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Multi-scalar influences on mortality change over time in 274 European cities

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Understanding determinants of urban health is of growing importance. Factors at multiple scales intertwine to influence health in cities but, with the growing autonomy of some cities from their countries, city population health may be becoming more a matter for city-level rather than national-level policy and action. We assess the importance of city, country, and macroregional (Western and East-Central Europe) scales to mortality change over time for 274 cities (population 80 million) from 27 European countries. We then investigate whether mortality changes over time are related to changes in city-level affluence. Using Urban Audit data, all-age all-cause standardised mortality ratios (SMRs) for males and females were calculated at three time points (wave one 1999–2002, wave two 2003–2006, and wave three 2007–2009) for each city. Multilevel regression was used to model the SMRs as a function of survey wave and city region gross domestic product (GDP) per 1000 capita. SMRs declined over time and the substantial East-West gap narrowed slightly. Variation at macroregion and country scales characterised SMRs for women in Western and East-Central European cities, and SMRs for men in East-Central European cities. Between-city variation was evident for male SMRs in Western Europe. Changes in city-region GDP per capita were not associated with changes in mortality over the study period. Our results show how geographical scales differentially impact urban mortality. We conclude that changes in urban health should be seen in both city and wider national and macroregional contexts.
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1. Background

The world's urban population is forecast to reach almost 5 billion by 2030 (Fragkias et al., 2013). Over 70% of Europe's 740 million inhabitants already live in cities (United Nations, 2013, 2014). Population health in Europe, and globally, is increasingly determined by the health of city dwellers. Whilst we know that there are substantial variations in health status between the countries of Europe (Leon, 2011; Mackenbach et al., 2013; Richardson et al., 2014), it is not clear whether these associations are replicated between cities across Europe.

There are reasons why the health status of cities might be different to that of the rest of a country. Historically, this possibility was reflected in the debate over the existence of an urban penalty or an urban advantage (Moon and Kearns, 2014; Vlahov et al., 2005). In contemporary Europe, many cities have now become increasingly dissimilar from their countries due to starkly different trajectories of demographic and economic development (Brenner, 1998; Salet et al., 2003). Younger, more affluent urban areas may hold a health advantage; conversely, urban economic crises and ageing city populations may link to poorer health. Further, in recent years there has been a devolution of resources and policy responsibilities to the city or regional level in many European countries, including the UK, Belgium, Italy, and Spain (Scully and Jones, 2010; Telò, 2014). Key decisions on health-related policy realms that were once the preserve of central governments are now often taken at the city level, albeit within a national framework. As a result, cities may develop health-influencing characteristics that are distinct from the rest of their country and/or from other cities

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within the same country: different labour markets, infrastructure, physical environments, and health care provision. Together, these contentions suggest the importance of geographical scale in the study of health outcomes (Kim and Subramanian, 2016).

Two broader structural influences overlay the juxtaposition of country and city as scales affecting the health of city residents. First, and of particular relevance in the European context, supranational groupings of countries, or ‘macroregions’, differ in their social and economic development trajectories. The major divide in health between Western Europe and the East-Central European countries of the former Soviet bloc has been well documented, reflecting historical political and economic divisions (Marmot, 2013). Population health in East-Central Europe remains generally worse than in the West, although there are indications that it is improving rapidly in some countries (Leon, 2011; Vågerö, 2010).

Second, and more generally, whilst a range of social, political and environmental factors are likely to influence health in European cities, affluence is likely to be a major determinant of differences in urban health (Borrell et al., 2013). Associations between affluence and population health are well established between countries (Marmot, 2005; Pearce and Dorling, 2009), but the extent to which the uneven changes in health across European cities are a function of changes in affluence is less clear. Addressing this omission is important because a better understanding of the relationship between trajectories in health and affluence will assist in identifying policy levers for improving health and reducing inequalities across Europe.

In this paper we use novel data to investigate the extent to which changes in the health of city populations across Europe reflect variations at the ‘city-level’, the ‘country-level’, and the macroregion (East-Central or Western Europe), and taking into account changing affluence. Comparisons of health between the cities of different European countries have, to date, been cross-sectional and have either focussed exclusively on cities in Western Europe (Baccini et al., 2008; Gray et al., 2012), or included only a small fraction of East-Central European cities (Gotsens et al., 2013; Katsouyanni et al., 2001). The relative contribution of city-, country-, and macroregion to city health trajectories is unknown, and there has been limited specific focus on city health. Our research questions were thus: i) how do variations in city mortality over time differ in relation to the city, country, and macroregion scale?, and ii) are variations in urban mortality over time related to variations in the affluence of the area in and around the city?

