Tiina Lankila

RESIDENTIAL AREA AND HEALTH

A STUDY OF THE NORTHERN FINLAND BIRTH COHORT 1966
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A study of the Northern Finland Birth Cohort 1966

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Abstract
Sparsely populated Finland is an interesting area for studying the effects of population density and distance on health. Previous studies indicate health problems in rural and remote areas. Aim is to study the importance of local residential area to health of young adults: how the residential area is associated with health, what is the role of geographical distance and how health is associated with moving.

Study utilises the 31-year follow-up data from the Northern Finland Birth Cohort 1966 study, initially including all children born in the provinces of Oulu and Lapland in 1966. Local residential area is defined with 1 km² population density grid data. Distances to municipality centre or health centre are calculated using Finnish road network data (Digiroad). Perceived health in rural and urban areas is studied with ordinal logistic regression; body mass index (BMI) and overweight in relation to distance to municipality’s centre and population density using a generalised additive model. Role of distance in health centre use and distance-related inequity are studied with negative binomial regression and concentration indices, and health’s association with moving in multinomial logistic regressions.

Poor perceived health increased from densely to sparsely populated areas. Among rural men adverse psychosocial and lifestyle factors were behind the associations, among women reasons for poor health in scattered settlement areas remained unclear. BMI and overweight increased at distances greater than 5 kilometres from municipality centre and with decreasing population density. No barrier effects of distance or distance-related inequity in the health centre use was found. Dissatisfaction with life and history of morbidity were associated with rural-urban moves, activity limiting illness with rural-rural moves, and frequent use of health services with all urban moves.

Geographical distance was not a major barrier in health service use among young adults. Individual’s health status was linked with moving and may be relevant for rural-urban health inequalities. Local health variations within small administrative areas can be identified by grid-based data, indicating the need of customised interventions. Urban sprawl may affect people’s bodyweight, also urging health-based planning of residential areas. Longitudinal perspective would improve predictive value of findings.

Keywords: cohort study, distance, epidemiology, geoinformatics, health inequality, medical geography, migration, Northern Finland, population density, residential area, rural area
Tiivistelmä

Harvaan asuttu Suomi on kiinnostava alue väentihyden ja etäisyyden terveysvaikutusten tutkimiselle. Aiempien tutkimusten mukaan maaseutumaisilla ja syrjäisillä alueilla on monia terveysongelmia. Tutkimuksen tarkoituksena on selvittää asuinympäristön merkitystä nuorten aikuisten terveydelle: miten asuinympäristö on yhteydessä terveyteen, mikä rooli etäisyydellä on ja miten terveys on yhteydessä muuttamiseen.


Asiasanat: asuinympäristö, asukastiheys, epidemiologia, etäisyys, geoinformatiikka, kohorttitutkimus, maaseutu, muuttoliike, Pohjois-Suomi, terveyserot, terveysmaantiede, väestö
To my family.
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Abbreviations

BMI  body mass index
HI   inequity index
CI   confidence interval
C_{need} concentration index for need
COR cumulative odds ratio
C_{use} concentration index for use
GAM generalised additive model
GIS geographical information system
IRR incidence rate ratio
MAUP modifiable area unit problem
NFBC Northern Finland Birth Cohort
OR odds ratio
List of original publications

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1 Introduction

The importance of geographical context to human well-being and health has been acknowledged for a long time; already Hippocrates (c. 460–377 B.C) noted the importance of the environment for human health (Solin 1986). This view stayed important in medicine until the middle of the 19th century, when the germ theory, “the doctrine of specific aetiology”, became dominant and replaced the emphasis of place in disease aetiology. After the World War II, when especially in industrialised countries infectious diseases had experienced a decline, the non-communicable diseases, which had no specific aetiology, emerged as major causes of ill-health and death. Biological, cultural, social and environmental factors were once again seen to be important for the health of population, and theories about society and cultural behaviour were needed (Meade & Emch 2010). Cultural-environmental interactions are important for disease aetiology, health promotion, and health service provision and they are a core study in medical geography (Meade & Emch 2010). Medical or health geography has evolved from the studies having focus on biomedical model of health and the studies of disease and health care services in certain places, to the studies of broader social models of health and health care and the extent to which place matters for these (Kearns & Collins 2010, Kearns & Moon 2002). It is now widely accepted that populations’ and individual’s health is shaped by personal, cultural and environmental conditions (e.g. Dahlgren & Whitehead 1991, CSDH 2008).

The place of residence can influence health in multiple ways: environmental contamination, health monitoring and available care, access to basic resources such as healthy food, clean water, adequate housing, rewarding work and social relationships and possibilities of outdoor recreation are geographically differentially distributed and affect the risk of disease or ill-health and thus the well-being (Gatrell & Elliot 2009). The context or environment can directly influence health (e.g. pollution) or the influences can come indirectly via, for example, health behaviour. Also individual characteristics can make people more or less susceptible to the contextual influences (Curtis & Rees Jones 1998, Diez Roux 2002, Balfour & Kaplan 2001).

Health differences among young adults may also predict the health and well-being differences at the later part of life. The self-reported health status and the limiting long-standing illness level have been found to be relatively stable (Manor et al. 2001, Miilunpalo et al. 1997). The area inequalities in health and well-being
in Finland have been quite stable as well, though there is also evidence that some differences are increasing, at least at the municipality level (e.g. Ohinmaa et al. 1996, Kainulainen et al. 2001, Karvonen & Kauppinen 2009, Karvonen & Rintala 2005). Understanding the mechanisms through which the place affects health, is important for identifying potential arenas for intervention (Cummins et al. 2007). Finding a potential causal link between the residential area and the health would have implications for the disease prevention and the health policy (Diex Roux 2002).

Northern Finland suits well for studies concerning the interplay of residential area and health, because many health and social adversities are pronounced in northern sparsely populated areas. The Northern Finland Birth Cohort 1966 (NFBC 1966), a longitudinal study of all children born in the two Northern provinces (Oulu and Lapland) in Finland in 1966, has been studied extensively, but so far the geographical study has been scant. Already Rantakallio (1986) noted the inequalities in childhood mortality between rural and urban areas. Studies addressing the cohort from a geographical point of view include: a municipality report of life situation, employment and health in Northern Finland (Vehkakoski et al. 2001), a study of decreased workability in different municipalities in urban-rural scale (Kujala et al. 2006), a study on life satisfaction and self-reported health among rural and urban migrants (Ek et al. 2008), an abstract on migration and educational attainment (Larivaara et al. 2002) and two master’s thesis: one on the regional variation in social exclusion (Kovala 1999) and the other on the geography of stress (Ponto 2009).

The spatial scale is important when studying the importance of residential area to health. There are some findings supporting the idea that local conditions may be more important to health and health behaviour of individuals than large regional areas (e.g. Blaxter 1990, Haynes et al. 2007, Karvonen 1997). The contextual effects start playing a greater role only at a relatively low level of locality, and at a very broad level, socio-demographic characteristics are important (Karvonen 1997).

The aim of this study is to investigate the importance of small-scale residential area (one-square-kilometre grid) to health and well-being of young adults. More detailed information is needed about the regional differences and their impact on people’s life and living conditions. The health differences have never before been studied in such a small area as in this study. Neither has the variation of the body mass index (BMI) in relation to actual road distances from the individual’s home to the municipality centre, nor the inequity of the use of the
health centre services in relation to actual road distances from individual’s home to municipality’s health centre been studied before in Finland. Both have potential implications for health: the former through positive effects of everyday physical activity to BMI and individual’s health, and the latter via potential barrier effects of distances for the use of the health services. The studies examining the role of health status in rural-urban migration process are few, also internationally, though the importance of health selective migration for health inequalities between areas has been recognised (e.g. Connolly et al. 2007, Verheij 1996).

1.1 Population health

Population health can be defined as the health outcomes of a group of individuals, including the distribution of such outcomes within the group (Kindig & Stoddard 2003). Population health has multiple determinants of health outcomes, which interact with each other: medical care, public health interventions, aspects of the social environment (e.g. income, education, employment, social support, culture), aspects of the physical environment (e.g. urban design, clean air and water), individual behaviour, biology and genetics (Kindig & Stoddard 2003, Kindig 2007). Also Aromaa et al. (2005) state that people’s health and ability to function depend on personal characteristics, living conditions, living habits and the interplay between these, and are also affected by prevention, early detection and treatment of disease and rehabilitation.

According to Harding & Taylor (2002) the individual’s health is shaped by personal, social, cultural and environmental conditions. In Western societies economic stratification is particularly significant in determining health, and socio-environmental influences are pronounced for the socially disadvantaged. Education is one important aspect of the socioeconomic status and there is a positive association with high education and health. The high educational attainment has been found to improve health directly and also indirectly through work and economic conditions, social-psychological resources and healthy lifestyle, including the use of medical care (Ross & Wu 1995, Pampel 2010). Similarly employment and high income are positively associated with health (Lahelma et al. 2004, National Research Council 2006, Ross & Mirowsky 1995, Wilkinson & Marmot 2003). Socioeconomic status from birth to early adulthood has also been found to have a cumulative effect on poor health (Power et al. 1999).
Social relations, such as social capital, support and networks, and psychosocial factors have been found to be associated with health status and even mortality (Dalgard & Lund Håheim 1998, Cohen 2004, Molarius et al. 2006, National Research Council 2006). Social connections benefit health by helping to cope with stress, and through social control and peer pressure that influences normative health behaviours (Cohen 2004). Social integration may benefit health also by influencing one’s sense of self. On the other hand social networks may also have adverse features, which increase the risk of poor health, and for example social isolation may induce ill-health (Cohen 2004). The lack of social support and social participation has been associated with poor health (Dalgard & Lund Håheim 1998, Molarius et al. 2006), and loneliness with a variety of health conditions (e.g. Heinrich & Gullone 2006).

As already noted, both the socioeconomic status and social relations are associated with health behaviour and lifestyle, and may in this way influence the overall health status (e.g. Cohen 2004, Lantz et al. 1998, Pampel et al. 2010, Ross & Wu 1995, Weyers et al. 2010). The health behaviour has been found to be associated with health; the adverse health behaviour such as smoking, physical inactivity, and the consequences such as obesity or underweight being associated with poor health (e.g. Kasmel et al. 2004, Molarius et al. 2006, Puska 2002). Also the use of health services can be regarded as one form of health behaviour, which is affected by personal characteristics but also by cultural, financial and distance-related difficulties in accessing health services (e.g. Arcury et al. 2005, Carr-Hill et al. 1996, Goddard & Smith, 1998).

1.2 Place effects on health

As Macintyre et al. (2002: 128) put it:

“...rather than there being one single universal “area effect on health” there appear to be some area effects on some health outcomes, in some population groups, and in some type of areas.”.

Several findings support the idea that where you live matters to your health in addition to the personal characteristics that you have (e.g. Picket & Pearl 2001). Macintyre et al. (1993, 2002) and Curtis and Rees Jones (1998) have suggested that material and infrastructure and socio-cultural features of an area can be important to health. For example, Cummins et al. (2005) have found that the poor physical quality of the residential environment, left-wing political climate, low
political engagement, high unemployment, lower access to private transport and the low number of high cost cars were associated with poor self-reported health. Stafford et al. (2005) gained similar results, though the associations with health were greater magnitude for women than men. In a Swedish study, living in areas with predominantly large blocks of flats or outside city centre and residential mobility were associated with poor self-rated health (Lindén-Boström et al. 2010). Picket and Pearl (2001) reported in their review that many studies showed an association of neighbourhood deprivation with mortality and morbidity. The multiple indicators of environmental deprivation, the presence or absence of physical environmental conditions, such as air pollution, noise pollution, traffic, undesirable land uses and crime, have also been associated with poor health (e.g. Richardson et al. 2012). A Finnish study by Kureniemi and Törmänen (2003) reported that high mortality in city districts in Helsinki was found in areas with high levels of traffic, noise and air impurities, mixed housing and industries, scarcity of good quality parks and poor connections to recreational areas, indicating the possible importance of residential environment to health. High carbon monoxide level has also been associated with all-cause and ischaemic heart disease mortality (Pönkä & Virtanen 2000).

