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Residential history and changes in perceived health—The Northern Finland Birth Cohort 1966 study

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ABSTRACT

Neighbourhood socioeconomic status and physical access to amenities and greenness are factors that have been associated with mental, physical and perceived health. However, associations between long-time exposure to these circumstances and changes in perceived health in the middle-age population have remained a relatively underexamined area. This study aimed to examine the association between residential environmental history and changes in perceived health in the Northern Finland Birth Cohort 1966 (N = 5973) population encompassing the two latest data collections at 31 and 46 years of age. Longitudinal time-varying geographical data on the residential environment's economic dependency ratio, population density, distance to local services and presence of green areas were derived from various spatial registers and linked to cohort members' exact residential history. According to a multivariable logistic regression analysis, having a residential history in municipalities with higher-than-average (poor) economic dependency ratios was associated with higher odds of poor perceived health changing to good. Among men, living farther than 2 km away from local services was associated with a higher risk of change from good perceived health to poor, and living farther than 300 m away from green areas was associated with a lower risk of change from good perceived health to poor. The residential environments's urban/rural context may be one factor contributing to the findings. The results point to the importance of considering local residential area characteristics and residence duration in certain areas as potential determinants of health. Finally, having long-term residential history in areas with poor access to services and amenities has the potential to undermine health during one's lifetime.

1. Introduction

Several studies have indicated that the residential environment is important for health (Diez Roux and Mair, 2010; Rao et al., 2007). Poor neighbourhood socioeconomic status has been linked with poor mental, physical and perceived health (Do and Finch, 2008; Dunstan et al., 2013; Glymour et al., 2010; Pickett and Pearl, 2001; Sharp et al., 2015), and neighbourhood affluence has been associated with less poor health (Cagney et al., 2005). The availability of resources that are relevant to health in different socioeconomic contexts is one potential explanation for health differences (Bernard et al., 2007; Pickett and Pearl, 2001; Smyth, 2008). Furthermore, a residential area's poor socioeconomic status has been found to affect health possibly through prolonged stress (Boardman 2004), adverse health behaviours and lower provision of health-supporting services or amenities (Spring 2018).

Urban and rural features in residential areas have been found to be associated with residents' health (Eberhardt and Pamuk, 2004; Lankila et al., 2012; Riva et al., 2009), with physical access likely being one important element of rural deprivation (Curtis and Rees Jones, 1998; Smith et al., 2008). Urban areas' characteristics, e.g. walkability and availability of amenities that enable an active lifestyle (sidewalks, bicycle paths, recreational facilities and nearby services) have been associated with greater physical activity and better health (Chandrabose et al., 2019; Doyle et al., 2006; Gordon-Larsen et al., 2006; Kärmeniemi

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et al., 2019), and longer perceived distances to local destinations have been associated with poor physical and mental health (Gidlow et al., 2010).

Neighbourhood greenness has been suggested as a beneficial factor for boosting physical activity, mental and physical health, mortality, birth outcomes (Adlakha and Sallis, 2020; Engemann et al., 2019; Gonzales-Inca et al., 2022; James et al., 2015) and perceived health (Astell-Burt and Feng, 2019). Furthermore, the proportion and quality of residential green space (Maas et al., 2006; Nguyen et al., 2021), as well as access to green environments (Carter and Horwitz, 2014; Pietilä et al., 2015), have been linked positively to perceived health, with a greater number of recreational visits and daily outings being one possible explanation for the association (Pietilä et al., 2015). However, not all studies have found a relationship between green spaces and perceived health (Dunstan et al., 2013), with some finding a negative association (Mitchell and Popham, 2007; Picavet et al., 2016).

Although an apparent link exists between residential environment attributes and health, the reasons for such associations are complex. Residential area characteristics may affect individuals' health either directly or indirectly, e.g. through health behaviours such as enabling or encouraging physical activity or healthy diet, thereby eliciting health differences between residential areas. These residential area health differences also may be due to people's selective mobility. People who have illnesses or perceive their health as being poor may move to or remain in certain residential areas (Lankila et al., 2013; Larson et al., 2004; Lu 2008), that they may view as beneficial to their health, though poor health also may limit the ability to move to desired areas (Moorin et al., 2006; Wilding et al., 2016). Thus, individuals with varying levels of health or who practice different health behaviours may choose to live in different residential environments (e.g., Boone-Heinonen et al., 2011; Jokela, 2014; Jokela 2015; Sampson et al., 2002) for health-related reasons.

