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Mortality inequalities by environment type in New Zealand

Niamh K. Shortt*, Elizabeth A. Richardson, Jamie Pearce and Richard J. Mitchell

*Corresponding Author.

Dr Niamh Shortt
Geography Building
Drummond Street
University of Edinburgh
Edinburgh, UK
EH8 9XP

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Abstract

In previous work a multivariate measure of health-related physical environment - the Multiple Environmental Deprivation Classification (MEDClass) - was created to investigate relationships between exposure to differing types of physical environment and health for the UK. Associations between MEDClass and all cause mortality, mortality from certain specific causes, and self-reported morbidity, independent of the level of socio-economic deprivation were found. In this short report we determine whether the MEDClass approach has potential for international replication and whether the relationships with health prevails. We use New Zealand as a case study. Six environmental clusters were identified and similar associations between environmental classification and health outcomes were observed. Whilst this report shows that the framework used to create MEDClass can be transferred in an international context, we are reminded of the need to engage locally with place based research upon which an evidence base of cumulative impacts of the environment can be built.

Key words: environmental deprivation, health, mortality, physical environment, New Zealand, health inequalities

Background

The relationship between health and socio-economic deprivation is well documented. Furthermore there is ample evidence linking various health outcomes to components of the physical environment, for example air pollution and green space (Finkelstein et al., 2003, Jerrett et al., 2001). Whilst a plethora of research documents the health implications of single environmental exposures, the relationship between *multiple* aspects of the physical environment and health is less well established (Evans and Kantrowitz, 2002, Morello-Frosch et al., 2011). Although environment and health research is beginning to examine collective aspects of the environment, this research is still in its infancy with environmental indices focusing largely on hazards, neglecting to consider beneficial aspects of the natural environment (Sadd et al., 2011, Su et al., 2009).

In our recent work we created two multivariate measures of health-related physical environment - the Multiple Environmental Deprivation Index (MEDIx) and the Multiple Environmental Deprivation Classification (MEDClass) - to investigate relationships between exposure to differing physical environments and health in the UK. In brief, MEDIx is an index that can distinguish areas exposed to greater or lesser environmental deprivation allowing us to explore health associations. On the other hand MEDClass characterises areas according to their shared physical environmental features. By focussing on *type* we are suggesting that profiling the local environment may help us to understand how specific combinations of physical environmental factors can influence health inequalities (Shortt et al., 2011). In the UK we found an association between both measures of the environment and all cause mortality, mortality from certain specific causes, and self-reported morbidity, independent of the level of socio-economic deprivation (Pearce et al., 2010, Shortt et al., 2011).

In this short report we determine whether our MEDClass approach has the potential for international replication. Our key question is whether the approach developed for the UK is valid in other environmental settings. We begin by outlining the steps taken to create NZ-MEDClass, we then consider the relationship between environment type and health in New Zealand and, finally, we reflect on the applicability of adopting such methods in different environmental contexts.

Methods

We first identified health-relevant dimensions of the physical environment for New Zealand. We reviewed national and international empirical evidence to identify factors which may have relevance in a New Zealand context. For inclusion the environmental factors required a plausible and robust association with health and that at least 10% of the population be exposed to the factor. The factors identified in the UK work (air pollution, climate, proximity to polluting industry, ultraviolet (UV) radiation) were also found to be relevant for New Zealand, and no additional environmental factors met the inclusion criteria (Pearce et al., 2011). Green space availability was also included as we sought to balance the international evidence with the sparse research that has been carried out on the relationship between green space and health in New Zealand.

