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Review article

New urban models for more sustainable, liveable and healthier cities post covid19; reducing air pollution, noise and heat island effects and increasing green space and physical activity

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ABSTRACT

Cities are centres of innovation and wealth creation, but also hotspots of air pollution and noise, heat island effects and lack of green space, which are all detrimental to human health. They are also hotspots of COVID19. COVID19 has led to a rethink of urban public space. Therefore, is it time to re-think our urban models and reduce the health burden?

We provide a narrative meta-review around a number of cutting edge and visionary urban models that that may affect health and that have been reported over the past few years.

New urban concepts such as the Superblocks, the low traffic neighbourhood, 15 Minute city, Car free city or a mixture of these that may go some way in reducing the health burden related to current urban and transport practices. They will reduce air pollution and noise, heat island effects and increase green space and physical activity levels. What is still lacking though is a thorough evaluation of the effectiveness and acceptability of the schemes and the impacts on not only health, but also liveability and sustainability, although they are expected to be positive.

Finally, the COVID19 pandemic may accelerate these developments and stimulus funding like the EU Next Generation funding should be used to make these changes.

1. Introduction

Cities are centres of innovation and wealth creation, but also hotspots of air pollution and noise, heat island effects and lack of green space, which are all detrimental to human health (Nieuwenhuijsen, 2020a). They are also hotspots of COVID19 now. Cities are complex systems and are attractive because of the jobs, social ecosystem, events and unlimited opportunities they offer. They have also close personal contacts and there are large inequalities, which have become more visible with the COVID19 pandemic (Nieuwenhuijsen, 2020b).

The noticeable visible impacts of the COVID19 pandemic are, for example, the lack of tourists, shop closures, and underused public transport in cities (Nieuwenhuijsen, 2020b). The high incidence of COVID19 and prevention measures such as hygiene (e.g. mask use) and social distancing have made us re-think how we use public space, our mode of transport and where we work (i.e. more teleworking).

During the COVD19 pandemic cities have started to push out cars, increase space for active transportation and increased their cycling lanes and rates (Weis, 2020; Vandy, 2020; POLIS, 2021; Bereitschaft and Scheller, 2020). Many of these initiatives started before the COVID19 pandemic, but have been accelerated during the pandemic. Air pollution and noise levels dropped considerably during the lockdowns (Venter et al., 2020; Asencio et al., 2020; Sharifi and Khavarian-Garmsir, 2020). And, around 90% of car drivers did not miss their commute at all or some aspects, while around 90% of cyclists missed commuting a lot or some aspects of it (Rubin et al., 2020).

Cities such as Vienna, Boston, Oakland, Philadelphia and Minneapolis have closed roads to give more space to pedestrians and cyclists

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(Laker, 2020; Bereitschaft and Scheller, 2020). These temporary road closures and other short-term measures are serving as testing grounds for changes that may eventually become permanent (Bliss, 2020). Recent evaluations showed a significant increase in cycling during the COVID19 pandemic in European cities, partly as a result of increased cycling infrastructure (Kraus and Koch, 2021; Buehler and Pucher, 2021)

It is unclear if the impacts of COVID-19 on public space will be as profound as they are in other aspects of our life. In the realm of public space and design, a key question concerns how long these impacts will be felt, and the degree to which they will be transformational (Honey-Rosés et al., 2020). It may take years before we are able to ascertain how the global pandemic has changed the planning and design of public space. Will the COVID19 pandemic define a before and after in planning and design?

Suboptimal urban and transport planning has always been one of the great challenges of cities is, with streets in many cities dominated by cars. For example, a city like Barcelona has some of the highest traffic density and air pollution and noise levels in Europe, which are responsible for an estimated 3000 premature deaths per year (Mueller et al., 2017). Sixty percent of public space (i.e. roads and parking) is used by cars, while only 1 out of 4 trips is by car.

Urban planning and design emerged as a practice with health and wellbeing considerations at the core of their work in late 19th and early 20th centuries, partly because of the poor living conditions that existed at that time in many cities. Cities like Barcelona, Paris, and London benefitted greatly from this in terms of health. Unfortunately, the link seems to have broken in more recent times, possibly because of the development of silos within city councils and economic interests. Is it time to re-establish this link and make health as guiding principle for the way we plan, design, build, run and maintain our cities?

And therefore, is it time to re-think our urban planning and our urban models? In the 20th Century cities appeared to be designed for cars (Khreis et al., 2016), but in the 21st Century, should we design or retrofit cities for people? Should we aim for cities that are smart, sustainable, liveable, equitable and healthy, apply nature based solutions, have a circular economy and promote active mobility and green space? The COVID19 pandemic could be a real turning and accelerate new urban planning developments, particular if they access the financial stimulus packages provided by, for example, the Europe Commission in the EU and the Biden Administration in the USA. Here we describe some urban models that cities could be aiming for, and the likely environmental and health impacts.

2. Methods

The paper is not a systematic, but a narrative meta-review around a number of cutting edge and visionary urban models that that may affect health and that have been reported over the past few years, and particularly in relation to COVID19 over the last year. The focus is on urban developments that are likely to improve the health of citizens. The paper results from a series of webinars given by the author and feedback received from participants. It focuses on urban models that recently received a lot of attention in the media and/or scientific literature. The focus is on Europe, but the relevance for other parts of the world is discussed.

3. Results

3.1. Historical perspective and previous models

Cities have existed now for thousands of years with Jericho as the he world's oldest continually-inhabited city. Archaeologists have unearthed the remains of 20 successive settlements in Jericho, dating back 11,000 years. Plovdic, Bulgaria is often regarded as the oldest European city. Initially cities tended to be small, compact and walkability. With large population shifts from the countryside to the city, the cites often became overcrowded with poor living conditions. In the 19th century, the Garden movement gained popularity. The garden city movement is a method of urban planning in which self-contained communities are surrounded by "greenbelts", containing proportionate areas of residences, industry, and agriculture. The idea was initiated in 1898 by Ebenezer Howard in the United Kingdom and aimed to capture the primary benefits of a countryside environment and a city environment while avoiding the disadvantages presented by both (Garden cities, 2021). The formation and design of cities that evolved during the 20th century has been heavily influenced by the needs of motorised vehicles (eg, cars, lorries, motorcycles) and a number of different designs have been described. (Thompson et al., 2020). Both the Garden cities and "car cities" are characterised by low density and lead often to urban sprawl and large distances between destinations, but with often a relative large amount of green space (Brody, 2013).

More recently compacts cities are being promoted as they are considered more sustainable and healthier (Giles-Corti et al., 2016; Nieuwenhuijsen, 2020a). Compact cities are cities with higher density, shorter travel distances, and higher diversity (Stevenson et al., 2016; Wikipedia, 2020). Compared with low density sprawling cities, their CO_2 emissions are lower and they are healthier because of higher land use mix and the shorter and healthier mobility opportunities. Making cities 30% more compact and thereby increasing density and land use, reducing travel distances, increasing public and active transportation could avoid around 400–800 DALYs per 100,000 people with respect to diabetes, CVD, and respiratory disease annually, depending on the type of city (Stevenson et al., 2016) Sprawled cities like Boston and Melbourne, where the transport mode share of cars is 80.1% and 85.1% respectively could improve health considerably by changes in land use and transport mode.