When studying area-based measures' effects on health, associations may vary depending on how contextual factors, e.g., residential areas, are delineated (Diez Roux and Mair, 2010; Kwan, 2012), as uncertainty is present in the timing and duration of contextual influences on individuals (Kwan, 2012; Pearce, 2018). Even though some characteristics are abundant in residential area, this does not mean that all individuals are exposed to them in a similar way. This bias may be mitigated if the contextual units can be delineated based on individualised activity spaces, i.e., actual areas where people move around during the day (Hasanzadeh et al., 2018; Kwan, 2012).

However, aside from moving around to undertake their daily activities, people also move around and change their residential locations over time. Residence duration and the accumulation of certain environmental circumstances can be important to adult health, as both past and contemporary living environments may contribute to health outcomes (Clarke et al., 2014; Glymour et al., 2010; Hertzman et al., 2001; Macintyre et al., 2002; Pearce, 2018; Pearce et al., 2018; Sharp et al., 2015; Spring 2018; Yang and South, 2020). In longitudinal studies conducted in the United States and Scotland, neighbourhood disadvantage has been found to predict poor perceived health (Glymour et al., 2010) and has been associated negatively with mental health outcomes (Pearce et al., 2018), as well as functional decline and mortality (Clarke et al., 2014). In a study in Almeda County, California, people reporting excellent or good health were found to have a higher risk of reporting fair or poor health nine years later if they had been living in poverty-stricken areas (Yen and Kaplan, 1999). Studies examining the same individuals living in different environments at different times in Australia (Jokela 2014) and in the UK (Jokela 2015) found no evidence of causal neighbourhood effects, but the associations between poor perceived health and residential area deprivation were related to selective mobility. With longitudinal study designs, the issues related to self-selection and residence time can be mitigated and studied.

Perceived health is a multidimensional measure that reflects physical and mental health; general feelings of fitness; attitudes towards illness, mortality, and to some extent health behaviour; socioeconomic status; and the social environment (Gallagher et al., 2016; Goldberg et al., 2001; Jylhä, 2009; Simon et al., 2005). Perceived health has been demonstrated to be more subject to contextual effects than objective measures, e.g., mortality (Curtis and Rees Jones, 1998). If one experiences a decline in perceived health already during a relatively healthy stage in life (between ages 31 and 46), it may predict poor health and shorter life expectancy in later years (e.g. Benyamini and Burns, 2020).

With annual defined and changing (time varying) environmental data, and perceived health measured at ages 31 and 46, we aimed to contribute to studies examining long-time exposure to residential environmental characteristics that potentially can support or undermine health among middle age individuals from the Northern Finland Birth Cohort 1966 living in Finland, Northern Europe. The specific aim was to investigate whether residential history in densely or sparsely populated areas, near or far from local services and green areas, and in socioeconomically viable or poor regions, comprising full-time exposure for 15 years, was associated with differing changes in perceived health individually for those whose perceived health status was good and for those whose health status was poor at age 31.

We hypothesised that long-time residency in socioeconomically viable or densely populated areas, or long-time residency near services are associated with maintaining good health and more frequent transitions from poor to good health than residing in socioeconomically poor areas or sparsely populated or remote areas, because the former areas more likely provide resources, e.g., work opportunities, services, social contacts, leisure time activities and possibilities for everyday physical activity, which may benefit and help maintain good health.

2. Material and methods

2.1. Study population and study setting

The study population was the Northern Finland Birth Cohort 1966 (NFBC1966), which comprised all individuals born in 1966 (12,058 live births) in the two northernmost provinces of Finland – Oulu and Lapland (Nordström et al., 2021). Prospective data were collected through postal questionnaires, interviews and medical examinations at ages of 1, 14, 31 and 46 years (University of Oulu 1966). Data from various national registers has been linked to the cohort data. For this study, the home coordinates of NFBC1966 residential history from 1997 to 2014 were acquired from Digital and Population Data Services Agency. The present study included cohort members (N = 5973) who answered questions about perceived health in both the 31- and 46-year follow-up postal questionnaires (1997–1998 and 2012–2014 respectively). Cohort members have migrated within Finland, and the most migration outside of Northern Finland has been to the Helsinki metropolitan area. At both time points, about a fifth of the cohort members lived in Oulu, the biggest city in Northern Finland, and about 9% of those age 31 and 5% of those age 46 were living in Helsinki. The study was approved by the Ethical Committee of the Northern Ostrobothnia Hospital District in Oulu, Finland (3/97, 94/2011). The subjects provided written consent for the study, and their personal identity information was encrypted and replaced with identification codes to provide pseudonymised data for research.