Comprehensive, contiguous and contemporary datasets pertaining to each of these factors were then gathered and assessed for reproducibility and validity (Pearce et al., 2011). Annual mean particulate matter concentrations (PM_{10}), annual average temperature, UV Index, and greenspace coverage data were obtained. No country-wide industrial facilities data were identified, hence this factor was excluded at this stage. Environmental data were rendered to the Census Area Unit (CAU) geography (n = 1860, mean population 2300): the smallest unit for routine health data dissemination in New Zealand. We sought to classify the CAUs based on their level of exposure to the environmental factors, such that all CAUs exposed to a similar type of environment would be grouped together. To prevent the correlated factors UV and average temperature from dominating the classification we used an unrotated principal components analysis (PCA) to summarise them to a single main component, which accounted for 95.44% of the variance in the original variables. We then used two-step clustering in SPSS (SPSS Inc., Chicago IL) to classify CAUs based on their standardised values of PM_{10}, green space and the climate and UV principal component. A six-cluster solution was identified by SPSS as capturing the salient environmental differences most effectively and efficiently. The clusters of this Multiple Environmental Deprivation Classification for New Zealand (NZ-MEDClass) were named based on the environments that they typified.

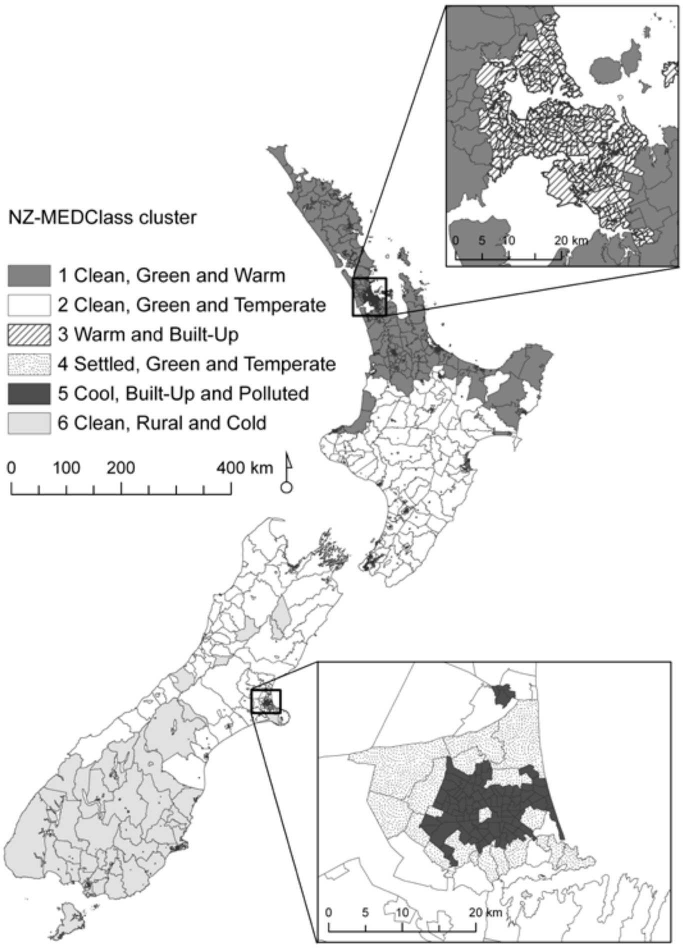
Individual mortality data (including age, sex, cause of death and place of residence at death) were obtained from the Ministry of Health for the 5 year period 1999 – 2003, and were matched to CAUs. Mortality counts for leading causes of death in New Zealand were generated by age group (0-14, 15-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75-84, 85+), sex and CAU. Age- and sex-specific population counts were extracted for each CAU from the 2001 census. The total study population was 3,734,985 (in 2001), with 129,645 deaths from all causes combined (excluding external) over the 5-year period. Three area-level confounders were adjusted for in our analyses; socio-economic deprivation, ethnicity and smoking rates. Socioeconomic deprivation scores from the 2001 New Zealand Deprivation Index (NZDep2001) were extracted for the CAUs (Salmond and Crampton, 2002). CAU-level ethnicity was extracted from the 2001 census (% Māori/Pacific Islander population), and CAU-level average smoking rate was derived from the 1996 and

2006 censuses. Negative binomial regression models were used to investigate the relationship between NZ-MEDClass and risk of mortality, after adjusting for age-group, sex and the area-level confounders.