However, compact cities are not without their problems if the existing (public) space is not used well. Many compact cites like Barcelona or Paris still suffer considerable adverse health impacts due to their high motorized traffic density, air pollution and noise levels and other exposures related to urban and transport planning (Mueller et al., 2017; Khomenko et al., 2021). Therefore, we need a better use of the new and existing public spaces.

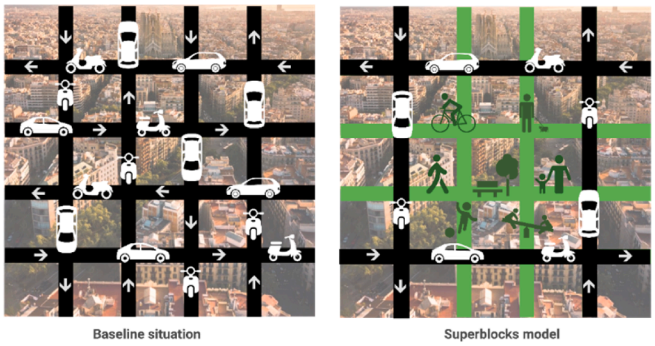
3.2. New urban models

A number of new urban concepts or models are being introduced in various cities that address the above described problems to some degree, such as the Superblocks, the low traffic neighbourhood, 15 Minute city, Car free city or a mixture of these (Fig. 1). What these models have in common is that they aim to reduce private car use and increase public and active transportation (walking and cycling), and thereby reduce air pollution, noise and heat island effects and increase physical activity and as a result promote and improve health. Cars take up a lot of public space (road) network and parking) that can be used in a better way, for example by creating green space and green infrastructure. In a city like Barcelona 60% of public space is used for cars, while they cars are only 25% of the transport mode. Also the shorter distance between homes and various destinations in the Compact or 15 Minute city will encourage walking and cycling and increase physical activity levels. The added benefits are that they reduce CO2 emissions and address the climate crisis and related health impacts.

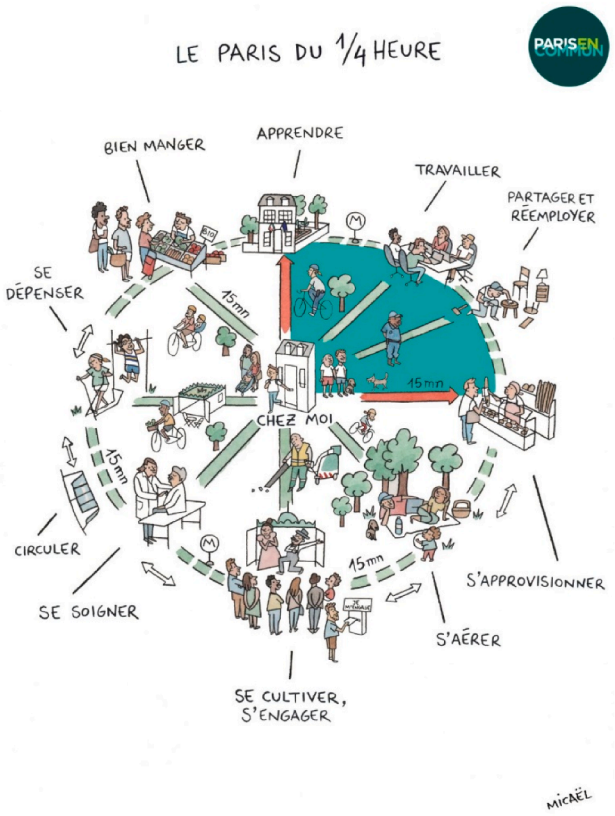
3.3. The Superblocks, Barcelona

Over 500 superblocks are planned in Barcelona, which reduce motorized traffic in some streets of a block and provide space for people, active travel, and green space. The goal is to create a healthy, greener, fairer and safer public space that promotes social relations and the local economy. They will reduce air pollution and noise levels, heat island effects and increase green space and physical activity and thereby could

a) low traffic neighbourhood, London



b) Superblock, Barcelona



c) 15-minute city, Paris

d) Car free Vauban, Freiburg, Germany

Fig. 1. New urban models to promote health; a) flower boxes to create a low traffic neighbourhood in London, b) a graphic description of a Superblock in Barcelona where various transport modes are allowed before and after the implementation c) a graphic description of the 15 min city in Paris with the possible destinations (in French) d) Green space and sustainable housing in Vaughban, the car free neighbourhood in Freiburg, Germany.

prevent nearly 700 premature deaths each year in Barcelona (Mueller et al., 2020). The largest number of deaths prevented come from a reduction in air pollution, followed by noise, heat island effects and then green space.

The Superblock model, the brainchild of urban planner Salvador Rueda, can be implemented fairly easily in urban areas with a grid system and sufficient population and facility densities. A Superblock is created by closing 4 junctions in a grid of nine (Fig. 1, Rueda, 2019) Particularly in warmer climates, the greening of the area can considerably reduce temperatures and thereby reduce premature mortality. Initially, implementation of a Superblock in the Poblenou neighbourhood of Barcelona was met with considerable resistance from the local population, and there were some concerns regarding gentrification and governance (López et al., 2020; Zografos et al., 2020) but later developments like the neighbourhoods of Sant Antoni and Horta are better received after improved consultation with the local population. A further expansion plan is currently under evaluation and 21 Superblocks, or Axis as they are now referred to now, are implemented (Ajuntament de Barcelona, 2021).

As part of the work, Barcelona City Council has conducted a detailed analysis of the city: citizen flows and mobility, neighbourhood facilities, green spaces, building and social fabric and so on. It is through this comprehensive approach that a road hierarchy has been created enabling some streets to be freed of road traffic and the creation of a network of green hubs and squares where pedestrians have priority.

This network is helping to create a new map of the city where citizens are the central players**.** This new vision will first and foremost be applied in the Cerdà section and, in particular, in the Eixample district, extending the network of green hubs and squares which have already started to be created in the Sant Antoni neighbourhood.

The twenty-one green axis that are being created in the Eixample, with a total of 33 km of street and 21 new squares, will provide a total of

3.9 ha of new public spaces. The Eixample will gain a total of 33.4 ha of new pedestrian areas and 6.6 ha of urban green areas.

3.4. Low traffic neighbourhoods, London

Similar principles are being applied in low traffic neighbourhoods (LLS, 2020; Aldred, 2020). They form part of a series of relatively cheap and quick streetscape changes, which are being encouraged and/or funded by government as emergency measures to provide safer walking and cycling environments (safer from Covid-19 and from traffic injury risk) and relatedly, to try and discourage growth in car use given that public transport is still operating with major capacity restrictions (Aldred, 2020). Low traffic neighbourhoods reduce traffic by using bollards, planters, and cameras to remove through traffic from neighbourhoods while retaining motor vehicle access to all homes. The carrot is safer, more pleasant walking and cycling (thanks to reduced motor traffic), with the stick being slightly less convenient car journeys. Such measures suit minor urban streets, where most people live (91% of people in London—a proportion similar across demographic and socioeconomic groups) (Laverty et al., 2021). Low traffic neighbourhoods can reduce car ownership, reduce street crime and injuries and also make residential streets safer for play, socialising, and exercise (Laverty et al., 2021; Aldred and Goodman, 2020). Finally, they appear to benefit the most deprived communities (Voce and Walker, 2021).

