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Individual, family, and area predictors of BMI and BMI change in an adult Norwegian population: Findings from the HUNT study

Erik Reidar Sund [a,*], Andy Jones [b], Kristian Midthjell [c]

[a] Department of Geography, Faculty of Social Sciences and Technology Management, Norwegian University of Science and Technology, Trondheim, Norway
[b] School of Environmental Sciences, University of East Anglia, Norwich, Norfolk, NR4 7TJ, United Kingdom
[c] HUNT Research Centre, Department of Public Health and General Practice, Norwegian University of Science and Technology, Verdal, Norway

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ABSTRACT

The global obesity epidemic is a major public health concern and there is strong evidence that the drivers are varied and operate via diverse pathways. Taking a systems approach allows the contextual influences operating upon the individual to be identified and quantified. We adopt such a perspective in this study, where longitudinal data from a cohort of 24,966 settled individuals participating in two major health surveys, the Nord-Trøndelag Health Study (HUNT 1 and 2) in the county of Nord-Trøndelag, Norway, were used to investigate associations between individual, family and area characteristics and two outcomes: body mass index (BMI) at follow-up and BMI change over an 11 year period. Linear multilevel models were fitted, with individuals nested in 17,500 families, 447 wards and 24 municipalities. A range of putative individual, family, and area predictors were tested. We found both outcomes were strongly associated with individual characteristics, with higher BMIs generally being amongst males, unmarried participants, non-smokers, those of lower education and those undertaking physically demanding work but participating in less physical activity outside work. The characteristics of those in the sample exhibiting higher BMI gain were rather similar except that women gained more and those with no employment income gained less. Contextual influences were also found to be important: although just 1% of the unexplained variance was located on the neighbourhood and municipality levels respectively, and hence suggesting small environmental influences, between 10 and 13% could be attributed to families, highlighting the importance of the familial contextual environment. Rather little is known about the manner by which family influences may operate on bodyweight hence further work is needed to understand likely mechanisms and guide future interventions.

Introduction

The increasing prevalence of obesity has been described as an epidemic process (James, 2008) and is now a major driver behind rises in the prevalence of certain chronic diseases and disabilities worldwide. Recent projections from the World Health Organisation (WHO) estimate that globally 1.6 billion adults were overweight and at least 400 million were obese in 2005, with these figures expected to grow to 2.3 billion and 700 million by 2015 (WHO, 2006). In Europe current trends are expected to give rise to 150 million obese adults by 2010 (Branca, Nikogosian, & Lobstein, 2007). The annual rate of increase in childhood obesity in this region is a particular cause for concern, with the current prevalence being over 10 times higher than in 1970 and with 15 million children expected to be obese by 2015 (Branca et al., 2007). Indeed, some have forecasted that youths of today may, on average, live less healthy and possibly even shorter lives than their parents (Olshansky et al., 2005).

In a recent WHO publication, Branca et al. (2007, p. xiii) state that "obesity presents Europe with an unprecedented public health challenge that has been underestimated, poorly assessed and not fully accepted as a strategic governmental problem with substantial economic implications". The authors further note that the prevention of obesity requires innovative environmental approaches. The term "obesogenic environment" refers to the role environmental factors may play in determining food intake and physical activity, both important determinants of bodyweight (Jones, Bentham, Foster, Hillsdon, & Panter, 2007). Swinburn and colleagues have defined the concept as "the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations" (Swinburn, Egger, & Raza, 1999, p. 564). These authors have further described the

* Corresponding author. Tel.: +47 73591922; fax: +47 73591878.
E-mail address: erik.r.sund@svt.ntnu.no (E.R. Sund).

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environment in terms of micro and macro components, where micro-environments are defined as settings that influence peoples' interactions (e.g. home, school, workplace, and neighbourhood) which are themselves influenced by macro-environments (e.g. the education and health system, government policy and society's attitudes and beliefs).

The concept of an obesogenic environment is grounded in a systems perspective where health related behaviour is contextualised in the environment within which it takes place. The advancement of the concept has been driven by the development of ecological models which suggest that weight related behaviours, such as food intake and physical activity, arise as the result of the combined action of psychosocial, demographic, as well as physical environmental processes (Diez Roux, 2007; Van Dyck, Deforche, Cardon, & De Bourdeaudhuij, 2009).

Numerous different environmental factors at various geographical scales have been put forward as potential determinants of overweight and obesity (Black & Macinko, 2008). There is some evidence of an effect of income inequality, with Pickett and colleagues (Pickett, Kelly, Brunner, Lobstein, & Wilkinson, 2005) finding a positive association between income inequality and rates of obesity in 21 developed countries, whilst Holtgrave and Crosby (2006) found higher levels of social capital in US states to be associated with a lower prevalence of obesity. At the neighbourhood level, many studies in the US (e.g. Diez-Roux, Link, & Northridge, 2000; Janssen, Boyce, Simpson, & Pickett, 2006; Rundle et al., 2008), UK (e.g. Moon, Quarendon, Barnard, Twigg, & Blyth, 2007) and in Canada (e.g. Ross et al., 2007) have reported that high material deprivation levels are associated with elevated adult obesity prevalence.