Results

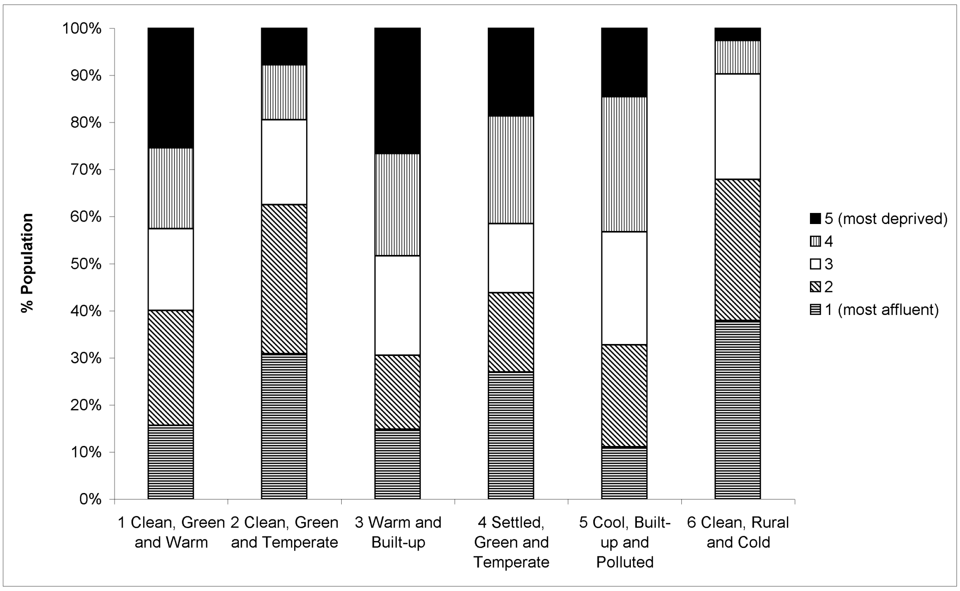
NZ-MEDClass consists of 6 clusters (see Figure 1), three of which were largely rural with high green space availability and little air pollution: Clean, Green and Warm (cluster 1), Clean, Green and Temperate (cluster 2) and Clean, Rural and Cold (cluster 6). Two urban groupings were formed, having high air pollution and low green space availability: Warm and Built-Up (cluster 3) and Cool, Built-Up and Polluted (cluster 5). Cluster 5 was characterised by the highest pollutant levels and lowest greenspace. An intermediate cluster was also formed: Settled, Green and Temperate (cluster 4). These CAUs experienced generally average levels of air pollution, green space and climate, and were found in small settlements or on the periphery of larger settlements such as Christchurch or Wellington.