3.5. The 15-minute city, Paris

Paris is introducing the 15-minute city, the brain child of Carlos Moreno, where work, school, shops, entertainment, culture, leisure, and other activities are reachable within a 15-minute walk or bicycle ride of the home (Moreno, 2019; Sisson, 2020). The 15-minute city involves the creation of a city of villages and a return to more traditional city design. Ecology (green space), proximity, solidarity among citizens and participation of citizens are some of the key aspects (Moreno, 2020). It is will require a massive decentralization, a reduction of motorized traffic and increase in bike lanes, more local shops and green spaces and multiple use of public space (Moreno, 2020). The envisaged new trees and cycling lanes, community facilities and social housing, homes and workplaces all reflect a potentially transformative vision for urban planning.

The aim is to make the city more pleasant, agile, healthy and flexible. Moreno (2020) envisages an increase in services into the neighbourhoods, but it may also require a fairly radical re-think of our contemporary cities and a mixing of different population groups rather than the current distribution of housing by socioeconomic status. The 15-minute city will encourage more physical activity and is likely to reduce urban inequalities and health inequities. Critically, it will also reduce the need for long distance travel and thereby reduce CO_2 emissions, and air pollution and noise levels. Overall the 15-minute city will be more people rather than car focused, with each square meter accounted for and with multiple use leading to neighbourhoods where people live, work and thrive. The 15-minute city calls for a return to a more local and somewhat slower way of life, where the current longer commuting time is instead invested in richer relationships with what's nearby. The COVID19 pandemic has accelerated the development as Paris is trying to reduce car use.

No evaluations of the effects on health have taken place yet, but considerable health benefits are expected through the increase in physical activity because of the expected increase in walking and cycling and physical and mental health benefits because of the increase in green space. A reduction in motorized traffic is likely to lead to a reduction in air pollution, noise and CO2 emissions.

3.6. The car free city and car free neighbourhood, Hamburg and Freiburg

A car free city is a population centre that relies primarily on public transport, walking, or cycling for transport within the urban area (Nieuwenhuijsen and Khreis, 2016). Districts where motorized vehicles are prohibited are referred to as car free zones or neighbourhood. Car free city models have gained traction due to current issues with congestion and infrastructure, and proposed environmental and quality of life benefits. A car-free city is an aim of a peaceful and enjoyable city, without the domination of the car. Many cities have already a pedestrianised mainly car free centre or shopping district. But some cities plan to go further.

Hamburg plans to be car free by 2034, partly to address the climate crisis. Car free cities or neighbourhoods reduce unnecessary private motorized traffic and provide easy access to active and public transportation. A successful example is Vauban and to a lesser extent Rieselfeld in Freiburg, Germany, that are neighbourhoods without cars and with sustainable housing (Peters, 2019). Vauban was built two decades ago as a radical experiment in sustainability. It's possible to walk to grocery stores, cafes, restaurants, offices, and schools within the mostly middle-class neighborhood of about 5000 people, which is made up of dense housing in apartment buildings. For those who need to go to downtown Freiburg for work, it's a 15 or 20-minute ride on the bus or light rail to the central station. Or by bicycle. Pontevedra is a small car-free city in Spain. Cars are banned from Pontevedra's city center, creating a model for a pedestrian-friendly future (Burgen, 2018). In the car-free zone, CO2 emissions have been cut significantly and walkers are free to roam (Burgen, 2018). Utrecht recently unveiled its latest plans for a completely car-free neighbourhood, Merwede (Sawbridge, 2020). The Merwede neighbourhood will be home to 12,000 residents. Important destinations, including Utrecht Central Station, will be within walking or cycling distance.

Other cities like Oslo; Helsinki and Madrid (Madrid Central) have recently announced their plans to become (partly) car free. Many cities have introduced different policies that aim to reduce motorized traffic including implementing car free days. Some of the main challenges will be how to change existing infrastructure that was mainly designed for cars to infrastructure for active and public transport, and how to change peoplés perceptions, attitudes and behaviors (Nieuwenhuijsen et al., 2019).

The transition to car free cities may substantially improve the liveability of neighborhoods - especially in these neighbourhoods that bear disproportional burdens of pollution, social disadvantage, crashes, and public transport disinvestment. A transition from car-dominated urban landscapes and transport policies towards car free cities that are considering the mobility needs of all people to access key destinations, regardless of their access to private cars would, therefore, constitute an important step towards a more inclusive and just urban environment that is also more sustainable and healthier (Nieuwenhuijsen et al., 2019).

Car free cities or neighbourhoods will reduce air pollution and noise levels, increase physical activity, and create room for green space, and thereby reduce heat island effects and improve public health (Nieuwenhuijsen and Khreis, 2016).

4. Discussion

We have introduced a number of new urban models such as the Superblocks, the low traffic neighbourhood, 15 Minute city, and Car free city and neighbourhood that may go some way in reducing the health burden related to current urban and transport practices. They will reduce air pollution and noise, heat island effects and increase green space and physical activity levels. What is still lacking though is a thorough evaluation of the effectiveness and acceptability of the schemes and the impacts on not only health, but also liveability and sustainability, although they are expected to be positive.

4.1. Common principles

What these new models appear to have in common is the changing

focus from the car to people i.e. changing from a city for cars to a city for people. They inverse the transport planning pyramid where the priority for planning for cars is replaced by giving priority to public transportation and walking and cycling (Fig. 2). They give more public space and create more infrastructure for the transport modes that are desired such as increasing safe cycling infrastructure. Walking is a sustainable and healthy mode of transport for trips up to 3 km, while cycling for up to 7 km and more with electric bikes. Furthermore, they increase green space.

Walking should be a basic human right, but too often it is not so easy to walk out of the door to whatever destination because of a variety of reasons. Walking has many health benefits, including reducing premature mortality and cardiovascular disease and improving mental health (Kelly et al., 2014; Kelly et al., 2018; Oja et al., 2018). Important aspects of the built environment to encourage walking are for example walkability, residential density, street connectivity, access to/availability of destinations and services, infrastructure and streetscape, and safety (Barnett et al., 2017; Gascon et al., 2019; Nieuwenhuijsen, 2018). Many premature deaths could be prevented if short trips by motorized transport would be replaced by walking (Olabarria et al., 2013).

Increasing the cycling network and thereby increasing cycling rates is a way to reduce motorised traffic and CO2 emissions and increase active mobility and therefore increase physical activity and peoplés health (Mueller et al., 2018; Brand et al., 2021a). We know that cycling has many benefits, as it increases physical activity and reduces e.g. premature mortality, cardiovascular disease and cancer risk, 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 (ISGlobal, 2019). It provides people with the opportunity to build physical activity into their daily lives like daily commutes, as they have often not enough time to go to the gym.