Although most people in Finland live in urban areas and population centres, the average population density is very sparse (18 per km^2), and distances are long, particularly in Northern Finland. The high-density urban environments are found only in downtown areas of Finland's largest cities (Statistic Finland, 2022). However, not only rural areas but also cities in Finland are relatively green (Kabisch et al., 2016). Simultaneously, health differences between urban and rural areas have been persistent, and have many potential contributors, including lifestyle, socioeconomic factors and availability of health and social services (Koskinen, 2019). Finland's Northern and Eastern regions have had poorer economic dependency ratios than Southern and Western regions in Finland for decades (Official Statistics of Finland, 2014), and the big urban municipalities have better economic dependency ratios than small rural municipalities in many cases.

2.2. Perceived health

Participants were asked about their *perceived health* with the question: 'How would you describe your health at the moment?' in the follow-up questionnaires for those ages 31 and 46. The response options were (1) very good, (2) good, (3) fair, (4) poor and (5) very poor. For statistical analysis, perceived health first was dichotomised as good (very good and good) or poor (fair, poor and very poor) at both time points. Thereafter, two binary outcome variables were established: (1) perceived health remained good vs. changed to poor (declined), and (2) perceived health remained poor vs. changed to good (improved).

2.3. Location data and geographical variables

A geographical information system (ArcMap 10.3 software, ESRI, Redlands, CA, USA) was used to manage geographical data and link it with coordinate-based cohort data. Geographical variables were calculated annually (1997–2014), based on the coordinate-based migration history of NFBC1966. All location coordinates at the beginning and end dates of residency durations were linked with the same durations' geographical data. If these were not available, then data for the closest possible year, with a maximum difference of three years, were used and in the event of ties the newer data were used. An exception was distance to green areas, which was calculated based on the 2012 data for every year. For every year, the longest period of residence was selected to represent the residential circumstances in that year, and only individuals who had coordinate-based residential information for every relevant year were included in the study.

Municipality's economic dependency ratio refers to the number of people unemployed or outside the labour force divided by the number of employed people and multiplied by 100. A fall in the economic dependency ratio is viewed as positive, and a rise as negative (Findicator, 2021). The national average economic dependency ratio value from each year (1997–2014) was used as a cut-off point, i.e., each municipality was grouped in lower-than-average and higher-than-average categories. Those who had lived the whole follow-up time in a municipality with a lower-than-average economic dependency ratio were placed in the *lower than average (good)* residential category, those who resided each year in a municipality with a higher-than-average economic dependency ratio were placed in the *higher than average (poor)* residential category and those who had resided in both types of municipalities were placed in the *varying* residential category. The economic dependency ratio depends on variations in economic cycles, development in employment situation, birth rate, ageing of the population and migration; thus, it reflects the employment markets in a municipality and also can impact a municipality's ability to provide services and amenities to its residents.

Population density *was* based on the Monitoring System of Spatial Structure and Urban Form (©YKR/SYKE/TK, 1995–2014) data in 250 × 250 m statistical YKR grids (Environment.fi, 2013). To determine the population density in a local residential area, a buffer with a 1 km radius was drawn around a cohort member's home, and the populations from all such YKR grids whose midpoints were located within the buffer were added up and divided by the buffer's area to produce a population-to-km^2 ratio. The population was divided into three categories, following the urban/rural classification in Rusanen et al. (2003), with 100 inhabitants per square kilometre as a cut-off point: *dense* if the population density in the buffer each year was >100; *sparse* if the population density in the buffer each year was ≤100; and *varying* if the population density varied above and below the cut-off point. The cut-off point of 100 inhabitants per square kilometre can be viewed as a limit that marks the transition from predominantly rural to predominantly built-up or urban areas in Finland (Rusanen et al., 2003).

