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Urban population density and mortality in a compact Dutch city: 23-year follow-up of the Dutch GLOBE study

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ABSTRACT

We investigated the association and underlying pathways between urban population density and mortality in a compact mid-sized university city in the Netherlands. Baseline data from the GLOBE cohort study (N = 10,120 residents of Eindhoven) were linked to mortality after 23 years of follow up and analyzed in multilevel models. Higher population density was modestly related to increased mortality, independently of baseline socioeconomic position and health. Higher population density was related to more active transport, more perceived urban stress and smoking. Increased active transport suppressed the mortality-increasing impact of higher population density. Overall, in dense cities with good infrastructure for walking and cycling, high population density may negatively impact mortality.

1. Introduction

Today, over 70% of Europeans reside in cities and this number is expected to increase in the coming decades (The World Bank, 2017). In order to host more residents, cities can either spread out (e.g. build new housing in the outskirts), or become denser (e.g. build apartment buildings and other high rises within the city's current boundaries). Recent papers advocated the need for 'compact cities', with "short distances that promote increased population density, mixed land use, proximate and enhanced public transport, and an urban form that encourages cycling and walking" (Stevenson et al., 2016; Giles-Corti et al., 2016). Denser populated cities are thought to enhance active transport (e.g. walking, cycling) because of the close proximity of shops, facilities, work and schools which in turn is beneficial to major non-communicable diseases, such as cardiovascular diseases and types of cancers (Sallis et al., 2016). How compactness relates to levels of air pollution and traffic accidents, is still debated. The paradox of intensification states that "ceteris paribus, urban intensification which increases population density will reduce per capita car use, with benefits to the global environment, but will also increase concentrations of motor traffic, worsening the local environment in those locations where it occurs."(Melia et al., 2011) Furthermore, living close together may also be associated with more urban stress, e.g. due to noise pollution, vandalism, crime or lower quality housing. These urban stressors could affect health in a negative way via perceived stress, a bad internal climate, or through unhealthy coping behaviours, such as smoking and alcohol consumption (Lederbogen et al., 2011; Peen et al., 2010; Putrik et al., 2015; Park and Iacocca, 2014). In addition, a closer proximity to shops and facilities may also increase the proximity to tobacco and alcohol outlets which can enhance smoking or drinking behaviour (Finan et al., 2018; Fone et al., 2016).

Most studies advocating compact cities for public health reasons originate in the U.S.A. or Australia where cities, after leaving down town, are generally widely set-up, with the risk of urban sprawl. Urban sprawl negatively affects the accessibility of public transport, local shops and services. In contrast, European cities are often more compact and, in many cases, are very densely populated - also in the outskirts. For example, a middle-sized city of 200,000–250,000 inhabitants in the US has an average population density of just over 1000 inhabitants per square kilometre (e.g. Orlando, Florida: 1017 inhabitants/km2; Madison, Wisconsin: 1173 inhabitants/km2; Fremont, California: 1162 inhabitants/km2). A city of the same size in Europe may have a population density that is more than twice or even five times as high (e.g. Eindhoven, the Netherlands: 2596 inhabitants/km^2; Bordeaux, France: 5000 inhabitants/km^2 (2005); Porto, Portugal: 5736 inhabitants /km^2 (2005)). Access to public facilities is less of an issue in these denser cities. In these urban areas, high levels of population density may reach a 'tipping point', after which the positive health consequences of high

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density do not outweigh the negative ones, related to urban stress. Indeed, evidence from densely populated areas in Europe suggests negative health consequences from increased population density on several health outcomes, including mortality (Chaix et al., 2006; Meijer et al., 2012; Fecht et al., 2016) and mental health (Sundquist et al., 2004). A study from the nineties, undertaken in Japan, hints towards the existence of a curvilinear association of density with mortality where increased urbanization was associated with lower mortality with the exception of inner-city areas with the highest density (Tanaka et al., 1996). This finding is in line with the common notion that mortality in cities is in general lower than in rural areas (Singh and Siahpush, 2014; Chen and Yang, 2014). It also suggests that within densely populated cities, increasing density may not be beneficial for health (Fecht et al., 2016).

The aim of this paper is to investigate the influence of population density on all-cause and cause specific mortality in a densely populated European city: the city of Eindhoven, a middle-sized city hosting a technical university situated in the South-East of the Netherlands, which grew from 190,000 inhabitants in 1990 to 227,100 inhabitants in 2017 - which makes it the fifth largest city in the Netherlands currently. Furthermore, potential mediating factors will be studied. Both positive mediators, expected to be associated with increased density and healthy behaviour (i.e. physical activity) and negative mediators (i.e. urban stressors, or inadequate coping responses, such as smoking) will be explored. The conceptual model describing these potential mediators is visualized in Fig. 1. We adjusted all analyses for indicators of individual and neighbourhood level socioeconomic position (SEP). Those with a lower SEP may be more likely to live in highly populated areas, but also to be less physically active, live in lower quality housing and experience higher mortality levels (Stringhini et al., 2017). Related, neighbourhood deprivation and population density may be correlated, and associations between neighbourhood deprivation and mortality are well-reported (Pickett and Pearl, 2001). Similarly, as a worse health status may sort people into specific neighbourhoods (potentially with higher population density), and may lead to higher mortality, we also adjusted for baseline health status.