People who walk or cycle have lower carbon footprints from daily travel (up to 84% compared to car users) (Brand et al., 2021a). Urban residents who switch from driving a car to cycling for just one trip per day can reduce their annual carbon footprint by about half a tonne of CO_2. If just one in five urban residents permanently changed their travel behaviour, it would cut emissions from all car travel in Europe by about 8% (Brand et al., 2021b).

A large number of car trips are less than 5 km (as high as 50%) and these could easily be replaced by other more sustainable and healthier

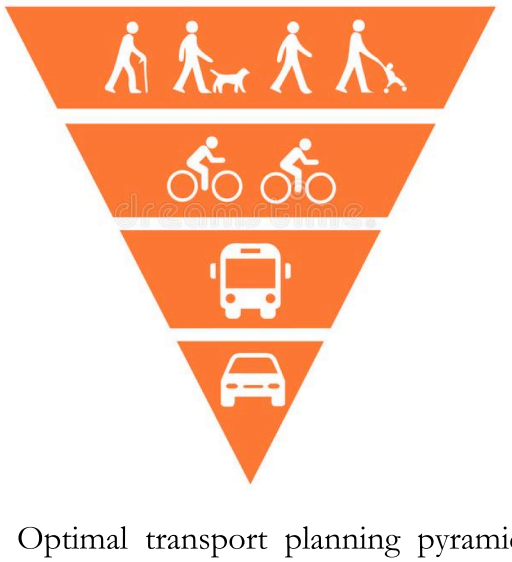


Fig. 2. Optimal planning pyramid with pedestrians on top and cars at the bottom.

modes of transport such as walking and cycling. New technology helps. Electric bikes have become more popular over the past few years, as the prices have come down. Electric bikes allow people to cycle for longer distances and/or in hillier areas, and also older people to cycle as they require less effort. But they still provide physical activity (Castro et al., 2019). In the Netherland and Belgium electric bikes have become popular for long distance commuting with distances up to 30 km. 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).

Cities urgently need to create (more) safe cycling networks throughout the city, or free up some streets altogether for only cycling and walking. A recent German study using cycling counters in 106 European cities showed that the 20 cities that had considerably increased their cycling network (on average by 11.5 km) during the COVID19 pandemic saw also an increase in cycling by 11 to 40% compared to those that did not (Kraus and Koch, 2021). Putting a safe segregated cycling lane in each street could save 250 premature deaths annually in a city like Barcelona because of the increase in physical activity (Mueller et al., 2018). Numerous studies have shown that the benefits of physical activity well outweigh any risk from inhaling more air pollution or accidents. Great progress has been made to create and increase cycling lanes in cities, but they work only if they are safe and form part of a network.

There are some challenges though to cycling, for example with the introduction of e-micromobility that compete somewhat for the same public space, but normally have a higher speed. Many cities have moved through trial and error stages in their search for solutions and appropriate legislation. It seems prudent for urban planners to introduce policies such as regarding maximum speeds, mandatory use of bicycle infrastructure, and dedicated parking, as well as to limit the number of licensed operators (Gössling, 2020). Where negative public opinion can be averted, e-scooters stand a chance to become a disruptive niche innovation with the potential to transform urban transport systems.

Furthermore, during the pandemic many people have taken to work at home (i.e teleworking), which reduces the need for commuting and reduces air pollution and CO2 emissions from commuting (Casale, 2020) although may lead to an increase from residential sources. The question is if this trend persists, and to what extent we should encourage and incentivise teleworking, for at least a few days per week. Unfortunately, E-commerce (online buying) has been growing dramatically, and this may lead to local shops closing and dead shopping streets in the long term and increased traffic and pollution in the short term, because of all the (home) deliveries. It is therefore important to make local shopping more attractive. Pedestrianizing streets and/or reducing car traffic are good ways to increase retail sales (Lawlor 2014). It could support the local economy and disencourage e-commerce.

What else these new urban models share to some extent is improving access to green space, which is important for, for example, peoplés mental health, cognitive functioning and life expectancy (Gascon et al., 2015; Kondo et al., 2020). The availability of green space varies quite considerably between cities and is also not equally distributed within cities, with some people having easy access to green space, while others have not (Schüle et al., 2017; Pereira Barboza et al., 2021; Mushangwe et al., 2021). There is not only a need for new developments like parks, but also more green in streets (Salmond et al., 2016; Wolf et al., 2020) and green infrastructure (Nieuwenhuijsen, 2021). We need to dig up asphalt and plant more trees, which will reduce heat island effects and contributes to CO2 sequestration and health (Nieuwenhuijsen et al., 2017a) and show more health benefits than for example open grassland (Astell-Burt and Feng, 2019; Jiang et al., 2020). Greening cities can have many health benefits including longer life expectancy, fewer mental health problems, improved cognitive functioning, better mood and healthier babies (Nieuwenhuijsen et al., 2017a, 2017b). It also mitigates air pollution, heat and noise levels. It adds to CO2 sequestration and

therefore helps in our fight again the climate crisis. And green space can improve ecosystems and increase biodiversity in cities, particularly through well designed green infrastructure through the city (Coutts and Hahn, 2015; Nieuwenhuijsen, 2021).

Particularly in early childhood this may be important as a recent study showed that children who went to a school with more green spaces had considerably better cognitive functioning than those who went to a school with less green spaces (Dadvand et al., 2015), while another study found that early child hood exposure to green spaces leads to fewer mental health problems in adult life (Preuß et al., 2019). Multiple studies have found that green space reduces premature mortality (Rojas-Rueda et al., 2019), and increasing tree canopy from 20% to 30% in a city such as Philadelphia could prevent more than 400 premature deaths annually (Kondo et al., 2020). Particularly, poorer neighbourhoods would benefit.

Recently Cecil Konijnendijk, an urban forester, proposed the 3-30-300 rule for green space in cities, where he suggested that every citizen should be able to see at least three trees (of a decent size) from their home, there should be 30 percent tree canopy cover in every neighbourhood and one should not live more than 300 m away from the nearest park or green space (IUCN, 2020). For some aspects like the 30% rule there is already some more consistent evidence that it is beneficial, while for access and visibility the evidence is more mixed or has been less reported (Labib et al., 2020; Astell-Burt et al., 2021; Astell-Burt and Feng, 2020; Astell-Burt et al., 2020). The evidence for greenness as measured by NDVI within 300 m appears to be more consistent. So although this rule has not been evaluated sufficiently yet, it could act as a good and desirable target for city councils to provide a green environment for their citizens. Some studies have suggested that it is not (only) the presence, but the actual visits to nature that is important for better health and well-being and suggested at least 2 h per week of visits (White et al., 2019; Kruize et al., 2020). A good quality green space nearbye will provide this opportunity.

Although there are many similarities in the urban models, there are also some differences. Low traffic neighbourhoods are likely to be easier to implement and are often seen as more temporary compared to the others. Car free cities are more likely to receive resistance as they foresee a ban of cars altogether and many people are still very fond of or reliant on the car. The 15-minute city focuses to a large extent on bringing in more destinations or activities into the neighbourhood to reduce mobility, while this is less focus for the other models or they assume that they are already there. The increase in green space appears to be a more important aspect in the implementation of the Superblocks than for the other models, although there an increase in green space envisaged for the others too.