Figure 1: NZ-MEDClass with insets for Auckland and Christchurch



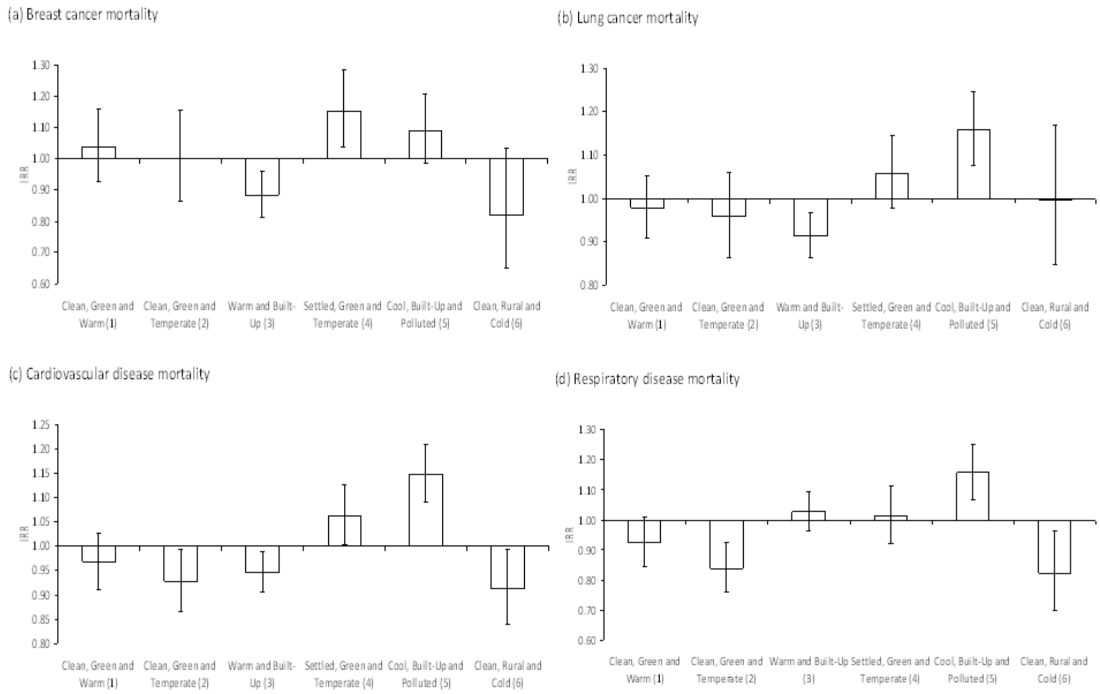
The population was unevenly spread between the clusters with resident population ranging from 127,479 in cluster 6 (Clean, Rural and Cold) to 1,739,832 in cluster 3 (Warm and Built-Up) (see Figure 2). At a coarse resolution the classification divided northern and southern regions, as temperature and UV levels vary along New Zealand's latitudinal axis. At a finer level of resolution differences between urban and rural CAUs were prominent, due to levels of air pollution and green space availability (see Figure 1 insets).

Figure 2: Percentage of population assigned to each NZDep 2001 quintile within each environmental cluster



The IRRs in Figure 3 are the adjusted risks of mortality in each cluster relative to the rest of New Zealand. The largest associations (both protective and harmful) were seen for respiratory disease mortality (IRR range 0.82 to 1.16) and lung cancer (IRR range 0.91 to 1.16). The residents of Cool, Built-Up and Polluted areas (cluster 5) generally had poorer health than the rest of New Zealand, with elevated risks for lung cancer (16%), cardiovascular disease (15%) and respiratory disease (16%). Those in Settled, Green and Temperate areas (cluster 4) also had relatively poor health, while some health risks were significantly reduced in areas classed as Clean, Green and Temperate (cluster 2), Warm and Built-Up (cluster 3) and Clean, Rural and Cold (cluster 6). We found an association with breast cancer in two clusters; an elevated risk in Settled, Green and Temperate areas (cluster 4) and a reduced risk in Warm and Built-Up areas (cluster 3).

Figure 3: Associations between NZ-MEDClass clusters and (a) breast cancer, (b) lung cancer, (c) cardiovascular disease and (d) respiratory disease mortality rates, relative to the rest of New Zealand (IRR = 1.0). Incidence rate ratios (IRRs) were adjusted for age-group, sex, socioeconomic deprivation score (NZDep2001), CAU-level smoking and ethnicity. Bars indicate 95% confidence intervals.