2. Methods

We conducted a repeated measures panel study of city-level mortality over three waves of the European Urban Audit. Assembling and curating our data was a substantial task, which we outline first prior to describing our analytical strategy.

2.1. Data

The Urban Audit was established to provide reliable and comparable information about the characteristics of European urban areas with more than 50,000 inhabitants (termed ‘cities’). It sought to represent at least 20% of the population of each country and included all capital cities, most regional capitals and a range of smaller cities. Three waves were available for analysis: 1999–2002 (‘wave one’), 2003–2006 (‘wave two’), and 2007–2009 (‘wave three’). By wave three, the Urban Audit included cities in each of the then EU countries except Cyprus, plus cities in Croatia, Turkey, Norway, and Switzerland. We excluded cities distant enough from the European mainland that they might be considered atypical ($n = 8$; e.g., Funchal, Madeira (Portuguese); Saint-Denis, Réunion (French)).

Urban Audit mortality and demographic data at each wave were obtained from Eurostat. This provided all-age, all-cause mortality counts by sex, city, and wave. Age- and sex-specific counts were not available, precluding direct standardisation. We calculated indirectly standardised mortality ratios (SMRs), standardised to 2001, to render rates comparable between cities and over time. For each wave and city we calculated the ‘expected’ number of all-age all-cause deaths, by applying average age group- and sex-specific mortality rates for a Europe-wide reference population from 2001 to the city's age group- and sex-specific population counts, and summing the result. The age groups were 0–4, 5–14, 15–19, 20–24, 25–34, 35–44, 45–54, 55–64, 65–74, and 75+. The reference population was that of the 21 Urban Audit countries providing complete data in the WHO Detailed Mortality Database (DMDB): Bulgaria, Croatia, Czech Republic, Estonia, Finland, France, Germany, Greece, Hungary, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, and United Kingdom. The age- and sex-specific mortality rates for this population were considered to represent the best available approximation of average rates for the Urban Audit cities. Five UA countries with SMR data – Belgium, Italy, Ireland, Portugal, and Denmark – were absent from the reference population. Their absence did not affect our subsequent results, therefore cities in these countries were retained in our analyses. Each city's 2001-referenced SMR was calculated as (observed deaths)*100/(expected deaths). A value below/above 100 indicated a standardised mortality ratio lower/higher than the reference population average for 2001.

City-specific measures of affluence were not available in the Urban Audit. We obtained gross domestic product (GDP) per capita from Eurostat for the wider ‘city-region’ in which each Urban Audit city was situated. City-regions were defined as level 3 of the Nomenclature of Units for Territorial Statistics (NUTS), a standard European unit for statistical reporting. On average, Urban Audit cities contained 53% of the population of their host NUTS3 area. GDP was expressed in purchasing power standards, an artificial unit of currency enabling comparisons of GDP across countries with different currencies and costs of living. Average GDP per capita was calculated for the years covered by each wave. Wave one GDP per 1000 capita was averaged over 2000 to 2002 due to missing data in 1999.

2.2. Data quality

Urban Audit data were collated from multiple countries with differing mechanisms and standards of statistical reporting, hence data quality was a concern and we checked the datasets extensively. Outlying SMR values (>2 standard deviations from expectations based on regional (NUTS2) or national mortality rates) were deemed suspect. Wave one mortality data for Spanish cities ($n = 13$) were excluded as a result, as well as a further 3%, 2%, and 5% of other cities with SMRs for waves one, two, and three, respectively. Missing GDP data resulted in the exclusion of cities in Norway, Switzerland and Turkey as well as all bar one city in Italy. The online supplementary data table gives details of excluded and included cities. The resulting dataset represented an average of 80 million people at each wave for 218 cities in wave one, 257 in wave two, and 196 in wave three. A total of 274 cities were represented in the dataset with 144 cities present in all waves.

2.3. Analyses

We chose to run separate models for East-Central and Western European cities, given the well-established European health divide

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