The new urban models discussed are from Europe and the question is to what extent they could be implemented in, for example, the hyper-dense cities of China, Singapore and Japan, and the ultra-low density cities typical of the US, Canada and Australia. Probably these models are best suited for the hyper dense cities where many destinations are nearby and where there is often already a good public transport system, and implementation could go ahead without much problems. As a matter of fact, many of these the cities have already neighbourhoods where the principles are applied. The models are less suited to low density cities, where there are few destinations nearby, public transport systems are poor and where there is a heavy reliance on the car to get around. Densification would be needed to make them more suitable. Exception may be business districts and city centres in these cities that may have already sufficient density for example like the Central Business District in Melbourne (Nieuwenhuijsen, 2019). Also when implementing these models, it is important to take into account local cultural and social norms, to avoid widening health and social inequalities.

Furthermore, it is important to consider weather conditions such as high temperatures in places like Africa, India and the middle East that may affect the ability for active transportation. In these cases it is particularly important to pay attention to the design and green space components of the new models that can provide shading and cooling for active transportation (Negev et al., 2020; Sun et al., 2021) in additional to appropriate and safe infrastructure. Cooler weather tends to be less of a problem as good clothing can provide sufficient protection against the cold but maintenance of the infrastructure is important e.g. clearing cycling lanes of snow.

Some of these changes take longer to implement, while we need to have faster action. New and easier to implement policies such as introducing 30 km/h speed limits on all roads in urban areas could have a significant impact on accidents and health (Grundy et al., 2009; Jones and Brunt, 2017). Further temporary tactical urbanism could help transform public urban space fairly quickly. Tactical urbanism refers to low-cost, temporary, and scalable interventions and policies intended to improve urban environments (Rojas-Rueda and Morales-Zamora, 2021). Although these tactical urbanism interventions are designed to be implemented in a temporary and low-cost approach, these interventions can be considered as pilot programs that could involve the community in selecting future permanent infrastructure.

4.2. *Systemic and holistic approaches, policies and investments*

Cities are complex systems and to address their challenges we need systemic and holistic approaches taking into many different factors and feedback loops, and address sustainability (i.e. climate crisis), livability, health and equity simultaneously. Too often we find silos by sector in cities, which stops the implementation of these approaches that address multiple challenges. We need approaches with involvement of multiple disciplines and stakeholders, including of course the citizens (Nieuwenhuijsen, 2018, 2020a).

The new urban models are a great opportunity to bring together different sectors and stakeholders and improve the link between urban planning and health again. Most of the models are initiated by urban planners at a great cost and it is essential to involve, for example, health researchers and practitioners in the process guiding the designs but also conducting evaluations of the effects and impacts on health to make sure that we will learn in the process and improve where necessary (Laverty et al., 2021; Aldred and Goodman, 2020; Mueller et al., 2020; Palència et al., 2020).

The new urban models won't address all the many complex challenges in the city and a more compressive strategies and policies are needed to address these with involvement of all the stakeholders. As is often seen, there is no magic bullet for the challenges and the new urban models are just one aspect of policies that address challenges, and of different policies and measures that are needed (Lin et al., 2021). Furthermore, issues of equity and gender should be addressed as there has been some concern about this when introducing new models like the Barcelona Superblocks (López et al., 2020; Zografos et al., 2020), and policy measures could be put in place to eliminate or mitigate the impacts (Oscilowicz et al., 2021). Spreading resources and changes throughout the city rather than focusing only on one or a few neighbourhoods may also avoid some unintended consequences.

The COP26 in Glasgow and the release of new air quality guidelines by the WHO in 2021 are putting new pressures on cities to act and reduce their climate impacts and air pollution levels. More than ever, it is time to act and to produce multiple benefits, including for health. But cities have great challenges for example to address outdated legislation e.g. zoning laws, which prevent mixed land use, which is essential for active mobility and good for health (Nieuwenhuijsen, 2018). Any new policy, action, or legislation, including for new urban developments should include planning indicators that improve health, which is often not the case (Mueller et al., 2021). Furthermore, any changes should be formally evaluated for effects on sustainability, liveability and health and health impact assessments should be used to assess, which are the healthiest planning scenarios (Nieuwenhuijsen et al., 2017b).

But there are great opportunities, and the COVID19 crisis may have a silver lining and could accelerate the changes that our cities need.

Recently the World Health Organisation published a manifesto for a healthy recovery from the COVID19, including building healthy and liveable cities (WHO, 2020). These ideas need support and investments. The COVID19 financial stimulus packages such as the Biden administration Infrastructure Plan and the EU Green Deal (EC, 2020a) and the Next generation funding (EC, 2020b) can contribute a great deal to improve urban and transport practices and provide an excellent opportunity to improve public health. The European Green deal is a comprehensive road map striving to make the EU more resource-efficient and sustainable, and a great opportunity to make cities carbon neutral, more liveable and healthier through better urban and transport planning and lower air pollution, noise and heat island effects and an increase in green space and physical activity (European Commission, 2020a).

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References

Ajuntament de Barcelona, 2021 https://ajuntament.barcelona.cat/superilles/es/ Entered March 19.

Aldred, R., 2020. http://rachelaldred.org/research/low-traffic-neighbourhoods-evidence/ (accessed June 2, 2021).

Aldred, R., Goodman, A., 2020. Low Traffic Neighbourhoods, Car Use, and Active Travel: Evidence from the People and Places Survey of Outer London Active Travel Interventions. Transport Findings. https://doi.org/10.32866/001c.17128.

Asencio, C., Pavon, I., Dde Arcas, G., 2020. Changes in noise levels in the city of Madrid during COVID-19 lockdown in 2020. J. Acoust. Soc. Am. 148 (3), 1748–1755.

Astell-Burt, T., Feng, X., 2019. Association of urban green space with mental health and general health among adults in Australia. JAMANetwork Open 2 (7), e198209.

Astell-Burt, T., Hartig, T., Eckermann, S., Nieuwenhuijsen, M., McMunn, A., Frumkin, H., Feng, X., 2021. More green, less lonely? A longitudinal cohort study. Int. J. Epidemiol. https://doi.org/10.1093/ije/dyab089.

Astell-Burt, T., Feng, X., 2020. Urban green space, tree canopy and prevention of cardiometabolic diseases: a multilevel longitudinal study of 46 786 Australians. Int. J. Epidemiol. 49 (3), 926–933.

Astell-Burt, Thomas, Navakatikyan, Michael A., Feng, Xiaoqi, 2020. Urban green space, tree canopy and 11-year risk of dementia in a cohort of 109,688 Australians. Environ. Int. 145, 106102. https://doi.org/10.1016/j.envint.2020.106102.

Barnett, D.W., Barnett, A., Nathan, A., Van Cauwenberg, J., Cerin, E., 2017. Built environmental correlates of older adults' total physical activity and walking: a systematic review and meta-analysis. Int. J. Behav. Nutr. Phys. Activity 14 (1), 1–24.

