs, where the “correct” decision depends on valuing various outcomes, and these are also aspects that warrant further research.

Declaration of Competing Interest

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

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https://www.youtube.com/watch?v=e6ZeeCyXC0k&t=51s.
https://www.youtube.com/watch?v=KKdJ8KlvkNA&t=235s.
https://www.youtube.com/watch?v=jm3Dnh19164&list=PLVpfzFDc4BUCRQSh9Gv5hJlRYJPdKO9dF&index=16&t=0s.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.envint.2020.105661.

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Further reading

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