Distance to local services was based on calculating the distance from cohort members' homes, along road network (Digiroad 2014), to the midpoint of the closest 1 × 1 km statistical YKR grid containing both a shop and a restaurant. The store buildings (111 shop halls; 112 commercial buildings, department stores and shopping centres; and 119 other store buildings) and restaurants (141 restaurants) were selected from the YKR buildings data-base and used to identify the 1 × 1 km grids that contained both services to identify the local centres that offered services. Road distance to local services was categorised as ≤ 2 km if the distance was no farther than 2 km in each year, > 2 km if the distance was over 2 km in each year and *varying* if the distance had varied over or under the cut-off point. The 2-km cut-off point can be viewed as a distance that also is feasible to travel by walking or bicycling (Finnish Transport Agency, 2018), making services in local centres readily available nearby via multiple transport modes.

Distance to green area was calculated as a straight-line distance from cohort members' homes to closest forest (3.1.1 broad-leaved forest; 3.1.2 coniferous forest; 3.1.3 mixed forest) or a green urban area (1.4.1 green urban areas) using the CORINE Land Cover generalised vector data set (2012). The data provide information on Finnish land cover and land use in minimum units of 25 ha and minimum widths of 100 m (SYKE metadata, 2021). Distance to green area was categorised as ≤ *300m* if the distance to the closest forest or park was 300m or less in each year, > *300m* if the distance was over 300m in each year, or *Varying* if the distance had varied over or under the cut-off point during these years. The 300 m distance to a green area is a common threshold value used in the literature when studying the use of green area (e.g. Schipperijn et al., 2010), and it also is in the WHO (2016) recommendation that green spaces should be accessible within a 300m linear distance from each residence.

Urban/rural classification of areas from the year 2010 (Environment.fi, 2014) was used to inspect the residential history characteristics of urban and rural populations at age 46, and to examine whether the associations between different residential area characteristics and perceived health were different for rural and urban residents. The urban/rural classification has seven regional classes: (1) inner urban area; (2) outer urban area; (3) peri-urban area; (4) local centres in rural areas; (5) rural areas close to urban areas; (6) rural heartland areas; and (7) sparsely populated rural areas. The variable was dichotomised as urban (Classes 1, 2 and 3) and rural (Classes 4, 5, 6 and 7).

2.4. Socioeconomic and health behaviour variables

All confounders except *gender* (men, women) were based on questions at ages 31 and 46. **Marital status** was categorised as: *in a relationship* (married, de facto relationship) *at both time points*; *started a relationship*; *single at both time points*; or *Divorced/widowed*. **Employment situation** was categorised as: *working, entrepreneur, or student*; *unemployed, laid off, parental leave, retired, or at home*; *changed to working, entrepreneur or student;* or *changed to unemployed, laid off, parental leave, retired or at home*. **Alcohol intake** was based on questions concerning frequency of use and typical quantity per occasion of mild drinks, wines and spirits. Daily consumption of alcohol in grams for each beverage was calculated by multiplying frequency with quantity, as defined in more detail previously (Vladimirov et al., 2018). The total daily alcohol consumption was arrived at by adding up all beverages consumed and whether the alcohol consumption had been under or over the limits of heavy use, categorised as: *non-heavy user; constant heavy user; former heavy user;* or *current heavy user*, with the limit for heavy use being ≥20g per day for women and ≥40g per day for men (Duodecim, 2019). **Leisure time physical activity** was enquired as the frequency and duration of light and brisk physical activities. Brisk physical activity was described as causing at least some sweating and breathlessness, while light physical activity was defined as causing no sweating or breathlessness. For both time points, the answers were categorised as: (1)

inactive; (2) moderately active; (3) active; or (4) very active following Tammelin et al. (2003). Using these categories and determining by comparison whether the category had been active (Categories 2–4) or inactive (Category 1) at both time points or had changed to either direction, the categories *active; from inactive to active; from active to inactive;* and *inactive* were created.

2.5. Statistical methods

Statistical analyses were conducted using IBM SPSS® software for Windows, Version 26.0 (IBM Corp., Armonk, USA). Descriptive data on perceived health, socioeconomic status, health behaviour and residential area characteristics were calculated according to perceived health status at age 46. The associations between residential history, socioeconomic and health behaviour variables, and perceived health from ages 31 to 46 were studied with cross-tabulations and chi-square tests – separately for those who had reported good and poor health at the age of 31.