The contextual effects of low social capital, the features of social organization that facilitate cooperation for mutual benefit, have been associated with the risk of poor self-reported health (Kawachi et al. 1999). In a study of Cattell (2001), the features of the neighbourhood context (e.g. its history, services, facilities, housing, opportunities for casual meeting and participation in associations and the reputation) were important to social networks and social capital, which contribute to health and well-being. Greiner et al. (2004) reported that the self-assessed health and physical activity were positively and smoking and depressive symptoms negatively associated with community ratings (perceived goodness as a place to live) and physical activity also positively associated with community involvement (participation in groups addressing community problems). Wilson et al. (2004) and Karvonen and Rintala (2006) have found that people’s perceptions of physical and social environment are important for health, as the neighbourhood dislikes were associated with poor health and likes with good health.

Relating to physical activity and bodyweight, it has been observed that bodyweight is associated with urban sprawl characterised by dependence on private cars, inadequate walkability of streets and roads and poor accessibility of well-equipped food stores (Garden & Jaludin 2008, Lovasi et al. 2009, McCann & Erving 2003, Smith et al. 2008). It has been suggested that the life style in rural
and semirural areas could be less active, because integrating physical activity to leisure time and daily activities can be difficult in those areas (Eberhardt & Pamuk 2004, Riva et al. 2009). Frank et al. (2007) have observed that creating walkable environment for those who prefer walkability, may result in higher levels of physical activity, less driving and slightly lower obesity prevalence. Stafford et al. (2007) found that in United Kingdom low levels of neighbourhood disorder, presence of local services such as pharmacies, opticians and dentists, proximity to postal office and high population density were associated with low levels of obesity. Studies have observed more overweight among people living far from or having poor access to supermarkets and shops (Giles-Corti et al. 2003, Liu et al. 2007, Yamada et al. 2012), recreational facilities (Boehmer et al. 2006, Giles-Corti et al. 2003, Gordon-Larsen et al. 2006), bike paths (Petrella et al. 2008), employment establishments and business centres (Yamada et al. 2012) and among those having few non-residential destinations (Boehmer et al. 2006). On the other hand, easy access to green areas (Bell et al. 2008, Nielsen & Hansen 2007) and healthy food stores or supermarkets (Larson et al. 2009, Rundle et al. 2009, Zick et al. 2009) have been associated with less overweight.

Distance and remoteness have been found to be one important factor potentially affecting the use of health services. A study by Nyman (1982) found that the differences in the use of outpatient doctor services in different municipalities and regions in Finland were attributable to the relative number of doctors in the area and to the distance to doctor services, so that areas with fewer and more distant doctor services had lower use of those services. Elsewhere, people living far away from GP and in rural areas have been found less likely to see a doctor than their counterparts living closer or in urban areas (e.g. Arcury et al. 2005, Carr-Hill et al. 1996, Goddard & Smith 1998, Hiscock et al. 2008, Haynes et al. 1999, Haynes & Bentham 1982, Nemet and Bailey 2000). Longer distance to health care providers has been reported to reduce regular check-up visits, but not visits made for acute or chronic illness (Arcury et al. 2005), and to reduce acute, psychiatric and geriatric episodes in hospitals, even after needs and service provision are controlled (Haynes et al. 1999) and among rural elderly to reduce physician utilisation (Nemet & Bailey 2000). Longer travel time to a GP practice has been found to result in fewer consultations, especially in rural areas (Hiscock et al. 2008). One study (Turnbull et al. 2008) also reported that call rates to out-of-hours services declined with increasing distance and rurality.

Migration is one factor that can affect person’s health, but also health may promote or hinder moving. The characteristics of a place can either push or pull
migrants depending on, what amenities they wish to use and how able they are to use them. In Finland, poor accessibility to social, health and public services was found to be one motive for moving among people, who were living in sparsely populated country districts and contemplating moving (Heikkilä et al. 2003). Some studies have also observed that people moving from less- to more-affluent areas are healthier, whereas those moving from more- to less-affluent areas are less healthy than those who do not move (Curtis et al. 2009, Martikainen et al. 2008, Norman et al. 2005, van Lenthe et al. 2007). Many studies have associated the good health with the readiness to move (e.g. Bentham 1988, Boyle et al. 2002, Lu 2008, Norman et al. 2005, Connolly et al. 2007, Cox et al. 2007), though others have observed that those with poor health, are the ones who move (e.g. Bentham, 1988, Larson et al. 2004, Lix et al. 2006, Verheij et al. 1998). According to some studies, it is the short distance movers that are less healthy than non-movers (e.g. Boyle et al. 2002, Norman et al. 2005).

There are few studies addressing the effects of health on moving specifically in rural-urban dimension (e.g. Ek et al. 2008, Larson et al. 2004, Lix et al. 2006, Riva et al. 2011, Stockdale & Catney 2014, Verheij et al. 1998). In a Northern Irish study (Stockdale & Catney 2014) people with limiting long-term illness were more likely to move to urban areas than those without such a condition. In a study by Larson et al. (2004) of middle-aged Australian women, chronic illness and poor mental health were associated with the moves between postal areas, long-term debilitating illness with local moves and the frequent use of health services with the moves to urban areas. In the same study, however, associations with self-reported health and moving were not found. Also, a Canadian study of persons with a severe mental illness did not find significant differences in moving between regions or from rural to urban areas (Lix et al. 2006). Poor health may also restrain moving, as an Australian study (Moorin et al. 2006) reported that onset of a serious disease reduced the migration of rural populations to service centres. Verheij et al. (1998) observed that young people with relatively bad perceived health were less inclined to move in urban areas, but those with high number of health complaints were more likely to move. Riva et al. (2011) found that in England migrants in general and rural in-migrants in particular, had better mortality outcomes than less mobile groups. Ek et al. (2008) found that among NFBC 1966 members, the moving from rural to urban areas was a protective factor against poor self-reported health, while women moving from urban to rural areas were more likely to have poor self-reported health. These associations were, however, explained by a range of psychosocial factors.
The studies considering the effects of residential area on health and well-being, have so far used administrative areas, such as municipalities (e.g. Karvonen & Rintala 2006), which are rather large, or sometimes city districts (e.g. Kureniemi & Törmänen 2003, Valkonen & Kauppinen 2001) in Finland. Also elsewhere, the local residential area has been quite often defined based on administrative boundaries or postal delivery areas such as census tracts, electoral wards, counties or postcode sectors (Macintyre et al. 2002). Though there are studies considering the areal variation of bodyweight in rural-urban scale in Finland (e.g. Fogelholm et al. 2006, Jokela et al. 2009, Lahti-Koski et al. 2008, Leino et al. 2000, Pietinen et al. 1996), so far there has not been a study considering the effects of distance on bodyweight or BMI. However, the distance has been related to other forms of health behaviour. A study by Halonen et al. (2012) found that proximity of a bar increased the odds of risky alcohol behaviour among Finnish working-aged men and women, with the longitudinal analysis suggesting that the association may be causal. Similarly, studies considering the health service use in relation to distance in Finland have been scarce, though elsewhere there is evidence that the growing distance may hinder the use of health services. However, many of these studies, which have distinctly measured distance to services, have used the distance from area centre assigning the same distance to all patients living in a certain area (e.g. Haynes et al. 1999, Hiscock et al. 2008), some have used a straight line distance from the patient’s address to the nearest open primary care centre (Turnbull et al. 2008), some the self-reported distance from home to the doctor (Nemet and Bailey 2000, Nyman 1982), and only few have used distances calculated along the road network (Arcury et al. 2005). There is also a lack of studies considering the effects of health status in the rural-urban migration processes in Finland, and also internationally, though it has been noted that migration of people is important for the health differences between areas (e.g. Connolly et al. 2007, Verheij 1996).

1.3 Studies on areal health differences in Finland

Finland is a subarctic, sparsely populated country. The population density in the study year 1997 was 17 inhabitants per square kilometre, in the province of Oulu and Lapland population densities were eight and two inhabitants per square kilometre respectively. Total land area of Finland is 338,435 km², of which 30% is inhabited. Especially in the far north, some of the settlements are located as far as 100 kilometres or more from the local municipality centre. The population is
concentrated in southern Finland and in few population centres elsewhere, as the sparsely populated rural areas have experienced population loss since the 1970s (Gloersen et al. 2005, Rusanen et al. 2003). In 1997 Finland was divided into 452 local government areas, municipalities, some of them (105 in 1997) are referred to as towns and rest are country communes.

The resolution of the studies of areal health differences in Finland stems from the vast regional differences on provincial or county level to municipality level and smaller city districts. Only few studies have so far used the grid-level approach. Some of the previous studies concerning the area differences in health, health behaviour and health service use on different spatial levels in Finland are briefly reviewed to get some overview of the known areal differences. In Finland, the differences in health and well-being, between the Northern and Southern areas and, on the other hand, between the rural and urban or densely populated centres and sparsely populated remote areas have been acknowledged since the 1950’s (Karvonen & Kauppinen 2009, Riihinen 1965).

Northern and eastern parts of Finland stand out as deprived areas health wise (e.g. Karvonen & Rintala 2006, Klaaukka 1982, Näyhä & Järvelin 1998). Already Kannisto (1947) showed the mortality difference between Eastern and Western Finland. The life expectancy is lower, chronic morbidity higher, disability pensions more common and poor self-reported health more prevalent in Northern and Eastern Finland than in Southern and Western Finland (Arinen et al. 1998, Koskinen 1994, Martelin et al. 2005, Nummela et al. 2000). Also serious mental disorders have been found to be most prevalent in the east and north (Marteling et al. 2005), though some have found higher occurrences in the south and in Helsinki metropolitan area (Aaljoki et al. 2000, Arinen et al. 1998, Nummela et al. 2000). Regional differences in health behaviour give a little more mixed picture, as there are both negative and positive features in the north (smoking and unhealthy diet is common, but so is recreational physical activity) and south (smoking and use of alcohol are most prevalent, but overall diet healthier and number of overweight people smaller than elsewhere) (e.g. Arinen et al. 1998, Nummela et al. 2000). Also the use of health services has been found to be higher in the Helsinki metropolitan area than elsewhere in Finland (Arinen et al. 1998, Klavus 2010).