Bereitschaft, B., Scheller, D., 2020. How might the COVID-19 pandemic affect 21st century urban design, planning, and development? Urban Sci. 4 (4), 56.

Bliss, L., 2020. Mapping How Cities Are Reclaiming Street Space. Available at: https://www.citylab.com/transporta tion/2020/04/coronavirus-city-street-public-transit-bike-lanes-covid-19/609190/ (accessed 8 April 2020).

Brand, C., Dons, E., Anaya-Boig, E., Avila-Palencia, I., Clark, A., de Nazelle, A,, Gascon, M., Gaupp-Berghausen, M., Gerike, R., Gotschi, T., Iacorossi, F., Kahlmeier, S., Laeremans, M., Nieuwenhuijsen, M.J., Orjuel, J.P., Racioppi, F., Raser, E., Rojas-Rueda, D., Standaert, A., Stigel, E., Sulikova, S., Wegener, S., Int Panis, L., 2021a. The climate change mitigation effects of daily active travel in cities. 102764.

Brand, C., Götschi, T., Dons, E., Gerike, R., Anaya-Boig, E., Avila-Palencia, I., De Nazelle, A., Gaupp-Berghausen, M., Lacorossi, F., Kahlmeier, S., Int Panis, L., Racioppi, F., Rojas-Rueda, D., Standaert, A., Stigell, E., Sulikova, S., Wegener, S., Nieuwenhuijsen, M.J., 2021b. The climate change mitigation impacts of active travel: Evidence from a longitudinal panel study in seven European cities. Global Environ. Change 67, 102224.

Brody, S., 2013. The characteristics, causes, and consequences of sprawling development patterns in the United States. Nature Educ. Knowledge 4 (5), 2.

Buehler, Ralph, Pucher, John, 2021. COVID-19 Impacts on Cycling, 2019–2020. Transp. Rev. 41 (4), 393–400. https://doi.org/10.1080/01441647.2021.1914900.

Burgen, S., 2018. https://www.theguardian.com/cities/2018/sep/18/paradise-life-spanish-city-banned-cars-pontevedra (accessed March 26, 2021).

Casale, 2020. https://therevelator.org/telework-environmental-benefits/.

Castro, Alberto, et al., 2019. Physical activity of electric bicycle users compared to conventional bicycle users and non-cyclists: Insights based on health and transport data from an online survey in seven European cities. Transp. Res. Interdisciplinary Perspect. 100017.

Coutts, Christopher, Hahn, Micah, 2015. Green infrastructure, ecosystem services, and human health. Int. J. Environ. Res. Public Health 12 (8), 9768–9798.

Dadvand, Payam, Nieuwenhuijsen, Mark J., Esnaola, Mikel, Forns, Joan, Basagaña, Xavier, Alvarez-Pedrerol, Mar, Rivas, Ioar, López-Vicente, Mónica, De Castro Pascual, Montserrat, Su, Jason, Jerrett, Michael, Querol, Xavier, Sunyer, Jordi, 2015. Green spaces and cognitive development in primary schoolchildren. Proc. Natl. Acad. Sci. 112 (26), 7937–7942.

European Commission. Communication, 2020a. From The Commission To The European Parliament, The European Council, The Council, The European Economic And Social Committee And The Committee Of The Regions. The European Green Deal. Bussels, 11.12.2019. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52019DC0640&from=EN (last accessed July 27, 2020).

European commission, 2020b. https://ec.europa.eu/commission/presscorner/detail/en/ip_20_940.

Garden cities, 2021. https://en.wikipedia.org/wiki/Garden_city_movement (accessed 30 April, 2021).

Gascon, M., Götschi, T., de Nazelle, A., Gracia, E., Ambròs, A., Márquez, S., et al., 2019. Correlates of walking for travel in seven European cities: the PASTA project. Environ. Health Perspect. 127 (9), 097003.

Gascon, Mireia, Triguero-Mas, Margarita, Martínez, David, Dadvand, Payam, Forns, Joan, Plasència, Antoni, Nieuwenhuijsen, Mark, 2015. Mental health benefits of long-term exposure to residential green and blue spaces: a systematic review. Int. J. Environ. Res. Public Health 12 (4), 4354–4379.

Giles-Corti, B., Vernez-Moudon, A., Reis, R., Turrell, G., Dannenberg, A.L., Badland, H., Foster, S., Lowe, M., Sallis, J.F., Stevenson, M., Owen, N., 2016. City planning and population health: a global challenge. The Lancet 388 (10062), 2912–2924.

Gössling, Stefan, Choi, Andy S., 2015. Transport transitions in Copenhagen: comparing the cost of cars and bicycles. Ecol. Econ. 113, 106–113.

Gössling, S., 2020. Integrating e-scooters in urban transportation: Problems, policies, and the prospect of system change. Transp. Res. Part D: Transport Environ. 79, 102230.

Grundy, C., Steinbach, R., Edwards, P., Green, J., Armstrong, B., Wilkinson, P., 2009. Effect of 20 mph traffic speed zones on road injuries in London, 1986–2006: controlled interrupted time series analysis. BMJ 339, b4469.

Honey-Rosés, J., Anguelovski, I., Chireh, V.K., Daher, C., Konijnendijk van den Bosch, C., Litt, J.S., Mawani, V., McCall, M.K., Orellana, A., Oscilowicz, E., Sánchez, U., Senbel, M., Tan, X., Villagomez, E., Zapata, O., Nieuwenhuijsen, M.J., 2020. The impact of COVID-19 on public space: an early review of the emerging questions – design, perceptions and inequities. Cities & Health. https://doi.org/10.1080/23748834.2020.1780074.

ISGlobal, 2019. https://www.isglobal.org/en/publication/-/asset_publisher/ljGAMKTwu9m4/content/7-maneras-en-que-las-bicicletas-pueden-hacer-las-ciudades-mas-saludables (accessed 10 May 2019).

IUCN, 2020. https://iucnurbanalliance.org/promoting-health-and-wellbeing-through-urban-forests-introducing-the-3-30-300-rule/ (accessed June 7, 2021).

Jiang, X., Larsen, L., Sullivan, W., 2020. Connections-between daily greenness exposure and health outcomes. Int. J. Environ. Res. Public Health 17 (11), 3965.

Jones, S.J., Brunt, H., 2017. Twenty miles per hour speed limits: a sustainable solution to public health problems in Wales. J. Epidemiol. Community Health 71 (7), 699–706.

Kelly, P., Kahlmeier, S., Götschi, T., Orsini, N., Richards, J., Roberts, N., Scarborough, P., Foster, C., 2014. Systematic review and meta-analysis of reduction in all-cause mortality from walking and cycling and shape of dose response relationship. Int. J. Behav. Nutr. Phys. Act 11, 132.

Kelly, P., Williamson, C., Niven, A.G., Hunter, R., Mutrie, N., Richards, J., 2018. Walking on sunshine: scoping review of the evidence for walking and mental health. Br. J. Sports Med. 52 (12), 800–806.