A large amount of research evidence on the role of the physical environment is available. A recent review of predominantly US studies found that the majority reported an association between some aspect of the neighbourhood built environment and obesity, with associations with features such as the walkability of neighbourhoods and the accessibility of greenspaces being found (Papas et al., 2007). In addition to objectively measured features, the findings of a recent meta-analysis support the view that perceptions of the neighbourhood environment, such as those regarding safety and the accessibility of destinations, are also important (Duncan, Spence, & Mummery, 2005).

A contextual unit rarely acknowledged in the obesity literature is the family or household. Yet here is compelling evidence in support of interventions at the parent or family level in paediatric obesity research (Zeller et al., 2007). Parental obesity has a strong predictive power in the development of child and adolescent obesity, arguably with a genetic component, but there are also studies suggesting that there are indeed modifiable determinants operating at this contextual level (Krahnstoever Davison, Francis, & Birch, 2005). These could include the availability of foods, and the provision of familial social support for physical activity, and weight management practices.

There is strong evidence that the drivers of the epidemic are varied and operate via diverse pathways. Systems approaches (see Bailey, 1994) to exploring health behaviour causation can be useful in such situations, as they allow the outcomes of individual actions to be examined within the social and environmental contexts within which the individual operates. We adopt such a perspective in this study, where the aim is to contribute to an understanding of how environments may directly and indirectly affect behaviour and how such behaviour is ultimately expressed in terms of bodyweight. This is done firstly by quantifying variation in body mass index (BMI) and changes in BMI associated with individual, family, and area characteristics. Secondly we try to explain how the composition of individuals in families and areas may account for this variation. Finally we test how contextual features like family and area socioeconomic status, and area deprivation and social capital may explain variability in the outcomes not associated with characteristics of individuals. The research is longitudinal, utilising anthropometric height and weight measurements from two time points amongst a large and settled adult population from the county of Nord-Trøndelag in Norway.

Methods

Data sources

The Nord-Trøndelag Health Study (HUNT) is one of the world's largest population health surveys. The first wave (HUNT 1) was carried out in 1984–1986. All residents of Nord-Trøndelag County in Norway aged 20 or above were invited to participate in the study which included a physical examination and self-completed questionnaires. Questionnaire 1 was attached to the invitation letter, and 74,977 (88.1%) of the 85,100 eligible persons completed and returned it when they attended. Of these, 74,332 (99.1%) had reliable height and weight measurements recorded with light clothes and without shoes by specially trained nurses. During the clinical investigation, participants were given a second questionnaire to complete and return by mail. This collected information on sociodemographic and behavioural issues (education, alcohol intake, smoking, lifestyle issues, and functional impairment) and was returned by 53,016 (70.7%) of the study members. More detailed descriptions of the methods in HUNT 1 are provided elsewhere (Holmen et al., 1990).

The second wave of HUNT (HUNT 2) was carried out in the same geographic region as HUNT 1 in the period 1995–1997 (Holmen et al., 2003). Similar methods for measuring height and weight were used. A total of 47,048 (72%) of the participants in HUNT 2 had also participated in HUNT 1. Data linkage between HUNT 1 and HUNT 2 was undertaken via the national Norwegian 11 digit unique personal identification number. This number was also used to link every individual to National statistics' registries from which we derived information on place of residence (ward number), family identification number, education and income data. These registries do not however, contain information on the entire follow-up period, but only for the four years preceding the second wave of HUNT. The exception is education for which there is information dating back to 1970. All data linkages were undertaken by a third party and preserved participant anonymity. The Norwegian Data Inspectorate and the Regional Committee for Ethics in Medical Research approved the protocols for HUNT 1 and HUNT 2. The protocol for this study was approved by the Regional Committee for Ethics in Medical Research and the HUNT Publication Review Board approved the manuscript.

The present study, carried out in 2009, includes men and women 25–64 years old at baseline (HUNT 1) and who participated in HUNT 2 eleven years later. Of the 47,048 participants attending both waves 24,966 were eligible for inclusion here. After excluding 7605 individuals who were outside the age-range 25–64 years and 853 (2%) with missing weight or height measurements from any of the two waves we were left with 38,590 individuals. From these we excluded 9447 individuals who had missing values on any of the covariates from the baseline survey (24%). In addition we left out 4152 individuals (11%) who had changed municipality of residence between the waves (or changed ward number or family number in the period 1992–1995) and 25 individuals (~0.1%) who had an error in municipality and ward coding. Norwegian municipalities are administrative units with an average population in 1998 of 10,155. Wards are a lower level statistical unit nested within the municipalities, with an average of 322 inhabitants in 1998. The