Univariate associations between each residential area characteristics and change in perceived health were analysed using logistic regression analysis, separately for those reporting good health and poor health at age 31. Multivariable associations were studied first by entering the residential area variable together with socioeconomic variables, then together with health behaviour variables and finally all variables together in the binary logistic regression analysis. The explanatory variables' collinearity was examined through correlations between explanatory variables, tolerance and VIF values, and variance proportions of explanatory variables in model dimensions. The interaction terms were used to examine the relation between gender and each of the potential predictor variables in determining outcomes. The analysis was conducted separately for women and men if significant interactions occurred between residential area and gender variable. Finally, the distribution of residential history characteristics was examined in urban and rural populations separately, and interaction terms were used to examine the relation between the urban/rural status of the residential area and each of the residential history characteristics in determining perceived health.

3. Results

3.1. Study population characteristics

Of those age 46 whose perceived health was good, 81.3% had also reported good health and 18,7% had reported poor health at 31,

Table 1
Characteristics of the population with good and poor perceived health at age 46.

Good perceived health at 46y	N	%	Poor perceived health at 46y	N	%	P-value
Perceived health, ages 31 and 46	**4021**	**100.0**	**Perceived health, ages 31 and 46**	**1952**	**100.0**	<0.001
Remained good (the same)	3269	81.3	Remained poor (the same)	1003	51.4	
Improved to good (changed)	752	18.7	Declined to poor (changed)	949	48.6	
Gender	**4426**	**100.0**	**Gender**	**2277**	**100.0**	0.007
Men	1965	44.4	Men	1090	47.9	
Women	2461	55.6	Women	1187	52.1	
Marital status, ages 31 and 46	**4000**	**100.0**	**Marital status, ages 31 and 46**	**1943**	**100.0**	<0.001
In a relationship at both time points	2695	67.4	In a relationship at both time points	1123	57.8	
Started a relationship	532	13.3	Started a relationship	280	14.4	
Single at both time points	387	9.7	Single at both time points	305	15.7	
Divorced/widowed	386	9.7	Divorced/widowed	235	12.1	
Employment, ages 31 and 46	**3885**	**100.0**	**Employment, ages 31 and 46**	**1874**	**100.0**	<0.001
Working, entrepreneur, student	2859	73.6	Working, entrepreneur, student	1157	61.7	
Unemployed, laid off, parental leave, retired, at home	130	3.3	Unemployed, laid off, parental leave, retired, at home	166	8.9	
Changed to working, entrepreneur, student	786	20.2	Changed to working, entrepreneur, student	389	20.8	
Changed to unemployed, laid off, parental leave, retired, at home	110	2.8	Changed to unemployed, laid off, parental leave, retired, at home	162	8.6	
Alcohol use, ages 31 and 46[a]	**3904**	**100.0**	**Alcohol use, ages 31 and 46**[a]	**1905**	**100.0**	<0.001
Non-heavy user	3524	90.3	Non-heavy user	1608	84.4	
Constant heavy user	61	1.6	Constant heavy user	75	3.9	
Former heavy user	104	2.7	Former heavy user	77	4.0	
Current heavy user	215	5.5	Current heavy user	145	7.6	
Leisure time physical activity, ages 31 and 46	**4018**	**100.0**	**Leisure time physical activity. ages 31 and 46**	**1954**	**100.0**	<0.001
Active	2779	69.2	Active	941	48.2	
From inactive to active	633	15.8	From inactive to active	302	15.5	
From active to inactive	331	8.2	From active to inactive	358	18.3	
Inactive	275	6.8	Inactive	353	18.1	
Economic dependency ratio, ages 31–46	**2634**	**100.0**	**Economic dependency ratio, ages 31–46**	**1371**	**100.0**	0.001
Lower than average (good)	1313	49.8	Lower than average (good)	748	54.6	
Varying	1037	39.4	Varying	521	38.0	
Higher than average (poor)	284	10.8	Higher than average (poor)	102	7.4	
Population (inhabitants/km^2), ages 31–46	**2631**	**100.0**	**Population (inhabitants/km^2), ages 31–46**	**1367**	**100.0**	<0.001
Dense (>100)	1771	67.3	Dense (>100)	829	60.6	
Varying	494	18.8	Varying	307	22.5	
Sparse (1–100)	366	13.9	Sparse (1–100)	231	16.9	
Road distance to local services, ages 31–46	**2634**	**100.0**	**Road distance to local services, ages 31–46**	**1371**	**100.0**	0.634
≤2 km	448	17.0	≤2 km	230	16.8	
Varying	1265	48.0	Varying	641	46.8	
>2 km	921	35.0	>2 km	500	36.5	
Distance to green area, ages 31–46	**2634**	**100.0**	**Distance to green area, ages 31–36**	**1371**	**100.0**	0.512
≤300 m	826	31.4	≤300 m	451	32.9	
Varying	1285	48.8	Varying	664	48.4	
>300 m	523	19.9	>300 m	256	18.7	