Kondo, M.C., Mueller, N., Locke, D.H., Roman, L.A., Rojas-Rueda, D., Schinasi, L.H., Gascon, M., Nieuwenhuijsen, M.J., 2020. Health impact assessment of Philadelphia's 2025 tree canopy cover goals. Lancet Planet Health 4, e149–e157.

Khreis, H., Warsow, K.M., Verlinghieri, E., Guzman, A., Pellecuer, L., Ferreira, A., Jones, I., Heinen, E., Rojas-Rueda, D., Mueller, N., Schepers, P., Lucas, K., Nieuwenhuijsen, M., 2016. The health impacts of traffic-related exposures in urban areas: Understanding real effects, underlying driving forces and co-producing future directions. J. Transport Health 3, 249–267.

Khomenko, S., Cirach, M., Pereira-Barboza, E., Mueller, N., Barrera-Gómez, J., Rojas-Rueda, D., de Hoogh, K., Hoek, G., Nieuwenhuijsen, M., 2021. Premature mortality due to air pollution in European cities: a health impact assessment. Lancet Planet Health. S2542-5196(20)30272-2.

Kraus, S., Koch, N., 2021. Provisional COVID-19 infrastructure induces large, rapid increases in cycling. Proc. Natl. Acad. Sci. 118, 15.

Kruize, H., van Kamp, I., van den Berg, M., van Kempen, E., Wendel-Vos, W., Ruijsbroek, A., Swart, W., Maas, J., Gidlow, C., Smith, G., Ellis, N., Hurst, G., Masterson, D., Triguero-Mas, M., Cirach, M., Gražulevičienė, R., van den Hazel, P., Nieuwenhuijsen, M., 2020. Exploring mechanisms underlying the relationship between the natural outdoor environment and health and well-being - Results from the PHENOTYPE project. Environ Int. 134, 105173.

Labib, S.M., Lindley, Sarah, Huck, Jonny J., 2020. Spatial dimensions of the influence of urban green-blue spaces on human health: a systematic review. Environ. Res. 180, 108869.

Laker, L., 2020. World cities turn their streets over to walk- ers and cyclists. The Guardian, 11 April. Available at: https://www.theguardian.com/world/2020/apr/11/world-cities-turn-their-streets-over-to-walkers-and-cyclists#maincontent.

Laverty, A.A., Goodman, A., Aldred, R., 2021. Low traffic neighbourhoods and population health. BMJ 372, n443.

Lawlor, E., 2014. The pedestrian pound. The Business Case for Better Streets and Places https://www.livingstreets.org.uk/media/3890/pedestrian-pound-2018.pdf - looks like there was an update in 2018.