To clarify the earlier studies on mortality, based on large provinces, Koskinen et al. (1983) studied the regional differences in cardiovascular diseases and other causes of death in 40 smaller areas, with a population at least 50,000. Later Joensuu (1989) studied the ischaemic heart disease in 217 small areas aggregated
from municipality data. The incidence of ischaemic heart disease, acute myocardial infarction and mortality from these causes were found to be high in the north-east and low in the south-west, dividing line being quite distinct. The adverse socio-economic conditions were associated with these outcomes. Study by Näyhä (1989) using the municipality data found a similar pattern, a frontier of high and low mortality zone running in central Finland from north-west to south-east, the high occurrence being in the north-west areas. However, cardiovascular mortality was found to be extremely high in Northern Ostrobothnia, Northern Karelia and frontier area in central Finland, which modified the notion that cardiovascular mortality was highest in Eastern Finland. Earlier study by Näyhä (1987) also showed that there were clusters of mortality inside Lapland at municipality level. The reasons for ischaemic heart disease mortality cluster, violent death cluster and high mortality cluster in the city of Kemi remained unclear, though selective migration and post-war social ill-being were potential factors. Vehkakoski et al. (2001) found that among the NFBC 1966 members living in Northern Finland poor perceived health was most common in some western municipalities in the provinces of Oulu and Lapland. There was no clear area difference in how much symptoms or illness were interfering people's lives. Smoking was most common in the middle parts of the provinces of Oulu and Lapland, and use of alcohol was greatest in middle and eastern parts of Lapland and in area extending from Oulu to Kajaani. There were no distinct area differences in the prevalence of overweight, though the relative number was high in Kainuu region.

Based on studies in rural and urban administrative areas (municipalities), the self-reported health is poorer, long-term illness more prevalent and age adjusted mortality higher in rural than in urban areas (e.g. Ek et al. 2008, Karvonen & Kauppinen 2008, Karvonen & Rintala 2006, Klaukka 1982, Näyhä & Hassi 1999). Differences in well-being and how it forms have been found to exist between urban and rural municipalities, but also between different rural municipalities (e.g. Kainulainen et al 2001, Karvonen & Rintala 2005, Karvonen & Rintala 2007, Rintala & Karvonen 2003). Relating to health behaviour, BMI has been found to be lower in urban than in rural areas (Fogelholm et al. 2006, Jokela et al. 2009, Lahti-Koski et al. 2008, Leino et al. 2000, Pietinen et al. 1996). Study by Näyhä et al. (1993), also revealed some areal BMI differences among reindeer herders in Northern Finland reindeer herding districts. These studies have been based on administrative areas, except of the study by Jokela et al. (2009) which used also self-reported rural-urban status and study by Lahti-Koski
et al. (2008), which used 10 km x 10 km grids. Those living in city centres have been found to use more health services than those living elsewhere (Häkkinen & Alha 2006, Nyman 1982), and in sparsely populated rural areas there are more of those, who feel that they do not get the medical treatment they need (Keskimäki & Alha 2006). Nyman (1982) also reported that the number of visits to a doctor became smaller as the distance to the nearest doctor increased.

There are also differences in health, health behaviour and health service use between smaller areas than municipalities. Small area variations in mortality have been studied in Helsinki metropolitan area (Valkonen & Kauppinen 2001), the alcohol-related deaths and cardiovascular diseases in addition to demographic variables (education, socio-economic position, family type and housing tenure) being among the most important reasons for mortality differences between the city districts. A study by Kureniemi & Törmänen (2003) matched the high mortality in city districts of Helsinki to environmental factors such as high levels of traffic, noise and air impurities, mixed housing and industries, scarcity of good quality parks and poor connections to recreational areas. Karvonen (1997) studied the health behaviour of adolescents in small areas, and concluded that local conditions are more important in determining health behaviour than the wider regional background. Poikolainen and Eskola (1995) found small regional inequalities in healthcare in seven health districts in the city of Helsinki, though the socioeconomic inequalities in health care were more distinct.

Some studies in Finland have also used grid-based data for defining the residential area. Grid-based data has been previously used in geographical studies of the population change (Hätälä & Rusanen 2010, Kotavaara 2012, Rusanen et al. 2003), studies of rural areas (Muilu & Rusanen 2003, Naukkarinen et al. 1991, Naukkarinen et al. 1993, Rusanen et al. 1993, Rusanen et al. 1995), residential differentiation within the metropolitan area of Helsinki (Vaattovaara 1998), migration (Kauppinen 2000), unemployment (Rusanen et al. 2001a) and income (Rusanen et al. 2001b, Rusanen et al. 2002). Health related studies that have used grid-data include a study of mortality in small areas (Rykönen et al. 2001), which revealed that the marked clusters of poor health may exist within local government areas. Antikainen (1999) studied the dietary and health behaviour in local and regional areas and found that dietary fat use was chiefly related to the regional hierarchy defined with local population density. Studies of childhood diabetes mellitus have utilised grid-based data (Karvonen et al. 1997, Ranta & Penttinen 2000, Rytkönen et al. 2001), and shown that the incidence of diabetes was higher in less densely populated rural areas, and that there were few
persistent high-risk and low-risk areas in Finland. Also the cancer risk has been studied utilising grid-based small area data in Finland (e.g. Kokki et al. 2001, Verkasalo et al. 2004).

The sparse population and long distances make Finland an interesting study area for a study considering the effects of population density and distance to individual’s health and well-being. From previous studies we also know that there are many health related difficulties in remote rural areas in Finland. In Finland, where the population is unevenly distributed, also in small administrative areas such as municipalities, the one-square-kilometre grids depict the close residential area and the degree of rural-urban status of residential environment more accurately than administrative areas, although the rural-urban status of an area is clear only in the extremes of population density (e.g. Karvonen et al. 1997).
2 Aim and study questions

This study is positioned in the wide-ranging field of geographies of health. Medical geography deals with geographical patterns, causes and spread of morbidity and mortality, planning and provision of health care services and geographical distribution of the socio-economic determinants of illness and health. Especially, under the label health geography, such constructs as wellness, identity and place experience have been introduced to geographical studies of health and illness (Dummer 2008, Kearns & Collins 2010). According to Meade & Emch (2010), the medical geography or health geography uses concepts and methodologies from the disciplines of geography to study health-related topics, and it is an overarching and multistranded subdiscipline. Also this study has close relations to public health, epidemiology, sociology and medicine in addition to geography. The focus is on the associations of different types of local residential areas (areas with different population density) and the distance with health-related factors. Through the population density and distance, the rurality and urbanity of local residential area and the issues related to accessibility can be considered.

The aim is to study the importance of a small-scale residential area to health of young adults of the Northern Finland Birth Cohort 1966. The study poses a question of how the local residential area is associated with the individual’s health and well-being and what is the role of geographical distance in the health of young adults. Also the health’s association with migration in local areas is examined. The aim is also to point out possible arenas for intervention and to seek, what issues would potentially merit further research, when seeking to narrow health inequalities and contributing to the good health of people. Allocating measures to improving the health and well-being of individuals is more effective, if the problem areas can be pointed out and factors associated with health and well-being distinguished as accurately as possible. Measures, which are targeted only at individuals, may not be adequate to tackle health inequalities, because the social and physical environment may also need to be changed in order to reduce health variation (Curtis & Rees Jones 1998).

The articles comprising the study, examine the health in local areas from different perspectives, through aspects which in local areas could induce health variation: the individual characteristics and area (article I), health behaviour (article II), health service use (article III) and migration (article IV). The population density used to define the type of local area (articles I, II, II and IV) and geographical distance (articles II and III) are important local characteristics
potentially having influence on health outcomes. The whole created by the articles is portrayed in figure 1.

<table>
<thead>
<tr>
<th>PERCEIVED HEALTH</th>
<th>HEALTH BEHAVIOUR</th>
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<tr>
<td>Article I</td>
<td>Article II</td>
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<tr>
<td>Associations of rural and urban local residential area with self-reported health among men and women were studied.</td>
<td>Associations of distance to municipality centre and population density in local area with body mass index and overweight were studied.</td>
</tr>
<tr>
<td>Individual level characteristics (psychosocial well-being, social relationships, health behaviour, education and residence time) were taken into account.</td>
<td>Individual level characteristics (sex, marital status, occupational class, socioeconomic group, education, leisure-time and occupational physical activity, diet, alcohol consumption and smoking) were taken into account.</td>
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**HEALTH SERVICE USE**

Article III

Association of geographical distance to health centre with health centre service use was studied and distance-related inequity in health centre service use was evaluated in rural and urban areas.

Individual level characteristics predisposing to health centre use (sex, marital status, having children, education, employment status, use of occupational and private health services) and indicating illness level (self-reported health, activity limiting illness and chronic conditions) were taken into account.

**MIGRATION**

Article IV

Associations of health status (satisfaction with life, self-reported health, life-time psychiatric and somatic morbidity, activity limiting illness and health service use) with moving to rural and urban areas were studied among rural and urban residents.

Individual level characteristics (sex, marital status, having children, housing tenure, education, employment status and previous move) were taken into account.

Fig. 1. Illustration of how health in local areas is addressed in each of the original articles.

The association of self-reported health with local residential area (1-square-kilometre grids) is studied among young adults (article I). The study questions are: Are there differences in self-reported health in different local residential areas? What factors in these local residential areas explain the association of self-reported health and residential area?

The associations of body mass index and prevalence of overweight with distance to municipality’s centre and population density in local residential area is studied among young adults (article II). The study question is: Is body mass index
and prevalence of overweight associated with an individual’s distance to the local municipality centre and population density in his/her resident area?

The health service use of young adults is studied in rural (grids with 1–100 inhabitants/km²) and urban (grids with > 100 inhabitants/km²) local residential areas and the influence of distance to the service use and distance-related inequity in health service use is examined (article III). The study question is: Does distance to local health centre affect the use of health centre services in rural and urban areas, when the need of services is also taken into account?

The association of health and well-being with moving is studied among young adults living in rural (grids with 1–100 inhabitants/km²) and urban (grids with > 100 inhabitants/km²) areas (article IV). The study question is: Is health associated with moving among young adults in rural and urban local residential areas?
3 Key concepts and theoretical framework

The concepts relevant to the study are defined, followed by a discussion about how, in the literature, health is connected to the residential area in general and rural and urban areas in particular, and what role the health selective migration might have in this.

3.1 Health

There are many different definitions for health in literature. Who (1948:100) defined health as:

“a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”.

This definition has been widely used, though it is also much criticised as an impossible condition (e.g. Gatrell & Elliot 2009, Last 2001). In the Who Health promotion initiative (WHO 1984) health was defined as the extent to which an individual or a group is able to realize aspirations and satisfy needs, and to change or cope with the environment; a resource of everyday living, not objective of living.

Other definitions of health listed in A Dictionary of Epidemiology (Last 2001) include: health as a state characterised by anatomical, physiological, and psychological integrity; an ability to perform personally valued family, work and community roles, to deal with physical, biological, and psychological stress, a feeling of well-being and freedom from the risk of disease and untimely death (Stokes et al. 1982); health as a state of equilibrium between humans and the physical, biological and social environment, compatible with full functional activity (Last 1997). Also Gatrell and Elliot (2009) list potential definitions of health, such as the availability of resources, both personal and societal that help us to achieve our individual potential; health as being physically and mentally “fit” and capable of functioning effectively for the good of the wider society; health as a “strength”, fitness or energy or engaging in healthy behaviours or life styles.