Discussion

Associations between NZ-MEDClass and mortality, whilst significant, were modest. The largest effect size was for respiratory disease. This was unsurprising given the strength of the relationship between respiratory mortality and pollution (World Health Organisation, 2004). Those in Cool, Built-up and Polluted areas had a 16% increased risk whilst those in Clean, Green and Temperate and Clean, Rural and Cold had significantly reduced risks. Lung cancer mortality was also significantly elevated in the most polluted cluster, Cool, Built-up and Polluted (cluster 5, predominantly CAUs in Christchurch), though reduced in the Warm and Built-up cluster (cluster 3, predominantly CAUs in Auckland). This seemingly contradictory relationship with lung cancer rates in two relatively polluted urban clusters reminds us that these clusters represent environment ‘type’; they reflect *combinations* of different aspects of the environment. Thus, whilst both clusters may be labelled ‘polluted’ (though cluster 5 more so) they are distinct in other ways: cluster 5 is colder, has lower UV levels and has marginally less green space. Lower levels of UVB, for example, have been independently associated with a higher incidence of lung cancer (Mohr et al., 2008). Seen in this context of higher pollution levels coupled with lower UV levels, the higher risk of lung cancer is plausible. Furthermore, other environmental risk factors which were not included may also be relevant, including exposure to indoor radon and/or to industrial or chemical pollutants. The UK version of MEDClass included proximity to industrial facilities to account for the latter, however these data were not available for New Zealand. Additionally, whilst these models have adjusted for smoking rates we cannot account for past smoking behaviours. Further adjustments in the model were made for area level deprivation, however, we recognise possible residual confounding from occupational exposure to environmental hazards. Further work could employ individual level data to explore these issues.

The relationship between breast cancer and NZ-MEDClass is intriguing. We found no relationships between environment and breast cancer in our UK studies (Pearce 2010, Shortt 2011) , nor when assessing the environment and health relationships in New Zealand using NZ-MEDIx (Pearce et al., 2011). In this study, we found a decreased risk in the Warm and Built-Up cluster and an increased risk in Settled, Green and Temperate areas. This is probably a function of residual confounding. Whilst we were able to adjust for several of the key risk factors (including age, deprivation, smoking and ethnicity), we could not adjust for them all. In particular, we could not adjust for ‘lifestyle’ risk-factors for breast cancer, such as age of first child, alcohol consumption and physical activity. Further work could explore whether women with more ‘risky’ lifestyles are more likely to live in the environments for which there is elevated risk, and less likely to live in the environments for which there is lowered risk.

Mortality from cardiovascular disease was found to be lower in “clean” or “warm” areas and elevated in settled/built-up mid to low latitude areas (clusters 4 and 5). This is perhaps unsurprising given the established relationship between cardiovascular disease, pollution and cold weather (Thakur et al., 1987, Seaton et al., 1995).

The challenges we faced when transferring our methodology to another country were largely related to data availability rather than that the methods were inappropriate or that they would not work. Our inability to gain data related to proximity to industry was a key problem but, the methodological steps taken to create an environmental classification were easily replicated from our UK study. The selection process which identified the environmental factors to include did require us to explore their relationships with health in a local context. The strength, direction and importance of relationships between an environmental factor and population health may vary by country, thus decisions over the inclusion or exclusion of variables must be made only after local health based analysis. To ignore this vital step would be conceptually weak. The central issue here of cross-country comparative research reminds us of the need to engage locally with place-based research upon which an evidence base of cumulative impacts of the environment can be built.

The framework used to create MEDClass is a useful one that ultimately acknowledges the need to move beyond single environmental stressors to explicitly address the multidimensional nature of the environment, both hazardous and salutogenic. Research that engages with multiple representations of the environment and the pathways through which these interlinking environmental features influence health and wellbeing broadens the field and responds to calls for researchers to engage with the pluralistic nature of the environment. These wider debates within geography and the social sciences have relevance when considering the interlinking of socio-environmental relations suggesting that particular groups may be more vulnerable, or resilient, and that an over-reliance on socio-spatial patterning of exposure may 'obscure inequalities' ((Walker, 2009), p.622).

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References

EVANS, G. W. & KANTROWITZ, E. (2002) Socioeconomic status and health: The potential role of environmental risk exposure. *Annual Review of Public Health,* 23**,** 303-331.

