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Health impacts related to urban and transport planning: A burden of disease assessment

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ABSTRACT

Introduction: Until now, estimates of the Global Burden of Disease (GBD) have mainly been produced on national or regional levels. These general estimates, however, are less useful for city governments who have to take decisions on local scales. To address this gap, we focused on the city-level burden of disease (BD) due to exposures affected by urban and transport planning. We conducted a BD assessment using the Urban and Transport Planning Health Impact Assessment (UTOPHIA) tool to estimate annual preventable morbidity and disability-adjusted life-years (DALYs) under compliance with international exposure recommendations for physical activity (PA), exposure to air pollution, noise, heat, and access to green spaces in Barcelona, Spain.

Methods: Exposure estimates and morbidity data were available for 1,357,361 Barcelona residents ≥ 20 years (2012). We compared recommended with current exposure levels to estimate the associated BD. We quantified associations between exposures and morbidities and calculated population attributable fractions to estimate the number of attributable cases. We calculated DALYs using GBD Study 2015 background DALY estimates for Spain, which were scaled to Barcelona considering differences in population size, age and sex structures. We also estimated annual health costs that could be avoided under compliance with exposure recommendations.

Results: Not complying with recommended levels for PA, air pollution, noise, heat and access to green spaces was estimated to generate a large morbidity burden and resulted in 52,001 DALYs (95% CI: 42,866–61,136) in Barcelona each year (13% of all annual DALYs). From this BD 36% (i.e. 18,951 DALYs) was due to traffic noise with sleep disturbance and annoyance contributing largely (i.e. 10,548 DALYs). Non-compliance was estimated to result in direct health costs of 20.10 million € (95% CI: 15.36–24.83) annually.

Conclusions: Non-compliance of international exposure recommendations was estimated to result in a considerable BD and in substantial economic expenditure each year in Barcelona. Our findings suggest that (1) the reduction of motor traffic together with the promotion of active transport and (2) the provision of green infrastructure would result in a considerable BD avoided and substantial savings to the public health care system, as these measures can provide mitigation of noise, air pollution and heat as well as opportunities for PA promotion.

Abbreviations: CVD, cardiovascular disease; DALYs, disability-adjusted life-years; dB(A), A-weighted decibel; EBD, Environmental Burden of Disease; ERF, exposure response function; ESCAPE LUR, European Study of Cohorts for Air Pollution Effects Land Use Regression model; GBD, Global Burden of Disease; HIA, health impact assessment; ICD-10, international classification of disease, version 2010; $L_{Aeq,16\ h}$, day time (7:00–23:00 h) equivalent sound pressure level; L_{den}, day-evening-night EU indicator with 5 and 10 dB weights for the evening and the night time; L_{dn}, day-night indicator with a 10 dB weight for the night time only; L_{night}, night time (7:00–23:00 h) equivalent sound pressure level; METs, metabolic equivalents of task; NDVI, Normalized Differenced Vegetation Index; NO_2, nitrogen dioxides; OECD, Organization for Economic Cooperation and Development; OLI, Operational Land Imager; O_3, ozone; PA, physical activity; PAF, population attributable fraction; $PM_{2.5}$, particulate matter with a diameter ≤ 2.5 μm; RR, relative risk; SDGs, Sustainable Development Goals; TIRS, Thermal Infrared Sensor; TRAP, traffic-related air pollution; UHI, urban heat island; UTOPHIA, Urban and TranspOrt Planning Health Impact Assessment tool; WHO, World Health Organization; YLDs, years lived with disability; YLLs, years of life lost; %HA, percentage of population highly annoyed; %HSD, percentage of population highly sleep disturbed

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1. Introduction

With continuing urbanization it is predicted that by 2050 70% of the world's population will be living in cities (United Nations, 2014). Urban life conveys great potential to improve our well-being, as it provides us with employment, access to essential goods and services and the opportunity for social interaction (United Nations, 2014).

At the same time, urban life and urban design also have detrimental effects on our well-being. Over the decades of urbanization processes, levels of physically-intensive labor and mobility activities have decreased, while convenience has increased and resulted in sedentary lifestyles (Sallis et al., 2015). Typically, our urban fabrics are made up of dense construction, with large amounts of public space being assigned to accommodating motor traffic. As a consequence, little space is available for green or blue infrastructure that could provide urban resilience, would beautify our cities and could be used for recreational purposes and to promote physical activity (PA) (Eakin et al., 2017; Nieuwenhuijsen and Khreis, 2016). With expansion of a city, scarcity of space and increases in housing prices, migration processes take place which force people to relocate to urban peripheries that often are low density neighborhoods that in return imply high motor vehicle dependency and long commuting times (Litman and Steele, 2017; Shoag and Muehlegger, 2015). Motor traffic exposes us not only to physical hazards, but also to hazardous emissions of air pollution, noise and anthropogenic heat (Mueller et al., 2017; Nieuwenhuijsen, 2016). Together with the effects of climate change, these emissions can contribute to increasing temperatures in cities.