Health is a multidimensional concept that can be measured in many different ways. Also the NFBC 1966 survey data offers several possibilities for operationalising health status. Life satisfaction is held as a reasonable measure of current and future well-being and health (Koivumaa-Honkanen 1998, Schaefer et
Self-reported health is a widely used measure of a person’s health status. It has been found to predict morbidity and it is an independent predictor of mortality (Kaplan et al. 1996, Manor et al. 2001, Idler & Benyamini 1997). Aspects that people consider, when assessing their health include: physical aspects (e.g. mental and somatic illness, medical treatment), functional ability, do they generally feel good or fit, adaptation and attitude towards an illness and also to some extent health behaviour and life style, psychosocial and socioeconomic status and social environment (Kaplan & Baron-Epel 2003, Shoostari et al. 2007, Simon et al. 2005). According to Finnish studies (Kaplan et al. 1996, Miilunpalo et al. 1997), self-reported health is a reasonably valid measure for health, even though it is also affected by subjective influences. Manor et al. (2001) has studied the validity of both self-reported health and limiting long term illness among young adults and concluded that they are valid measures of serious diseases (e.g. cancer, diabetes, epilepsy) and also milder conditions (e.g. eczema, hay fever). Cohen et al. (1995) found that limiting long term illness was associated more strongly to items of physical functioning and limitations and pain than for items of emotional and mental wellbeing. Many conditions (e.g. arthritis, low back pain, eyesight problems, stomach problems, hearth disease and depression) were found to be two or three times more common among those with limiting long term illness than those without.

Bergmann et al. (1998) have concluded that self-reported diagnoses of some diseases (e.g. breast cancer, cataract, hip fractures and ischaemic heart disease) are quite accurate, though other conditions (e.g. colon polyps, ulcers) may require medical verification. Relating to behavioural aspect of health, BMI is widely used in clinical settings and population studies in assessing obesity, and high BMI has been associated with premature mortality and is a risk factor for several health conditions, such as diabetes and cardiovascular diseases (e.g. Canoy & Buchan 2007). Greater use of health services has been associated with chronic conditions and multiple somatic and psychiatric health problems (e.g. Broemeling et al. 2008, Gijsen et al. 2001). Self-reported health care use has been found to be reasonably valid estimate for the use of services (Reijneveld & Stronks 2001), though some have observed a tendency to over-estimate the actual use (Bellón et al. 2000).
3.2 Health in geographical context

Meade and Emch (2010) state that in both medical and health geography, health is viewed to be more than the absence of disease. In geographies of health, the importance of setting and place for health is emphasised. Meade & Emch (2010) present “Triangle of human ecology” that has habitat, population and behaviour as the vertices of a triangle that enclose the state of human health. Habitat is the part of the environment within which people live (e.g. houses, work places, settlements, society, biotic and physical phenomena, services, transportation systems), population is concerned with humans as biological organisms (e.g. genes, age, gender, nutritional status) and behaviour is the observable aspect of the culture (e.g. mobility, cultural practices, technology) and all these contribute to the health of individuals. Cromley and McLafferty (2012) frame it so that people are affected by their environment, which is connected to natural, social and economic processes that operate on different scales, and thus health has the environment of the person as its geographical context.

Also in WHO Ottawa Charter 1986 the context is seen to be important for health promotion and it is stated that links between people and their environment constitute the basis for a socioecological approach to health (WHO 1986). Environmental health is defined by WHO as those aspects of the human health and disease that are determined by factors in the environment, encompassing also the assessment and controlling of factors in the environment that can potentially affect health (WHO 2014). Health can also be portrayed as being made up of different layers (Dahlgren & Whitehead 1991). In the core there are immutable characteristics of an individual (e.g. sex, age, genes) and around this in layers there are mutable and moulding characteristics: lifestyle and health behaviour, social relationships and community networks, living and working conditions and available resources (food, education, work environment, employment status, water, sanitation, health care services, housing). Beyond these there are general socioeconomic conditions, cultural and environmental contexts.

In this study health is seen as a state of physical, mental and social well-being that is determined by individual characteristics, health behaviour and socio-environmental context.
3.3 Residential area

Space represents a dimension in which phenomena are distributed (Curtis & Rees Jones 1998). Location can be a point or area with certain coordinates, and that location becomes a place, when a meaning is given to it (Gatrell & Elliot 2009). In a neighbourhood health study, an area specifically defined as a neighbourhood is the unit of analysis, and such units may have very different representations (e.g. administrative areas, areas within a given distance from house, social activity areas, areas with certain environmental context) (Flowerdew et al. 2008, Meade & Emch 2010). The scale or size of the unit depends on the study question. If one is studying the very local scale processes, then the measurement of effect must be at a local scale. Lupton (2003) distinguishes three important aspects of neighbourhoods, which should be considered in neighbourhood studies: neighbourhoods are both physical and social spaces; the size of the relevant neighbourhood boundaries may vary from area to another and different boundaries of areas may be reasonable for different aspects; neighbourhoods are not isolated, rather their characteristics are shaped by their relationship to other places together with their internal features (Lupton 2003).

There is not any universally preferred definition of rural (or urban) areas (Coburn et al. 2007, Helminen et al. 2013). Rurality is not a stable concept, because designating something as rural may change, when population distribution changes or when geographical boundaries change (Coburn et al. 2007). In Finland there are several rural-urban classifications, which vary, among other things, in their geographical scale. Classifications are based on administrative areas such as municipalities (e.g. Malinen et al. 2006), one-square-kilometre grids with certain population density (e.g. Rusanen et al. 2003) and most recently on geographic information, which is independent of administrative data (Helminen et al. 2013). Rural and urban areas can be portrayed as distinct units or as a continuum or hierarchy of environments from inner city areas to sparsely populated rural areas (e.g. Helminen et al. 2013). Instead of using some geographically defined area, assigning the place of residence as rural or urban can also come from the subjects, whose health or other attributes are being studied in relation to rural and urban living environments (Curtis & Rees Jones 1998, Diex Roux 2002, Jokela et al. 2009).

Administrative areas have the benefit that information is in most cases readily available and possible policy or intervention measures are most easily conducted at this level. The administrative areas may however have significant variation in
their local residential environments, and the smaller area units, such as the one-square-kilometre grids more likely depict the actual circumstances in an individual’s local residential area (Karvonen et al. 1997, Rusanen et al. 2001a). The local residential areas are not independent and the characteristics of the surrounding areas can modify the effects of local areas (Cummins et al. 2007, Lupton 2003, Meade & Emch 2010). Intervention and policy actions can also be hard to implement in grid-level, let alone if definition of rural-urban status is based on perceptions of individuals.

Concepts of ecological fallacy, modifiable area unit problem (MAUP) and scale are a central in area level studies, and are to some extent being tackled with grid-level approach in the current study. Ecological fallacy refers to a situation where associations at aggregate level regional populations are used to make inaccurate assumptions about the individuals in the population. When individual data are aggregated to area level, central tendency levelling takes place, and patterns of associations can be different at different levels of scale (Curtis & Rees Jones 1998, Macintyre et al. 2002). Though, the ecological fallacy cannot be fully avoided when area level aggregate data is being used, it can be assumed that using the small grid-level data it can be reduced (Rusanen et al. 2001a). MAUP refers to the arbitrariness of areal units, so that when data is aggregated to differently configured area units, different results may emerge (Gatrell & Elliot 2009). Modifiable area unit is a problem only if the areas are arbitrary, but if there is a hypothesis about the mechanism of the link between neighbourhood and health, then the set of areal units should be defined accordingly (Flowerdew et al. 2008, Haynes et al. 2007). Also relating to these, the scale is important, because likely relationships which are seen at one scale may disappear at another (Gatrell & Elliot 2009, Graham et al. 2004). Factors that explain certain health outcomes may be different at different scales, and local scale effects must be measured at local scale.

3.4 Health and residential area

Individuals are a part of neighbourhoods, communities and regions and the processes in these different levels can influence the individuals’ health (Meade & Emch 2010). Residential area offers a setting for human action, and different possibilities and risks that influence the well-being and health of the individual (Karvonen & Rintala 2006, Macintyre et al. 1993). Characteristics of the
residential area, migration and person’s health form a multidimensional process, where different factors influence one another.

Geographical variation in health may be due to compositional characteristics (e.g. people with certain characteristics living in particular areas), contextual characteristics (referring to the opportunity structures in physical and social local environment), collective functioning (e.g. norms, values, traditions of community) (Curtis & Rees Jones 1998, Macintyre et al. 1993, 2002) or all these together. Cummins et al. (2007) emphasise the mutually reinforcing and reciprocal relationship between people and place, and they see the varying context in different time and space and the scale to be important. Also Löytönen (1998) states the importance of time of residence in certain places, migration of people and time-lag between exposure and outcome, when health variation relative to residential area is being studied.

Age and life phase may be important for health and residential area interactions. It has been hypothesised that especially such groups that spend a large part of their daily lives in their neighbourhood, for example the elderly, the unemployed or women taking care of the children at home, would be particularly vulnerable to the health enhancing or damaging effects of the environment (Balfour & Kaplan 2002, Cummins et al. 2005, Diez Roux 2002, Robert 1999). There is also some evidence that contextual factors may be differently important for men and women (Blaxter 1990, Kavanagh et al. 2006, Stafford et al. 2005), and that health disadvantage may be experienced differently by socially disadvantaged individuals according to their geographical setting (Blaxter 1990, Curtis & Rees Jones 1998, Rintala & Karvonen 2003, Stafford & Marmot 2003). Local neighbourhoods have in some studies been found to associate more strongly with health and health behaviour than the larger region in which the neighbourhood is located (Blaxter 1990, Haynes et al. 2007, Karvonen 1997). Health differences between areas can also be artificial, in a sense that administrative divisions and different rural-urban classifications can combine very different kinds of areas (Cummins et al. 2007, Karvonen & Rintala 2006).

Material and social environment (e.g. Curtis and Rees Jones 1998, Macintyre et al. 1993, 2002, Robert 1999, Taylor et al. 1997) have been proposed as important factors affecting human well-being and health at the contextual level. According to Macintyre et al. (1993, 2002) features of the residential environment that affect the individual’s health include the material and infrastructure factors (e.g. climate, quality of air and water, state of housing, safe working and recreational conditions, services provided in the area) and cultural and social
practices (e.g. political, economic and religious history, norms and values, crime and safety, the reputation of an area). Physical features of the environment are shared by all residents in a locality. Healthy or unhealthy environments at home, at work or at play including housing, safe working conditions, recreational facilities and other services, are opportunities, which may or may not be taken up by individuals. Socio-cultural features include political, economic, ethnic and religious history as well as values, norms and community integration. The reputation of a neighbourhood is linked to that how residential area is perceived by different actors (Macintyre et al. 1993, 2002). Taylor et al. (1997) state that unhealthy environments are such that they threaten safety, limit the ability to create social ties and are conflictual, abusive or violent, whereas healthy environments provide safety, opportunities for social interaction and the ability to control and predict aspects of the environment.

The rural and urban environments may also have implication for health, but it is difficult to separate out the effects of urbanisation or rurality from the more general contextual effects of socio-economic environment. However, the physical accessibility can be a significant factor especially in rural settings, and the risks of non-contagious diseases may be channelled by changes in social organisation, public attitude and health behaviour in rural and urban spaces (Curtis & Rees Jones 1998, Peterson et al. 2009, Watt et al. 1994). A recent study in Finland shows that while young mothers in rural areas have the readiness to use public services, the long distances and lack of services may diminish the trust in social services and weaken the feeling of security (Hämeenaho 2014), which can have implications for subjective well-being.

Curtis and Rees Jones (1998) have outlined factors that could be salient for health in rural environments. In sparsely populated rural areas the lacks of employment opportunities, services and other amenities, poor transportation conditions and scarcity of social contacts may induce the risk for poor health, whereas low pollution, affordable housing, closeness of green spaces and nature and tranquillity may be beneficial to health (Curtis & Rees Jones 1998). Also Smith et al. (2008) have reviewed factors, which might be important to the rural health status in developed countries. These include the rural physical environment, access or distance to services (e.g. health services), health behaviour and socio-economic characteristics, which effects on health may be pronounced in rural areas. They conclude that the overcoming rural health disadvantage requires concurrent action to improve employment opportunities, physical infrastructure and education (Smith et al. 2008). Bourke et al. (2012) have
outlined a framework for understanding the health in rural areas. They see that the geographic isolation, social relations within a locale, local health actions and broader health system, social structures and power are the key for understanding rural health (Bourke et al. 2012).