FINKELSTEIN, M. M., JERRETT, M., DELUCA, P., FINKELSTEIN, N., VERMA, D. K., CHAPMAN, K. & SEARS, M. R. (2003) Relation between income, air pollution and mortality: a cohort study. *Canadian Medical Association Journal,* 169**,** 397-402.

JERRETT, M., BURNETT, R. T., KANAROGLOU, P., EYLES, J., FINKELSTEIN, N., GIOVIS, C. & BROOK, J. R. (2001) A GIS - environmental justice analysis of particulate air pollution in Hamilton, Canada. *Environment and Planning A,* 33**,** 955-973.

MOHR, S. B., GARLAND, C. F., GORHAM, E. D., GRANT, W. B. & GARLAND, F. C. (2008) Could ultraviolet B irradiance and vitamin D be associated with lower incidence rates of lung cancer? *Journal of Epidemiology and Community Health,* 62**,** 69-74.

MORELLO-FROSCH, R., ZUK, M., JERRETT, M., SHAMASUNDER, B. & KYLE, A. D. (2011) Understanding The Cumulative Impacts Of Inequalities In Environmental Health: Implications For Policy. *Health Affairs,* 30**,** 879-887.

PEARCE, J., RICHARDSON, E. A., MITCHELL, R. & SHORTT, N. K. (2011) Environmental justice and health: A study of multiple environmental deprivation and geographical inequalities in health in New Zealand. *Social Science & Medicine,* 73**,** 410-420.

PEARCE, J. R., RICHARDSON, E. A., MITCHELL, R. J. & SHORTT, N. K. (2010) Environmental justice and health: the implications of the socio-spatial distribution of multiple environmental deprivation for health inequalities in the United Kingdom. *Transactions of the Institute of British Geographers,* 35**,** 522-539.

RICHARDSON, E. A., MITCHELL, R., SHORTT, N. K., PEARCE, J. & DAWSON, T. P. (2010) Developing summary measures of health-related multiple physical environmental deprivation for epidemiological research. *Environment and Planning A,* 42**,** 1650-1668.

SADD, J. L., PASTOR, M., MORELLO-FROSCH, R., SCOGGINS, J. & JESDALE, B. (2011) Playing It Safe: Assessing Cumulative Impact and Social Vulnerability through an Environmental Justice Screening Method in the South Coast Air Basin, California. *International Journal of Environmental Research and Public Health,* 8**,** 1441-1459.

SALMOND, C. & CRAMPTON, P. (2002) NZDep2001 Index of Deprivation. IN DEPARTMENT OF PUBLIC HEALTH, W. S. O. M. A. H. S. (Ed.) Wellington.

SEATON, A., MACNEE, W., DONALDSON, K. & GODDEN, D. (1995) PARTICULATE AIR-POLLUTION AND ACUTE HEALTH-EFFECTS. *Lancet,* 345**,** 176-178.

SHORTT, N. K., RICHARDSON, E. A., MITCHELL, R. & PEARCE, J. (2011) Re-engaging with the physical environment: a health-related environmental classification of the UK. *Area,* 43**,** 76-87.

SU, J. G., MORELLO-FROSCH, R., JESDALE, B. M., KYLE, A. D., SHAMASUNDER, B. & JERRETT, M. (2009) An Index for Assessing Demographic Inequalities in Cumulative Environmental Hazards with Application to Los Angeles, California. *Environmental Science & Technology,* 43**,** 7626-7634.

THAKUR, C. P., ANAND, M. P. & SHAHI, M. P. (1987) COLD WEATHER AND MYOCARDIAL-INFARCTION. *International Journal of Cardiology,* 16**,** 19-25.

WALKER, G. (2009) Beyond Distribution and Proximity: Exploring the Multiple Spatialities of Environmental Justice. *Antipode,* 41**,** 614-636.

WORLD HEALTH ORGANISATION (2004) Health aspects of air pollution: results from the WHO project "Systematic review of health aspects of air pollution in Europe". Geneva, World Health Organisation.