2. Methods

2.1. Study population

Data for this study were collected among a stratified sample of the adult population of the city of Eindhoven in the Netherlands, that participated in the prospective cohort study GLOBE (a Dutch acronym for 'Health and Living Conditions of the Population of Eindhoven and surroundings'). At baseline, in 1991, a postal survey was send out to a random sample, stratified by age, degree of urbanization, and socioeconomic position, of non-institutionalized Dutch persons aged 14–75 years living in Eindhoven and surrounding municipalities (response rate 70.1%, N = 18,973). There were no significant differences in response rates by age, sex, social class (zip code), marital status and level of urbanization. The majority of the participants (n = 10,450, 52.7%) were inhabitants of the city of Eindhoven (the fifth largest city of the Netherlands with approximately 190,000 inhabitants in 1991) and lived in 86 different neighbourhoods (average size of a neighbourhood is ca. 2200 residents, with an approximate inter quartile range of 1000–3200). More detailed information on the objectives, study design, and data collection of the Dutch GLOBE study can be found elsewhere (Mackenbach et al., 1994; Van Lenthe et al., 2014). The use of personal data in the GLOBE study is in compliance with the Dutch Personal Data Protection Act and the Municipal Database Act and has been registered with the Dutch Data Protection Authority (number 1248943).

2.2. Measures

2.2.1. Mortality

Mortality data up to and including December 31st, 2014 were obtained from Statistics Netherlands. We were able to link 10,125 participants to the register data (96.9%). Participants were censored at their date of death or end of follow-up. During the almost 24 years of follow-up, 3024 individuals (29,9%) died from all causes. In addition to all-cause mortality, we also investigated the three major groups of cause specific mortality: cancer mortality, cardiovascular mortality, and respiratory mortality. Cause of death was recorded based on the International Statistical Classification of Diseases and Related Health Problems (ICD) of the World Health Organisation (WHO) (World Health Organization, 2004). Until 1996, the ICD-9 codes were used. From 1996 onwards, ICD-10 is used. Cancer mortality included ICD-10 codes C00-D48 (ICD-9: 140–239). Cardiovascular mortality included ICD-10 codes I00-I99 (ICD-9: 390–459). Respiratory mortality included ICD-10 codes J00-J99 (ICD-9: 460–519).

2.2.2. Population density

Population density was derived in 1992 from routinely collected descriptive statistical information about neighbourhoods from the statistical division of Eindhoven municipality. The average number of

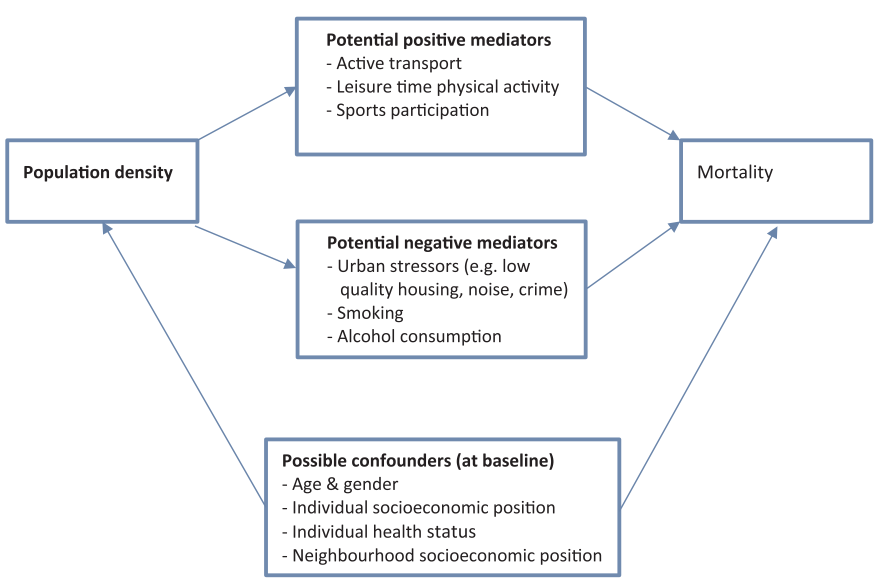

Fig. 1. Conceptual model describing the expected relationship between population density and mortality.