There has been a lot of interest in physical accessibility and its effects in rural settings. The studies indicate that the distance may have a barrier effect on health service use, especially in rural areas, (e.g. Carr-Hill et al. 1996, Goddard & Smith 1998, Haynes 2003, Hiscock et al. 2008, Nemet & Bailley 2000), and it may thus potentially exacerbate the health conditions in remote areas. The rural residential area does not automatically indicate poor health, though when rurality is combined with low socioeconomic position or other personal risk factors, it may be unfavourable to health through poor service supply or poor transportational conditions (Rintala & Karvonnen 2007, Smith et al. 2008). The health disadvantage may be exacerbated in socially and economically impoverished settings in general (Blaxter 1990, Curtis & Rees Jones 1998, Nähä & Hansen 1999). Rintala and Karvonnen (2007) conclude that the living environment does not merely shape the well-being of people, but also the way the well-being is formed and associated with different things depending on the living environment.

The residential area may affect health also indirectly through health behaviour (Meade & Emch 2010, Riva et al. 2009, Robert 1999). Built environment can influence the everyday physical activity and be associated with human health via that (Meade & Emch 2010, Riva et al. 2009). The features of the local social and physical environment have been proposed to affect obesity through encouraging physical activity by providing a clean and unthreatening environment to walk and local facilities as destinations and through promoting healthy eating by offering reasonably priced healthy food and not easy access to fast-food outlets (Stafford et al. 2007, Meade & Emch 2010). Both the proximity of people’s homes to other people’s homes measured as population density and the proximity of services can be important measures, as the more “obesogenic” neighbourhoods will likely have low population density, fewer travel destinations within the neighbourhood, single use zoning and low connectivity (Meade & Emch 2010). Ecob and Macintyre (2001) also state that the influence of area in health related behaviours vary according to the behaviour and the way it is measured, and the influence of area deprivation can vary by age and household deprivation.

The factor potentially affecting the health differences between areas, also rural and urban, is the health selective migration of people (Verheij 1996). The
area and individual’s personal characteristics, including health status, influence the migration of people (Niedomysl 2008, Nivalainen 2004, Walters 2000). Indirectly health-selective moving occurs, when health-related factors, such as socioeconomic status, are associated with moving (e.g. Curtis et al. 2009, Martikainen et al. 2008). Better health among those with a high socioeconomic status and high level of education can be a factor in their greater propensity to move (Bentham 1988). Directly health selective migration occurs for health reasons, for example people may want to get away from areas perceived to be hazardous to health or move closer to health services or unofficial care from relatives (Bentham 1988, Larson et al. 2004, Lix et al. 2006, Lu 2008). Poor health may also adversely affect a person’s livelihood and hence the ability to live in a certain place (Moorin et al. 2006, van Lenthe et al. 2007, Lix et al. 2006). The relationship between moving and health is, however, complex and also migration can have an influence on health.

The area characteristics can either push or pull people depending on what kind of services or amenities people want from their residential area (Niedomysl 2008, Walters 2000). In rural and urban areas the associations of health and moving can be different because of different resources offered and demanded by these residential environments. The migration of people with different health status may have implications for area variations in health. For example leaving those with poor health behind, may increase the area-based health inequalities (Brown & Leyland 2009). Some studies have indeed reported that lacking financial resources due to illness or feeling too sick to move may entrap people to certain areas (e.g. Cox et al. 2007, Moorin et al. 2006, Riva et al. 2011). People with, for example high socioeconomic status, moving from rural to urban areas, would likely increase the good health in the urban areas and decrease it in the rural areas. On the other hand, if people needing health care or other health related services in urban areas move towards the health services, then poor health might increase also in urban areas in relation to rural areas (Bentham 1988).

How the contextual characteristics, individual characteristics and migration might be connected and produce health difference between rural and urban areas are illustrated in figure 2.
Fig. 2. Contextual characteristics which may, together with individual level characteristics, affect health either directly or indirectly via health behaviour in rural and urban areas (according to Curtis & Rees Jones 1998, Macintyre et al. 1993, 2002). Migration is influenced by both the context and individual attributes, including health status, but migration can also contribute to health at individual level and induce area variations in health.
4 Material and methods

4.1 Material

4.1.1 Northern Finland Birth Cohort 1966

The study population is the Northern Finland Birth Cohort (NFBC) 1966, which consist of all individuals in the two northernmost provinces (Oulu and Lapland) of Finland, whose mothers’ expected time of delivery was in 1966. The total number of births was 12,231 (12,058 live births), which covers 96.3% of all births in the area in 1966. The cohort has been followed up since pregnancy and birth and at the age of 1, 14 and 31 years, which is the latest usable data at the moment, a particularly rich data on individual’s social well-being (life course, development, health, education and lifestyle) has been collected. The 46-year survey is currently under way. Data from various national registers and hospital records have also been collected and linked to the cohort (NFBC website 2014, Rantakallio 1988, Sorri & Järvelin 1998).

The final study population was defined a bit differently in each of the four studies, because of the availability of different study variables (Fig 3.), but all were initially based on the individuals, who had returned the postal questionnaire of health and well-being in 1997–1998 (8767 subjects). The coordinates of the home addresses of the cohort members were obtained from the Finnish Population Register Centre.

In articles I, III and IV the NFBC members’ locations were based on the coordinates of their home addresses on 31 December 1997 (Fig 4.). In article I, the final study population comprised of the subjects, who had answered the postal questionnaire in 1997–1998, and whose residential address could successfully be linked to the population density of his/her resident grid of 1997 (8036 subjects). The study population in article II was based on subjects, with known address in 1 January 1997, who had attended a medical examination and filled in a separate questionnaire about working conditions, and were successfully linked to 1997 grids of population density (5363 subjects). The study comprised of three areas: the city of Oulu, the rest of northern Finland and Helsinki metropolitan area.
Fig. 3. Study populations of different articles.
Fig. 4. Regional distribution of Northern Finland Birth Cohort 1966 (NFBC 1966) in Finland in 31.12.1997 (N = 8036). Circles indicate cohort members, one circle depicting one cohort member though some circles overlap.
In article III, because the coordinates of health centre facilities were available only from northern Finland (Provinces of Oulu and Lapland) the study population was restricted to subjects living in those areas in 1997, additional requirements being: living in the same residential area for at least a year and availability of the data on health service use (4503 subjects). In article IV, the final study population was formed of those subjects whose address for the period from 1 January 1998 to 31 December 2000 could be also linked to their new resident grid of the corresponding year (only first change in coordinates during that period was taken into account) (7845 subjects).

4.1.2 Geographical data

The type of persons local residential area was defined in terms of population density in his/her resident grid (one-square-kilometre geographical grid). Geo-referenced 1 km x 1 km grid data of population density is provided by Statistics Finland (see Statistics Finland 2013). These grids can be classified, according to Rusanen et al. (2003), to different groups describing different types of residential environments in rural-urban continuum. Classification is referred to as “spatial demographic structure”, as it describes the relation between population density and settlement structure without taking into account the functional elements of regional structure, such as dwellings, jobs and infrastructure. The Residential environments include areas of scattered settlement (1–5 inhabitants/km²), rural areas proper (6–20 inhabitants/km²), transition zone (21–100 inhabitants/km²), built-up areas and suburbs (101–1000 inhabitants/km²) and high-rise centres and big suburbs (> 1000 inhabitants/km²). Also, according to Rusanen et al. (2001a), the urbanisation processes, including the elements such as growing population density and the concentration of population, are evident in the one-square-kilometre grid cells comprising over 100 inhabitants per km², and processes of decline such as depopulation, ageing of population and loss of jobs in agriculture, are typical of grids having < 100 inhabitants per km². The population distribution in one-square-kilometre grids and the municipalities of Finland in 1997 are shown in figure 5.
Fig. 5. Population density in one-square-kilometre grids and municipalities in Finland in 1997.
The Finnish road network data (Digiroad 2003) was utilised when calculating each subject’s distance to the local municipality centre (densest populated one-square-kilometre grid) or to the local health centre. Digiroad is a national road and street database developed by the Finnish transport agency (see Finnish Transport Agency 2014). The database includes the accurate geometry and length of road segments, which enable the calculation of actual distances between any two points along the road network. The roads include the regional and local main streets, collector streets, feeder streets and private streets and in the coastal archipelago the ferry connections between these streets.

4.2 Methods

4.2.1 Applying geographical information system (GIS)

The geographical information system (GIS) can be defined as a system for the collection, storage, integration, analysis and display for spatially referenced data (Gatrell & Löytönen 1998). GIS was utilised in this study mainly in linking different datasets together, defining and calculating population density (residential area) and distance related variables, and for visual exploring and displaying data as maps.

The population density data and the NFBC data were linked with coordinate-based information using ArcGIS, software developed by ESRI for the management of geographical data. Each NFBC member have home coordinates indicating the place of residence, which were then spatially linked with the one-square-kilometre geographical grids with certain population density, depicting the close residential area of a cohort member. The one-square-kilometre grids were attached to the map as described in Statistics Finland (2014). The population density data was used also for locating the municipality centre, which was selected on the grounds of being the densest populated one-square-kilometre grid in the municipality.

The calculations of distances along road network were done using Network Analyst extension in ArcGIS. Cohort members home coordinates were used as the starting point and the midpoint of municipality’s densest populated grid (article II) or the coordinates of home municipality’s main health centre facility (article III) as the endpoint. The coordinates of health centre facilities were acquired from the Register of Buildings and Dwellings maintained by the Population Register.
Centre, and their accuracy was checked against the postal address of that health centre (Swahne 1996). The original coordinates failed to match in 29 cases and were replaced by address-based coordinates. The shortest distance along the road network was calculated. If there were multiple health centre facilities in the municipality, the distance to the closest facility was calculated. Figure 6. shows the routes of the cohort members to municipality’s centre in northern Finland, city of Oulu and Helsinki metropolitan area in 1997, and in figure 7. there are the routes of cohort members to the nearest health centre facility in cohort member’s municipality in Northern Finland in 1997.

4.2.2 Statistical methods

Ordinal logistic regression

The respondents own assessment of his/her health was used as an outcome variable, and the type of person’s local residential area (the one-square-kilometre grid) as the explanatory factor (article I). The association of self-reported health and residential area type was examined by logistic regression. Because the outcome was measured in ordered classes i = 1–4 (1: very good, 2: good, 3: moderate, 4: bad/very bad), the ordinal logistic regression was used to provide cumulative odds ratios (COR) and their 95% confidence intervals (CI) (Norusis 2008). The COR expresses the ratio of odds for having a health status equal or worse than category i. This method combines information from all ordered categories under the assumption that the ORs over all pairs of categories \( \geq i \) versus \(< i \) are similar (proportionality assumption). The potential confounders were entered into the model in succession. The proportionality assumption was checked by Chi-square test each time a variable was entered into the model, using a 5% significance level. Women and men were analysed separately. Analyses were done with SPSS.