Good perceived health: very good/good; poor perceived health: fair/poor/very poor.
P-value from the χ^2 test for the difference between those reporting good health and poor health at age 46.
[a] Heavy user: women ≥20 g/day, men ≥40 g/day.

whereas of those who reported poor health at age 46, 51.4% had also reported poor health and 48.6% had reported good health at age 31 (Table 1). Significant differences were found in socioeconomic, health behaviour and residential area characteristics between those who had reported good and poor health at age 46. Those whose perceived health was good at age 46 years were more likely to be women ($p = 0.007$), in a relationship ($p < 0.001$), employed ($p < 0.001$), not heavy alcohol users ($p < 0.001$) and active or changed from inactive to active ($p < 0.001$) during follow-up. Those who reported good perceived health at age 46 also were more likely to have lived, from ages 31 to 46, in municipalities with varying or higher-than-average (poor) economic dependency ratios ($p = 0.001$), and in densely populated areas ($p < 0.001$) than those who reported poor perceived health at age 46.

3.2. Univariate determinants of changes in perceived health

Among those who reported good perceived health at age 31, a larger proportion of people also reported good health at age 46 if their residential history had been in densely populated areas, rather than in sparsely populated areas ($p = 0.023$) (Table 2). Otherwise, not any statistically significant differences were found in maintaining or changing perceived health status between ages 31 and 46, according to residential history characteristics. However, the percentages indicate that living continuously in areas with lower-than-average (good) economic dependency ratios was associated with a smaller proportion of perceived health improving from poor to good (41.1% vs. 52.6%) or maintaining good (75.4% vs. 80.3%) than living continuously in areas with higher-than-average (poor) economic dependency ratios.

Those who remained in a relationship, employed, non-heavy users of alcohol and physically active maintained good perceived health status

Table 2
Residential area, socioeconomic and health behaviour characteristics (numbers and percentages) from ages 31–46, for Northern Finland Birth Cohort 1966 Study members according to perceived health at age 46. Numbers are shown separately for those who at 31 years old reported good health and those at 31 years old reported poor health.

	Perceived health good at 31 years of age			Perceived health poor at 31 years of age		
	Perceived health remained good	Perceived health declined to poor	P-value	Perceived health remained poor	Perceived health improved to good	P-value
	N (%)	N (%)		N (%)	N (%)	
RESIDENTIAL AREA						
Economic dependency ratio, ages 31–46			0.141			0.104
Lower than average (good)	1023 (75.4)	334 (24.6)		401 (58.9)	280 (41.1)	
Varying	830 (77.6)	240 (22.4)		273 (57.7)	200 (42.3)	
Higher than average (poor)	233 (80.3)	57 (19.7)		45 (47.4)	50 (52.6)	
Population (inhabitants/km^2), ages 31–46			0.023			0.332
Dense (>100)	1427 (78.3)	395 (21.7)		421 (55.9)	332 (44.1)	
Varying	383 (73.7)	137 (26.3)		167 (60.9)	107 (39.1)	
Sparse (1–100)	274 (73.5)	99 (26.5)		127 (58.5)	90 (41.5)	
Road distance to local services, ages 31–46			0.573			0.777
≤2 km	350 (77.4)	102 (22.6)		126 (57.8)	92 (42.2)	
Varying	1020 (77.4)	298 (22.6)		334 (58.5)	237 (41.5)	
>2 km	716 (75.6)	231 (24,4)		259 (56.3)	201 (43.7)	
Distance to green area, ages 31–46			0.802			0.818
≤300 m	625 (76.1)	205 (23.9)		238 (58.2)	171 (41.8)	
Varying	1022 (76.9)	307 (23.1)		346 (57.9)	252 (42.1)	
>300 m	412 (77.6)	119 (22.4)		135 (55.8)	107 (44.2)	
SOCIOECONOMIC FACTORS						
Gender			0.089			0.010
Men	1438 (76.3)	447 (23.7)		467 (60.6)	304 (39.4)	
Women	1831 (78.5)	502 (21.5)		536 (54.5)	448 (45.5)	
Marital status, ages 31 and 46			0.001			<0.001
In a relationship at both time points	2210 (78.9)	591 (21.1)		523 (52.1)	480 (47.9)	
Started a relationship	442 (78.6)	120 (21.4)		157 (63.8)	89 (36.2)	
Single at both time points	300 (71.8)	118 (28.2)		185 (68.3)	86 (31.7)	
Divorced/widowed	292 (73.2)	107 (26.8)		128 (58.4)	91 (41.6)	
Employment, ages 31 and 46			<0.001			<0.001
Working, entrepreneur, student	2372 (80.1)	590 (19.9)		559 (53.7)	482 (46.3)	
Unemployed, laid off, parental leave, retired, at home	91 (61.1)	58 (38.9)		106 (73.1)	39 (26.9)	
Changed to working, entrepreneur, student	607 (77.1)	180 (22.9)		208 (54.0)	177 (46.0)	
Changed to unemployed, laid off, parental leave, retired, at home	85 (53.1)	75 (46.9)		87 (77.7)	25 (22.3)	
HEALTH BEHAVIOUR						
Alcohol use[a], ages 31 and 46			<0.001			0.003
Non-heavy user	2872 (78.2)	801 (21.8)		799 (55.3)	645 (44.7)	
Heavy user	49 (60.5)	32 (39.5)		43 (78.2)	12 (21.8)	
Former heavy user	72 (72.7)	27 (27.3)		50 (61.0)	32 (39.0)	
Current heavy user	174 (70.2)	74 (29.8)		70 (63.1)	41 (36.9)	
Leisure time physical activity, ages 31 and 46			<0.001			<0.001
Remained active	2361 (81.8)	525 (18.2)		409 (49.7)	414 (50.3)	
Inactive to active	439 (77.4)	128 (22.6)		172 (47.0)	194 (53.0)	
Active to inactive	271 (60.2)	179 (39.8)		178 (75.1)	59 (24.9)	
Remained inactive	190 (63.3)	110 (36.7)		242 (74.5)	83 (25.5)	