Lin, B.B., Ossola, A., Alberti, M., Andersson, E., Bai, X., Dobbs, C., Tan, P.Y., 2021. Integrating solutions to adapt cities for climate change. Lancet Planetary Health 5 (7), e479–e486.
LLS, 2020. https://londonlivingstreets.com/low-traffic-liveable-neighbourhoods/.
López, I., Ortega, J., Pardo, M., 2020. Mobility infrastructures in cities and climate change: an analysis through the superblocks in Barcelona. Atmosphere 11 (4), 410.
Moreno, 2019. http://www.moreno-web.net/the-15-minutes-city-for-a-new-chrono-urbanism-pr-carlos-moreno/ (accessed Mach 22, 2021).
Moreno, 2020. https://www.ted.com/talks/carlos_moreno_the_15_minute_city?language=en (accessed Mach 22, 2021).
Mueller, N., Rojas-Rueda, D., Basagaña, X., Cirach, M., Cole-Hunter, T., Dadvand, P., Donaire-Gonzalez, D., Foraster, M., Gascon, M., Martinez, D., Tonne, C., Triguero-Mas, M., Valentín, A., Nieuwenhuijsen, M., 2017. Urban and transport planning related exposures and mortality: a health impact assessment for cities. Environ. Health Perspect. 125 (1), 89–96.
Mueller, N., Rojas-Rueda, D., Salmon, M., Martinez, D., Ambros, A., Brand, C., de Nazelle, A., Dons, E., Gaupp-Berghausen, M., Gerike, R., Götschi, T., Iacorossi, F., Panis, L.I., Kahlmeier, S., Raser, E., Nieuwenhuijsen, M., PASTA consortium, 2018. Health impact assessment of cycling network expansions in European cities. Prev. Med. pii: S0091-7435(17)30497-8.
Mueller, N., Rojas-Rueda, D., Khreis, H., Cirach, M., Andrés, D., Ballester, J., Bartoll, X., Daher, C., Deluca, A., Echave, C., Milà, C., Márquez, S., Palou, J., Pérez, K., Tonne, C., Stevenson, M., Rueda, S., Nieuwenhuijsen, M., 2020. Changing the urban design of cities for health: the superblock model. Environ. Int. 134, 105132.
Mueller, N., Carolyn Daher, C., Rojas-Rueda, D., Delgado, L., Vicioso, H., Gascon, M., Marquet, O., Vert, C., Martin, I., Nieuwenhuijsen, M., 2021. Integrating health indicators into urban and transport planning: a narrative literature review and participatory process. Int. J. Env. Health Hyg. 235, 113772.
Mushangwe, S., Astell-Burt, T., Steel, D., Feng, X., 2021. Ethnic inequalities in green space availability: evidence from Australia. Urban For. Urban Greening, 127235.
Negev, M., Khreis, H., Rogers, B.C., Shaheen, M., Erell, E., 2020. City design for health and resilience in hot and dry climates. BMJ 371.
Nieuwenhuijsen, M.J., Khreis, H., 2016. Car free cities: Pathway to healthy urban living. Environ. Int. 94, 251–262.
Nieuwenhuijsen, M.J., Khreis, H., Triguero-Mas, M., Gascon, M., Dadvand, P., 2017a. Fifty shades of green: pathway to healthy urban living. Epidemiology 28, 63–71.
Nieuwenhuijsen, M.J., Khreis, H., Verlinghieri, E., Mueller, N., Rojas-Rueda, D., 2017b. Participatory quantitative health impact assessment of urban and transport planning in cities: a review and research needs. Environ. Int. pii: S0160-4120(17)30128-9.
Nieuwenhuijsen, M.J., 2018. Influence of urban and transport planning and the city environment on cardiovascular disease. Nat. Rev. Cardiol. 15 (7), 432–438.
Nieuwenhuijsen, M., Bastiaanssen, J., Sersli, S., Waygood, E.O.D., Khreis, H., 2019. Implementing car-free cities: rationale, requirements, barriers and facilitators. In: Integrating Human Health into Urban and Transport Planning. Springer, Cham, pp. 199–219.
Nieuwenhuijsen, M., 2019. https://theconversation.com/seven-steps-melbourne-can-take-to-regain-its-liveable-city-crown-113726.
Nieuwenhuijsen, M.J., 2020a. Urban and transport planning pathways to carbon neutral, liveable and healthy cities; a review of the current evidence. Environ. Int. 105661.
Nieuwenhuijsen, M., 2020b. COVID19 and the City: the COVID19 pandemic and the transformation of the city. Amazon.com ISBN-13: 979-8553841249.
Nieuwenhuijsen, M.J., 2021. Green infrastructure and health. Annu. Rev. Public Health 42, 12.1-12.12.
Oja, P., Kelly, P., Murtagh, E.M., Murphy, M.H., Foster, C., Titze, S., 2018. Effects of frequency, intensity, duration and volume of walking interventions on CVD risk factors: a systematic review and meta-regression analysis of randomised controlled trials among inactive healthy adults. Br. J. Sports Med. 52 (12), 769–775.
Olabarria, M., Pérez, K., Santamariña-Rubio, E., Novoa, A.M., Racioppi, F., 2013. Health impact of motorised trips that could be replaced by walking. Eur. J. Public Health 23 (2), 217–222.
Oscilowicz, E., Anguelovski, I., Cole, H., Cañizares, A., 2021. http://www.bcnuej.org/wp-content/uploads/2021/04/Toolkit-Urban-Green-Justice.pdf (accessed August 16, 2021).
Palència, L., León-Gómez, B.B., Bartoll, X., Carrere, J., Díez, E., Font-Ribera, L., Pérez, K., 2020. Study Protocol for the Evaluation of the Health Effects of Superblocks in Barcelona: The "Salut Als Carrers"(Health in the Streets) Project. Int. J. Environ. Res. Public Health 17 (8), 2956.
Pereira Barboza, E., Cirach, M., Khomenko, S., Iungman, T., Mueller, N., Barrera-Gomez, J., Rojas-Rueda, D., Kondo, M., Nieuwenhuijsen, M., 2021. Green Space and Mortality in European cities: a health impact assessment study. Lancet Plan Health. In print.
Peters, A., 2019. What can we learn from this thriving, car-free German neighborhood? Get rid of parking spaces. https://www.fastcompany.com/90327301/what-can-we-learn-from-this-thriving-car-free-german-neighborhood-get-rid-of-parking-spaces (accessed March 23, 2021).
POLIS, 2021.https://www.polisnetwork.eu/document/covid-19-keeping-things-moving/ (accessed 30 April 2021).
Preuß, M., Nieuwenhuijsen, M., Marquez, S., Cirach, M., Dadvand, P., Triguero-Mas, M., Gidlow, C., Grazuleviciene, R., Kruize, H., Zijlema, W., 2019. Low childhood nature exposure is associated with worse mental health in adulthood. Int. J. Environ Res. Public Health. 16 (10), E1809.
Rojas-Rueda, D., Nieuwenhuijsen, M.J., Gascon, M., Perez-Leon, D., Mudu, P., 2019. Green spaces and mortality: a systematic review and meta-analysis of cohort studies. Lancet Planet. Health 3 (11), e469–e477.
Rojas-Rueda, D., Morales-Zamora, E., 2021. Built environment, transport, and COVID-19: a review. Curr. Environ. Health Rep. 1–8. https://doi.org/10.1007/s40572-021-00307-7.
Rubin, O., Nikolaeva, A., Nello-Deakin, S., te Brömmelstroet, M., 2020. What can we learn from the COVID-19 pandemic about how people experience working from home and commuting?. Centre for Urban Studies, University of Amsterdam. Available at: https://urbanstudies.uva.nl/content/blog-series/covid-19- pandemic-working-from-home-and-commuting.html.
Rueda, S., 2019. Superblocks for the design of new cities and renovation of existing ones: Barcelona's case. In: Nieuwenhuijsen, M., Khreis, H. (Eds.), Integrating human health into urban and transport planning. Springer, Cham, pp. 135–153.
Salmond, J.A., Tadaki, M., Vardoulakis, S., Arbuthnott, K., Coutts, A., et al., 2016. Health and climate related ecosystem services provided by street trees in the urban environment. Environ. Health 15 (1), 95–111.
Sawbridge, F., 2020. https://dutchreview.com/traveling/cities/utrecht/utrechts-exemplar-city-design-that-prioritises-people-over-cars/ (accessed march 26, 2021).
Schüle, S.A., Gabriel, K.M., Bolte, G., 2017. Relationship between neighbourhood socioeconomic position and neighbourhood public green space availability: an environmental inequality analysis in a large German city applying generalized linear models. Int. J. Hyg. Environ. Health 220 (4), 711–718.
Sharifi, A., Khavarian-Garmsir, A.R., 2020. The COVID-19 pandemic: impacts on cities and major lessons for urban planning, design, and management. Sci. Total Environ. 142391.
Sisson, 2020. https://www.bloomberg.com/news/articles/2020-07-15/mayors-tout-the-15-minute-city-as-covid-recovery?cmpid=BBD071620_CITYLAB&utm_medium=email&utm_source=newsletter&utm_term=200716&utm_campaign=citylabdaily.
Stevenson, M., Thompson, J., de Sá, T.H., Ewing, R., Mohan, D., McClure, R., Wallace, M., 2016. Land use, transport, and population health: estimating the health benefits of compact cities. The Lancet 388 (10062), 2925–2935.
Sun, Q.C., Macleod, T., Both, A., Hurley, J., Butt, A., Amati, M., 2021. A human-centred assessment framework to prioritise heat mitigation efforts for active travel at city scale. Sci. Total Environ. 763, 143033.
Thompson, J., Stevenson, M., Wijnands, J.S., Nice, K.A., Aschwanden, G.D., Silver, J., Morrison, C.N., 2020. A global analysis of urban design types and road transport injury: an image processing study. Lancet Planet. Health 4 (1), e32–e42.
Vandy, 2020. https://www.bbc.com/news/world-europe-54353914.
Venter, Z.S., Aunan, K., Chowdhury, S., Lelieveld, J., 2020. COVID-19 lockdowns cause global air pollution declines. Proc. Natl. Acad. Sci. 117 (32), 18984–18990.
Voce, A., Walker, P., 2021. Low-traffic schemes benefit most-deprived Londoners, study finds.https://www.theguardian.com/world/ng-interactive/2021/mar/02/low-traffic-schemes-benefit-most-deprived-londoners-study-finds (accessed March 19, 2021).
Weis, 2020. https://www.bloomberg.com/news/articles/2020-07-04/bicycles-are-pushing-aside-cars-on-europe-s-city-streets?cmpid=BBD070620_CITYLAB&utm_medium=email&utm_source=newsletter&utm_term=200706&utm_campaign=citylabdaily.
White, M.P., Alcock, I., Grellier, J., et al., 2019. Spending at least 120 minutes a week in nature is associated with good health and wellbeing. Sci. Rep. 9, 7730.
WHO, 2020. https://www.who.int/news-room/feature-stories/detail/who-manifesto-for-a-healthy-recovery-from-covid-19.
Wikipedia, 2020. https://en.wikipedia.org/wiki/Compact_city.
Wolf, K.L., Lam, S.T., McKeen, J.K., Richardson, G.R., van den Bosch, M., Bardekjian, A.C., 2020. Urban trees and human health: a scoping review. Int. J. Environ. Res. Public Health 17 (12), 4371.
Zografos, C., Klause, K.A., Connolly, J.J., Anguelovski, I., 2020. The everyday politics of urban transformational adaptation: struggles for authority and the Barcelona superblock project. Cities 99, 102613.