Generalised additive model (GAM)

The outcomes were the body mass index (BMI) and overweight (BMI \( \geq 25.0 \) kg/m²) (article II). BMI was a continuous and overweight dichotomous (yes/no) variable. The shortest road distance between subject’s home and the municipality centre was the first explanatory variable. The distance was used as continuous
Fig. 6. Routes of the members of the NFBC 1966 to municipality’s centre (the densest populated grid) in northern Finland, city of Oulu and Helsinki metropolitan area in 1997 (© Näyhä et al. (2013) BMC Public health 13(938); Published under the terms of the Creative Commons Attribution License, licensee BioMed Central Ltd).
Fig. 7. Routes of the NFBC 1966 to the nearest health centre in cohort member’s municipality in northern Finland in 1997.
variable, but also classified to intervals of 0–1.9 km, 2.0–4.9 km, 5.0–9.9 km, 10.0–19.9 km and > 20 km for descriptive purposes. The second explanatory variable was the population density in one-square-kilometre grid in which a cohort member resided. The population density was treated as continuous variable, but also classified to different residential area types according to Rusanen et al. (2003).

BMI and prevalence of overweight were regressed on logged distance and population density using a generalised additive model in which smoothing was achieved by cubic splines with 4 degrees of freedom. The gaussian error distribution was used for BMI and binomial for overweight, and the identity link function in both cases. The results were expressed as smoothed predictions for BMI and the prevalence of overweight together with their 95% confidence bands. The method has the advantage of retaining the continuity of the explanatory variables without assuming any regular shape of the relationship (Hastie & Tibshirani 1990). Potential confounders were added to the model depending on whether they caused any marked change in the smoothed predictions. The intra-class correlations of BMI and overweight within the resident municipalities were checked, and they were close to zero (< 0.01). Calculations were done using R software.

Negative binomial regression

The respondent’s self-reported use of health centre services (doctor, public health nurse, psychologist, physiotherapist or other health care professional) during the past year was the dependent variable (article III). The use of services is a count variable expected to follow Poisson distribution in which the variance equals the mean. In this data the variance exceeded the mean indicating over dispersion, which was allowed for by using negative binomial regression with dispersion parameter (Cameron & Trivedi 1998). The distance to health centres was the main explanatory variable, but also associations with other characteristics predisposing to health service use and variables indicating the illness-level were examined. The crude and adjusted incidence rate ratios (IRR) and their 95% confidence intervals (95% CI) for distance and predisposing and illness-level variables were calculated. Rural and urban areas were analysed separately. Analysis was done with SPSS.
Concentration indices

For each individual the need of health centre services was computed as the expected value of use (Wagstaff & van Doorslaer 2000). Predicted values were produced with negative binomial regression by regressing health service use simultaneously, using a logarithmic link function, on predisposing (excluding use of occupational health services and private health services) and illness-level variables (article III). The model-predicted count for each individual was used as an estimate for the need of health centre services. The distance related inequity in health centre use was evaluated by calculating the concentration indices for use (C_use) and need (C_need), and the inequity index (HI) (Wagstaff & van Doorslaer 2000). C_use and C_need are defined in reference to the concentration curve, which plots the cumulative percentage of the health variable (y-axis) against the cumulative percentage of population, ranked by distance to the health centre, beginning with the nearest and ending up with the farthest (x-axis). The concentration index is defined as twice the area between the concentration curve and the line of equality (45° diagonal line running from the bottom left corner to the top-right) (O’Donnel et al. 2007). HI is the difference between the C_use and C_need, a zero HI implying horizontal equity, i.e. persons’ use of health services is proportional to their needs (e.g. Wagstaff & van Doorslaer 2000). C_use and C_need range from -1 (use or need is more prevalent among those living near) to 1 (use or need is more prevalent among those living far). HI also ranges from -1 (health services are used only by those living near, given equal needs) to 1 (health services are used only by those living far, given equal needs). The 95% CIs for concentration indices were calculated following the procedures presented by Kakwani et al. (1997) and Wagstaff & van Doorslaer (2000). Analyses were done with SPSS, for the rural and urban areas separately.

Multinomial logistic regression

The outcome variables were, whether or not the subject had moved during the period of 1 January 1998 to 31 December 2000 to a grid cell of the same or different type (rural/urban) than where he/she had lived in 31 December 1997 (article IV). Moving was regressed separately on five health and well-being variables using a multinomial logistic model (Hosmer & Lemeshow 2000: 260–287) in which moving was a three-class response variate (0: not moved; 1: moved to different type of grid; 2: moved to similar type of grid). Adjustments were
made for potential confounders. The results are shown as odds ratios (OR) and their 95% confidence intervals (CI) expressing the ratio of odds for each type of moving compared with the odds for not moving. Rural and urban areas were analysed separately. Analyses were done with SPSS.

4.3 Ethical considerations

The NFBC program has been reviewed by the Data Protection Ombudsman of Finland and the ethical committee of Northern Ostrobothnia Hospital District has approved it. Each individual study has also been reviewed by the Ethical Committee of the Northern Ostrobothnia Hospital District. The permission of hospital record and register linkages was given by the Finnish Ministry of Social Affairs and Health. An informed written consent was requested from members of NFBC 1966 at 31-years, and at that time the participants had an option to refuse the use of their data. Those, who refused the use, were excluded from the studies.

When NFBC 1966 data is linked to geo-referenced geographical data, questions about personal privacy become especially important. If any cartographic visualisations are made, it has to be ascertained that no individual cohort member can be recognised according to the location. For this reason, no detailed maps about the locations of cohort members are shown.
5 Results

5.1 Self-reported health in rural-urban continuum (Article I)

Most of the cohort members perceived their health to be good or very good (68%), 28% as moderate and 3% as bad or very bad. The good and very good self-reported health was most common in high-rise centres and built-up areas among both genders: 70.5% in high-rise centres and big suburbs vs. 62.3% in areas of scattered settlement among women, and 71.3% in high-rise centres and big suburbs vs. 58.3 in areas of scattered settlement among men.

The crude regressions also showed that there are differences in the self-reported health between different types of local residential areas. The CORs for poor health increased from high-rise centres to scattered settlement, though there was an elevated COR also in the transitional zone, among both genders.

The factors underlying the associations between local residential area and self-reported health were found to be different in different types of areas and among women and men. Among women, adjusting with feeling of loneliness, social relationships and physical activity increased the CORs in most areas. When education and time of residence were added to the model, the pattern remained largely similar, though the CORs became smaller and remained significant only in areas of scattered settlement. Among men, adjusting with feeling of loneliness did not alter the CORs very much, but further adjustments with social relationships and health behaviour significantly reduce the CORs for rural areas proper and areas of scattered settlement. The adjusting with education reduced the CORs further in all areas, and there were no longer any distinct differences in men’s self-reported health between area types.

5.2 Body mass index and overweight in relation to residence distance and population density (Article II)

The cohort members in this study were concentrated on short distances and densely populated grids: 92% lived at distances shorter than 20 km, and most of them (76%) lived in grids having more than 100 inhabitants per square kilometre. Majority of the subjects (85%) lived in the city of Oulu or elsewhere in Northern Finland, and 15% had moved to Helsinki metropolitan area. The longest distance
to municipality centre was 25 km in Oulu and 26 km in Helsinki, but could reach to 184 km in the countryside.

The average BMI was 24.7 kg/m² and 41% of the subjects were overweight (BMI ≥ 25 km/m²). The BMI and overweight were found to be associated with individuals distance to the local municipality centre and population density in local residential area, so that BMI and overweight increased with greater distance and decreasing population density. The regression, using road distance as continuous explanatory variable, showed an inverse L-shaped pattern with relatively low BMI (24.6 kg/m²) at distances shorter than 5 km and smooth rise of 3.0 kg/m² at distances longer than that. The overweight increased by 35 per cent units beyond the distance of approximately 5 km. The adjustment for sex, marital status, occupational class, education, leisure-time and occupational physical activity, alcohol consumption and smoking made the increases slightly smaller (2.6 kg/m² and 30 percent units respectively). The adjustment with socioeconomic group and diet did not cause any substantial changes. There was a greater distance-related increase in BMI and overweight beyond 5 km among women than men, but the regression estimates were less precise. BMI and overweight increased also with decreasing population density, the unadjusted estimates for the whole population density scale being 2.8 kg/m² for BMI and 28 per cent units for overweight and adjusted estimated 2.5 kg/m² and 20 percent units respectively. The differences between men and women were less consistent than the distance related sex differences.

5.3 Geographical distance and use of public primary health services in rural and urban areas (Article III)

Almost seventy percent of the study subjects lived in urbanised areas, where the median distance to the local health centre was 2 kilometres, while the rest lived in rural areas where the median distance was 12 kilometres. There was only little difference in average health centre service use between rural and urban areas (3.6 vs. 3.3 respectively). In general however, more of the subjects in rural (72%) than in urban (67%) areas had used health centre services at least once during one year, and this was also true for most subgroups. Only subjects living farther than 10 kilometres from local health centre (71% vs. 85% in rural and urban areas respectively), subjects without children (63% vs. 72%), those with only basic education (69% vs. 73%) and the unemployed (66% vs. 74%) had used less health centre services in rural than in urban areas.
There was only weak indication that distance to the local health centre might affect the health centre service use. In rural areas, the percentage of subjects using health services decreased slightly with increasing distance to health centre, while it increased in urban areas, the trend being similar, but much weaker, in the number of visits. Also the IRR indicated that in urban areas, living farther than 10 kilometres from the health centre was associated with 1.5 fold higher rate of health centre visits compared to living at distances shorter than 2 kilometres. The adjusting with predisposing and illness-level variables did not cause any notable changes in the IRRs. In rural areas, the IRRs did not indicate any significant association with distance and health centre use.

There was no significant distance-related inequity in health centre service use in either type of residential area: HI indices were 0.015 in rural areas and 0.009 in urban areas, but the 95% confidence intervals included the index value of zero.

5.4 Health and well-being of movers in rural and urban areas (Article IV)

There were more movers among the urban (52%) than among the rural (25%) population. In rural area moves were mostly directed to urban areas (62% of all moves made in rural area), whereas in urban areas most moves were directed to other urban areas (89% of all moves in urban area).

Subject’s poor health status was found to be associated with moving, but different health indicators were associated with different types of moves. In rural areas, dissatisfaction with current life and psychiatric morbidity predicted the moves from rural to urbanised areas with two times higher odds compared to being satisfied with life and having no reported life-time morbidity. Somatic morbidity compared to having no life-time morbidity was also associated with rural-to-urban moves. These associations also remained when adjusted with potential confounders. Having an activity limiting illness predicted the moving within rural residential areas. Initially, also the lifetime morbidity and dissatisfaction with current life were associated with rural-to-rural moves, but these reduced to insignificance, when adjusted with socio-demographic variables. Self-reported health and the use of health services were not associated with any moves among rural residents.

Only the use of health services was associated with the moves in urban areas, regardless of the type of the target area, and even after adjustments with socio-demographic variables. Initially there was an association with satisfaction with
life among all urban moves, but it reduced to insignificance when adjusted with confounders. Moderate or poor self-reported health was also found to reduce moving within urban areas.

5.5 Summary of the main results

The main results in relation to rural and urban local residential areas are summarised in table 1. The local residential area was associated with poor perceived health so that there were more poor perceived health in sparsely populated areas than in densely populated areas, and the associations were explained slightly differently among men and women. The BMI and prevalence of overweight were found to increase with growing distance from municipality centre and with decreasing population density in local residential area. Distinct barrier effects of distance in health centre use were not found in rural areas, and in urban areas the health centre use even increased with growing distance. Poor health was found to be associated with moving in rural and urban areas, with different kind of poor health associated with different types of moves.
Table 1. Summary of the main results.