The 'city', nowadays the primary settlement form, is increasingly becoming the unit of analysis and is gaining in importance in policy decision-making (WHO, 2015). Cities have direct local accountability and may be more agile to act in terms of governance structures compared to national governments. Cities can identify local problems and therefore develop specific policies that can target actions more effectively. The importance of local accountability on how urban spaces are managed has been recognized recently in the Sustainable Development Goals (SDGs) and the aligned adoption of the New Urban Agenda that make sustainable cities and communities a pressing issue for sustainable urban renewal (United Nations, 2017, 2015). The New Urban Agenda proposes how urban spaces should best be planned to provide sustainable urbanization processes and specifically allocates power to cities and towns by committing to "support local governments in determining their own administrative and management structures, in line with national legislation and policies, as appropriate, in order to adapt to local needs" (United Nations, 2017).

Until now, estimates of the Global Burden of Disease (GBD) have mainly been produced on national or regional levels (Forouzanfar et al., 2015). These estimates, however, are less useful for city governments that have to allocate resources and take decisions on the local scale with direct impacts on residents' daily lives. To address this gap, we aimed to evaluate the city-level burden of disease (BD) impact and direct economic implications of current urban and transport planning practices. We therefore, estimated annual preventable BD and direct economic health gains under compliance with international exposure recommendations for PA, exposure to air pollution, noise and heat, and access to green spaces.

2. Material and methods

2.1. Study setting

We further developed and applied the Urban and Transport Planning Health Impact Assessment (UTOPHIA) tool (Mueller et al., 2017) (Supplementary material A, Fig. A.1) to the city of Barcelona, Spain. Barcelona has one of the highest population densities in Europe with 1.6 million people living on 100 km^2. Its urban design is made-up of dense, semi-tall construction, streaked by narrow street canyons. Only 10% of the city area is assigned as green space (Barcelona City Council, 2012). As typical for the Mediterranean region, Barcelona's climate (classified as dry-summer subtropical) is comprised of warm summers and mild winters with an annual mean temperature of 18 °C and low precipitation (Barcelona City Council, 2012; Brines et al., 2015). Despite a well-connected public transport system with frequent service (i.e. metro, bus, trams, trains) within the municipality area, which in 2013 carried almost 900 million passengers (Barcelona City Council, 2013a), the provision of public transport for the wider metropolitan area is less well-developed. Of the almost two million daily commuter trips from the metropolitan area, over 40% are made in private motor vehicle (Barcelona City Council, 2013a). Barcelona's internal motor vehicle fleet of over 500,000 cars and 300,000 motorcycles plus the large daily motorized metropolitan commuter fleet result in a large traffic volume and one of the highest emission levels in Europe (Barcelona City Council, 2013b; Nieuwenhuijsen et al., 2014). During the summer months urban heat islands (i.e. UHI; urban areas being hotter than surrounding areas) can form and the UHI effect for

Table 1
International exposure recommendations and current exposure levels in Barcelona.

Exposure	Recommendation	Current exposure
Physical activity		
Adults 18–64 years	600 MET min/week	78 MET min/week
Adults ≥ 65 years	450 MET min/week	39 MET min/week
Air pollution		
Annual mean $PM_{2.5}$	10 μg/m^3	16.6 μg/m^3
Noise		
Day time (7:00–23:00 h) outdoor activity noise ($L_{Aeq,16\ h}$) level	55 dB(A)	65.1 dB(A)
Night time (23:00–7:00 h) outdoor activity noise (L_{night}) level	40 dB(A)	57.6 dB(A)
Heat	Changes to urban plan may provide cooling of 4 °C	Traffic accidents with injury[a]: > 26.6 °C on 98 days (mean exceedance by 2.3 °C) Respiratory hospital admissions[b]: > 30.5 °C on 21 days (mean exceedance by 1.1 °C) Preterm birth[c]: > 25.3 °C on 132 days (mean exceedance by 2.8 °C)
Green spaces	Access to green space ≥ 0.5 ha within 300 m linear distance	31% of residents without access to green space ≥ 0.5 ha within 300 m linear distance

[a] Threshold: Mean maximum temperature from April 1st, 2012 to October 31st, 2012 = 25.3 ºC.
[b] Threshold: 90th percentile of maximum temperature from April 1st, 2012 to September 30th, 2012 = 30.5 ºC.
[c] Threshold: Mean maximum temperature from April 1st, 2012 to October 31st, 2012 = 25.3 ºC.