<table>
<thead>
<tr>
<th>Publication</th>
<th>Rural area (1 km² grids)</th>
<th>Urban area (1 km² grids)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1–5 km²</td>
<td>6–20 km²</td>
</tr>
<tr>
<td></td>
<td>21–100 km²</td>
<td>101–1000 km²</td>
</tr>
<tr>
<td></td>
<td>&gt;1000 km²</td>
<td></td>
</tr>
<tr>
<td>Article I</td>
<td>Occurrence of poor perceived health increases with decreasing population density, with the exception of transitional zone (21–100 inhabitants/km²), where perceived health is relatively poor. Among men associations are explained by adverse social and lifestyle factors and education. Among women the occurrence of poor health in areas of scattered settlement (1–5 inhabitants/km²) remains unknown, otherwise education and time of residence explain the associations.</td>
<td>Reference category</td>
</tr>
<tr>
<td>Article II</td>
<td>BMI and overweight increased with decreasing population density. BMI and overweight increased from distance of approximately 5 kilometres to further from municipality centre (the densest populated grid).</td>
<td></td>
</tr>
<tr>
<td>Article III</td>
<td>Health centre service use decreases only slightly with increasing distance. No distance-related inequity in health centre service use is found.</td>
<td>Health centre service use increases with increasing distance. No distance-related inequity in health centre service use is found.</td>
</tr>
<tr>
<td>Article IV</td>
<td>Dissatisfaction with life and lifetime psychiatric and somatic morbidity are associated with the moves to urban areas. Activity limiting illness is associated with the moves to rural areas.</td>
<td>Frequent use of health services is associated with the moves to rural and urban areas. Poor perceived health reduces moving to urban areas.</td>
</tr>
</tbody>
</table>

*NF = Northern Finland, CO = City of Oulu, HMA = Helsinki Metropolitan Area*
6 Discussion

6.1 Overview of the results and comparison with previous studies

The local residential area (one-square-kilometre grid) was found to be associated with perceived health of young adults, and both distances to municipality centre and population density in local area were associated with bodyweight of young adults. Health status was also found to be a potential factor predicting the moving of people in rural and urban local residential areas. The barrier effects of distance in health service use in rural areas could not be confirmed. Direct comparison to other similar studies is not possible, because the grid-level has not been utilised before in this kind of research. Comparison base is however offered by the studies using small administrative areas, such as municipalities, or other census areas.

Men’s adverse health in rural areas was attributable to the social and lifestyle factors, while in transitional zone and built-up areas, men’s poor health was more related to educational level. Macintyre et al. (1993, 2002) and Curtis and Rees Jones (1998) have suggested that socio-cultural features, social isolation and lack of services can be reasons for poor health in rural areas, and also the life style in rural and semirural areas might be less active, because opportunities for integrating physical activity to leisure time and daily activities can be scarce (Eberhardt & Pamuk 2004, Riva et al. 2009). The results among men seem to be in accordance with these conclusions.

Among women the poor self-reported health was explained in most areas by the educational level and time of residence, but the reasons for elevated occurrence of poor health in areas of scattered settlement remained unclear. It is possible that the residential area itself may be more important for the perceived health of women, as has been suggested by Kavanagh et al. (2006) and Stafford et al. (2005). The local aspects of the socio-political environment such as low integration into wider society, low trust and low political engagement, lack of services and other amenities, economic characteristics such as lack of transportation and high unemployment that have been associated more consistently with women’s health (Stafford et al. 2005), probably describe somewhat the conditions in the most sparsely populated areas in Finland. Rusanen et al. (2001a), who studied the unemployment in grid data, found that the unemployment was highest, and also the duration of unemployment was long in the most sparsely populated grids. Typical of the most sparsely populated grids is
also the loss of population and the ageing of the population (Rusanen et al. 2001a, 2003). Also Blaxter (1990) found evidence that contextual factors may be differently important for men and women. If women spend more time at home and in their residential area (for example when taking care of the children), they may be more vulnerable to the health promoting or damaging effects of the local environment (Balfour & Kaplan 2002, Cummins et al. 2005, Diez Roux 2002, Robert 1999). The selective migration of highly educated people to densely populated areas can partly explain, why the cohort members residing in sparsely populated areas had poorer health. Young women in rural areas have been found to be more willing than men to move in order to have better education and job prospects (Muilu & Rusanen 2003).

Studies on municipality level have found that people in sparsely populated rural municipalities have poorer health than people living in urban municipalities (e.g. Ek et al. 2008, Karvonen & Kauppinen 2008, Karvonen & Rintala 2006). Findings that the perceived health is poorest in most sparsely populated grids accord with these, though the results highlight also the distinct variability inside small administrative areas. In Finland, where the inhabited and uninhabited areas mix even within small municipalities, the grid data more likely depict the actual local circumstances in an individual’s environment (Rusanen et al. 2001a), and the complexity of rural residential areas is effectively unveiled by the grid data (Karvonen et al. 1997). However, the characteristics of surrounding areas can modify the effects of local areas (e.g. Cummins et al. 2007, Lupton 2003). Also, while the grid data can identify geographical health patterns effectively, any local interventions are probably best accomplished by local or regional authorities, which have the necessary infrastructure and resources.

Studies of BMI and obesity in Finland have found that there are variations in these between areas, and the BMI and prevalence of obesity has been found to be higher in rural than in urban areas (Pietinen et al. 1996, Lahti-Koski et al. 2008). Elsewhere results have been either similar (Reeder et al. 1997) or different (Peytremann-Bridevaux et al. 2007). The road distance indicates travel lengths and mode of moving, and population density or subject’s local residential area the connectivity of daily destinations (e.g. Meade & Emc 2010), which both are related to the intensity of physical activity and the accessibility of services and amenities. Though associations of higher bodyweight among people living in remote and sparsely populated areas were partly due to social, demographic and lifestyle factors, the associations persisted also after adjustments. Thus the true effects of distance and population density are conceivable. There is evidence that
individual’s physical environment can affect the amount of physical activity in daily life, the important issues being the distance at which daily destinations are located and how daily destinations are reached, e.g. by foot, by bicycle, by car. The long distance and poor access to large supermarkets or shops, recreational facilities, bike paths, employment establishments and business centres have been associated with higher bodyweight (e.g. Boehmer et al. 2006, Giles-Corti et al. 2003, Gordon-Larsen et al. 2006, Liu et al. 2007, Yamada et al. 2012). On the other hand, easy access to green areas, healthy food stores, supermarkets and restaurants as well as the walkability of streets are associated with less overweight (e.g. Bell et al. 2008, Larson et al. 2009, Rundle et al. 2009, Smith et al. 2008, Zick et al. 2009). The results suggest that urban sprawl, characterised by outward spreading of cities and their suburbs and car dependency, may have an effect on the bodyweight and the health of people, also in Finland.

In several studies concerning the health differences or health inequalities between rural and urban areas, the use of health services has been highlighted as one potential reason behind these differences (Curtis & Rees Jones 1998, Smith et al. 2008, Watt et al. 1994). There are also many studies that have reported decline in health service use with increasing distance and rurality (e.g. Arcury et al. 2005, Carr-Hill et al. 1996, Goddard & Smith 1998, Hiscock et al. 2008, Haynes et al. 1999, Haynes & Bentham 1982, Nemet and Bailey 2000). In Finland, a study by Nyman (1982) reported that in sparsely populated areas distance to outpatient doctor services decreased the use of those services. Findings of the present study did not fully accord with the previous findings, as only modest decrease in health centre service use was detected in rural areas, and in the urban areas the service use even increased with distance. Results also indicated that there was no distance-related inequity in health service use. A possible explanation may be that the people in need of services in rural areas have located themselves near services, or that rural people are accustomed to making longer trips and have private cars, so distance is normally not an issue (e.g. Håmeenaho 2014, Zitting & Ilmarinen 2010). Also the association with distance and health service use has been proposed to be stronger with less serious conditions (e.g. Arcury et al. 2005, Haynes & Bentham 1982), which were not possible to distinguish in this study. The increased use of health centre services in distant urban areas is possibly related to personal economy and adequate transportational conditions, which does not deter the use of services in urban densely populated residential areas.

The socioeconomic differences in health service use in Finland have been found to be among the highest in Europe (van Doorslaer & Masseria 2004).
Socioeconomic health differences are wide also considering the wealth of the country (Teperi 2005). The socio-economic and supply differences were reflected also in this study as the occupational and private health services were used more in urban than in rural residential areas. Though in general, the health centres were used more in rural than urban areas, some subgroups (people living beyond 10 kilometres from the health centre, people without children, people with only basic education and the unemployed) reported less use in rural areas. It is a possibility that among these people, living in rural areas, the use of health services is hindered by poorer access (e.g. physical distance, lack of transportation, financial or time barriers) or attitude towards health care (Haynes & Bentham 1982, Goddard & Smith 1998, Nemet & Bailey 2000). Haynes and Bentham (1982) have also suggested that in urban areas people with health problems more easily seek medical attention, as they are guided to use services by professionals in related fields, such as social workers, which could explain some of the rural-urban differences.

The findings that poor health is associated with moving agree with some studies (e.g. Larson et al. 2004, Lix et al. 2006, Stockdale & Catney 2014, Verheij et al. 1998), but is contrary to other studies (e.g. Bentham 1988, Connolly et al. 2007, Cox et al. 2007, Lu 2008, Norman et al. 2005). Many studies have however found that short distance movers are less healthy than non-movers (e.g. Boyle et al. 2002, Norman et al. 2005), and in this study the majority of moves were short distance moves. This study is also not entirely comparable with those studies addressing moving between affluent and deprived areas.

The finding that being unsatisfied with life was associated with rural-urban moves, was in accordance with previous studies as urban areas may offer more factors that are important to life-satisfaction of young adults, such as human relationships and employment possibilities (Martikainen 2006), and thus encourage moving from rural to urban areas. Also, having a history of multiple health problems was associated with rural-urban moving. It has been found elsewhere that a chronic illness and poor mental health may predict moving (Larson et al. 2004, Lix et al. 2006), and better access to services and other amenities, as well as the stigma associated especially with psychiatric conditions are likely factors encouraging people to move from rural to urban areas. Some authors have suggested that some health conditions might impede moving to certain areas, as the poor health may compromise livelihood and ability to work and thus entrap people to certain areas (Cox et al. 2007, Lu 2008, Moorin et al. 2006, Riva et al. 2011). An activity limiting illness was linked to moving, but
only among rural residents moving to other rural areas. The activity limiting illness has the potential of limiting also the employment prospects, which may reduce the attractiveness of urban areas. However, contrary to this, a Northern Irish study found that those with limiting long-term illness, were more likely to move to urban areas (Stockdale & Catney 2014). Among urban residents, the poor self-reported health was found to be associated with lower propensity to move, but only in moves within urban areas. This was consistent with the finding of Verheij et al. (1998).

Contrary to what was expected (e.g. Larson et al. 2004), the frequent use of health services was not associated with moving from rural to urban areas. Even though the health services in Finland are more diverse in urban areas, the high quality services are also universally available in the countryside, and thus the need of health services is maybe not a significant factor in propensity to move among rural residents. The frequent use of health services was on the other hand associated with moving among urban residents, especially in moves to rural areas. The rural residential areas might be perceived by some individuals to be better for health (Curtis & Rees Jones 1998). Also the unofficial care from rural relatives, more affordable housing, and if the use of health services is related to the need of antenatal health services, the need for more spacious accommodations might increase the attractiveness of rural areas (e.g. Ellis & Muschin 1996, Heikkilä et al. 2003, Tuorila 2006).

The poor health among urban movers manifests itself as a need for health services, and among rural movers as a history of health problems. The flow of people with poor health from urban to rural areas is countered by the flow of people with differently poor health from rural to urban areas. Certain type of poor health may also impede moves to certain areas, as is perhaps seen among those with activity limiting illness in rural areas and those, who perceive their health to be poor in urban areas. There was some evidence also of socioeconomically selective migration, as those having high level of education or job were moving up in rural-urban scale (from sparsely to densely populated residential areas) and those, who were unemployed, were moving down. In a Swedish study, a counter urban mover was characterised also as not participating in the labour force, in addition to being older, less-well off, having a university degree and being single (Lindgren 2003). Perhaps, in the long run, these migration flows may have some implication also for the health differences between local residential areas.
6.2 Strengths and limitations of the study

The main strength of this study is the possibility to use the population-based cohort, NFBC 1966, which offers the extensive data of the individual level characteristics, social well-being, as well as the accurate coordinate data of the place of residence. A notable strength is also to be able to use data at accurate spatial resolution: the one-square-kilometre grid data of residential area, distances calculated along actual road network and coordinate-based locations of health centre facilities, together with the individual-level coordinate data of the place of residence.

With the grid-based data, which allow the investigations of residential area and health at a much higher resolution than the commonly used administrative areas, the complexities of the rural and urban areas are effectively uncovered. The one-square-kilometre grid is also small enough to possibly reflect the influence of the individual’s close environment, for example to bodyweight. The road distance likely serves as a reasonable estimate for the length of actual trips people make daily, though no data of actual travel lengths, mode of moving or duration of trips of cohort members were available.

However, there were no other direct measures of context than the population density, which was also used to deduce the type of the residential area and the distance measures to municipality centre and health centres. Otherwise deductions of possible contextual effects must come through theory and other research. The possible effects of surrounding areas were not considered, though it has been stated that also larger surrounding areas may modify the effects of local areas (Cummins et al. 2007, Lupton 2003). The grids depict the residential structure well as the grids with over 100 inhabitants are concentrated to certain locations and grids with less than 100 inhabitants are more dispersed. There is however a probable difference in local conditions, if the grid with, say 1-5 inhabitants/km², is located next to similar grids or next to grids with >100 inhabitants/km², but these cases are reasonably few.

Many variables used in the studies were based on self-reports and subjective assessment, which may cause some uncertainty to the results. The validity of these measures is discussed in more detail in each of the articles. Some of the other more detailed limitations concerning certain articles are briefly discussed here.

In the study considering the associations of distance and population density with BMI and prevalence of overweight (article II), there was no information of
the actual lengths of work travels or the mode of travelling to work, so the effects of leisure time physical activity and commuting for bodyweight cannot be distinguished. The unemployment in sparsely populated areas may cause some confounding in the associations of bodyweight and residential area or distance, as the unemployment was not specifically controlled for. The bias associated with migration is also a possibility (e.g. Jokela et al. 2009). The municipality centre was defined as the most densely populated 1 km x 1 km grid in the municipality, which is a reasonable choice, as there is no predefined definition, how the municipality centre should be selected. This likely works well in the majority of Finnish municipalities, especially in rural municipalities, where the main part of the people is concentrated near services and 1 km x 1 km grid is large enough to contain both the people and the services. Problems may arise in highly urbanised areas, e.g. Helsinki metropolitan area, where multiple service centres may exist. People may also use some services outside their home municipality, if the neighbouring municipality’s centre is closer.

In the study of health centre service use and distance (article III) the need of health services was calculated with the aid of certain enabling and illness-level variables. The concept of need is however ambiguous and different definitions of need might result in different findings. The lack of information about the use of private cars can be significant, as it may affect service utilisation especially in sparsely populated areas (Haynes 1991). People were assumed to use the health centre facility nearest to their home, and though this was likely to be true in the majority of cases, there may also be exceptions.

In the study considering the effects of health on moving (article IV), only the first moves in a relative short period of time were considered, as the idea was to catch the impact the health has on moving and not the other way around. The permanence of the move is thus not known, and Kauppinen (2000) has identified grids, where people spend only a short while after moving again. Also, it was not possible to include the moving distance in analysis due to small numbers. There was a considerable amount of short distance moves (63% moved less than 10 km, representing more residential mobility than migration proper) in the data. However, moving distances under 10 km were more typical for those moving within similar kind of areas (rural 59% and urban 70%) than for those moving to different type of area (rural-to-urban 32% and urban-to-rural 37%).

Though there is information of socio-demographic conditions from time prior to move in 1997, there is no information about the changes that might have occurred in these during the period 1998–2000. Thus it is possible that certain
changes in life circumstances, such as family formation or unemployment, could underlie the observed associations (Heikkilä et al. 2003, Martikainen et al. 2008). The main part of the young adults in their thirties, as in this study, is healthy. The young adults at their thirties live a time period that involve many aspects, such as moving away from home, forming a relationship, birth of children and settling down in working life (Isohanni et al. 1998), that are closely linked to decisions to move and also to health.

The cross sectional study design prevents claiming any causality of observed associations in studies of perceived health (article I), body mass index (article II) and health centre service use (article III). The migration article (article IV) has, in principle, a longitudinal design, but caution must be practiced, if any causal conclusions are drawn from the study, as the association of health and moving are complex, and only limited number of factors associated with moving could be taken into account.

The response rates in surveys were satisfactory, and populations studied large. Though, some degrading of study population was present, when associations were studied, for example in different groups according to residential area. The distribution of NFBC 1966 to different residential area types (Article I) was very similar as the distribution of the whole Finnish population to those areas in 1997, high-rise centres and suburbs of major cities being slightly underrepresented among NFBC 1966, probably due to the fact that NFBC originates from sparsely populated Northern Finland. The non-participation of the NFBC 1966 has not been studied so much. One study (Haapea et al. 2008) however indicated that the subjects with psychiatric morbidity answered to postal questionnaire and participated to clinical examination less actively than those without a psychiatric condition.

The survey data was from the year 1997. The found associations probably are relevant still, though since 1997, for example, the expansion of internet and social media has lessen the isolation of sparsely populated areas. On the other hand, there has likely been further cut offs of services in the most sparsely populated areas. The results cannot easily be generalized to other age groups or countries with different population distribution, different health care system and availability of services.

The findings, however, indicate that studies conducted at local level can shed light into health inequalities and small scale variations inside larger administrative units, if there is relevant data available for conducting such research. The areas,
possibly needing customized interventions, may be more easily detected also inside larger area units.

6.3 Practical implications and future research

The grid-based data can identify local geographical health patterns more effectively than data based on administrative divisions, as marked clusters of poor health may also exist within administrative areas. Also inside rural areas there may be distinct variability in local contexts (Levin 2003, Rusanen et al. 2001a, 2001b). However, the time needed between the exposure to certain health damaging or promoting effects and the outcome can vary substantially depending on the issue studied. The current place of residence may not always be the only relevant context for health (Cummins et al. 2007, Macintyre et al. 2002, Löytönen 1998, Meade & Emch 2010), and longitudinal perspective on exposure to the different types of local residential areas and the migration of individuals would be valuable in the future. Taking into account the surrounding area, as the health outcomes are multi-scalar and the effects of local area may operate differently according to larger regions, where they are located (Curtis & Rees Jones 1998, Meade & Emch 2010), would also be valuable. In the future the multilevel analysis could be applied in the studies, if possible (e.g. Diex-Roux 2000, Luke 2005). In addition to using the grid-level data, also the new rural-urban classification of areas in Finland (Helminen et al. 2013) could be used in local level area studies.

According to the findings related to the associations of body mass index and overweight with residential area and distance, approximately 40% of young adults live in areas that may adversely affect their body weight, because their place of residence is located too far away from local centre or is too sparsely inhabited. One prospect for future research would be to continue the study of body weight and residential area, with a longitudinal perspective, also taking into account the migration of people. This could be done by using the new data of the 46-year survey of the NFBC 1966–members and the data collected previously of the same population, coordinate-based residential histories, and the data of close residential areas. The public health burden caused by overweight attributable to place of residence could potentially be diminished by community planning.

Though there were no distinct distance-related differences in health service use among young adults residing in rural areas, studies considering certain groups such as the unemployed might still be valuable, as the barrier effect of distance
can be especially important among them. An interesting prospect for future studies would also be the possible effects of rurality and remoteness to outcomes of certain diseases; does rurality or remoteness contribute to the late detection of some diseases and thus poorer health outcomes in sparsely populated remote areas (e.g. Campbell et al. 2001).

The health status of an individual was found to predict migration at local level. Further studies are however needed in order to get confirmation to these results. Longer follow-up periods and possibility to detect certain life changes, that can influence migration, would be important. To see the changes that the migration may have on the area-level health differences would also benefit from longer follow-up times and possibilities to measure the health status at different points in time.
7 Conclusions

1) The local residential area type was associated with perceived health, as the perceived health was much poorer in the rural and transitional local residential areas than in the high-rise centres, with different factors explaining the variation among men and women and in different local area types. While poorer health among men in areas of scattered settlement was explained by a complex of psychosocial factors, among women the reasons remained unknown. Customised measures might be needed to improve poor health in different area types, also within rural areas, and the gender should be taken into account as well.

2) The distance to the municipality centre and the population density in local residential areas were associated with the BMI and overweight of young adults, as the BMI and prevalence of overweight increased with the increasing road distance to the local municipality centre from the distance of approximately 5 kilometres onwards, and from densely populated areas to sparsely populated areas. This indicates possibly the importance of close residential area for the everyday physical activity and consequently for the bodyweight of an individual. The health-based planning of residential areas, which takes into account the possibilities of different modes of moving during daily activities, might be one way of influencing the amount of physical activity and thus the bodyweight of individuals. Further studies of this subject, which take into account the distances of work travels, actual modes of moving of individuals and longitudinal perspective on migration effects, are needed to improve the predictive value of findings.

3) Access to health services, measured as road distance from individual’s home to the municipality’s health centre, was markedly worse among the people living in rural than in urban areas, but was not found to be an important barrier in the health service use in either types of the area. Other factors than distance may be more important in the health service use in Finland, where the health services are universally available also in the countryside. Though no distinct barrier effect of distance was found among young adults living in rural and urban local residential areas, the studies of certain groups, such as the unemployed, might still be valuable. There was some indication that certain groups, e.g. the unemployed, and those with only basic education were using less health centre services in rural than in urban areas, though in general rural people used health centre services more than urban people. Comparing the people with access to a private car and
those without access to a private car might also shed more light on the actual barrier effects of distance in rural areas.

4) Finally, movement of people in rural-urban continuum, can be affected by the health status of the individuals, and has potentially relevance also for rural-urban health inequalities in local areas. While the people dissatisfied with life and with a history of health problems may move closer to services, in areas where coping with poor health is easier, other health conditions, which limit everyday life, may prevent people from moving at all or to certain areas. The availability of health services may contribute also to moves from urban to rural areas, where high-level health services enable a good quality of life for those attracted by the pastoral environment. A longer follow-up of movers and a possibility to take into account other changes in life, such as changes in marital status, family size and employment situation, which potentially affect moving, would be valuable in future research and bring confidence for the current findings. Also the effects of migration on the distribution of health differences between local residential areas should be studied in more precise longitudinal design.
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