Good perceived health: very good/good; poor perceived health: fair/poor/very poor.
P-value from the χ 2 test.
[a] Heavy user: women ≥20 g/day, men ≥40 g/day.

or changed from poor to good perceived health more often than those who had been single, unemployed, used alcohol heavily or had remained physically inactive or had declined from active to inactive (all p-values ≤ 0.003) (Table 2).

3.3. Multivariable determinants of changes in perceived health

In multivariable logistic regression, living continuously in municipalities with higher-than-average (poor) economic dependency ratios was borderline significantly associated with increasing odds of poor health improving to good (OR 1.55, 95% CI 1.00–2.40) compared with those who continuously lived in municipalities with lower-than-average (good) economic dependency ratios (Table 3). The association remained when adjusted with changes in health behaviour (OR 1.61, 95% CI 1.02–2.54) and with both socioeconomic and health behaviour (OR 1.61, 95% CI 1.01–2.57). Living continuously in sparsely populated areas (1–100 inhabitants/km^2) was borderline significantly associated with increased odds of good perceived health declining to poor (OR 1.28, 95% CI 0.99–1.67) when compared with those who had lived in densely populated areas (>100 inhabitants/km^2) continuously. However, when changes in socioeconomic and health behaviour were adjusted, the association decreased and became insignificant (OR 1.22, 95% CI 0.92–1.60). Distance to local services or green areas was not associated with changes in perceived health.

However, there was an interaction between gender and distance to local services, and gender and distance to green area, among those who reported good health at age 31, and thus the multivariable associations also were studied separately for men and women for this group (Table 4). An association of increased odds of good perceived health declining to poor was found for men who continuously had lived farther than 2 km from local services compared with those who continuously had lived within 2 km from local services (OR 1.63, 95% CI 1.05–2.51). The association remained when changes in socioeconomic and health behaviour were adjusted (OR 1.64, 95% CI 1.03–2.69). Also, among men, decreased odds of good perceived health changing to poor were found if the place of residence was farther than 300 m from green areas (OR 0.63, 95% CI 0.42–0.95), and this remained the case after adjusting for socioeconomic and health behaviour (OR 0.62, 95% CI 0.41–0.96). Among women, the associations were the opposite, but none were significant.

3.4. Residential history of urban and rural populations

To strengthen our understanding of residential history, we compared the characteristics of residential histories of urban and rural populations at age 46 (Table 5). Most (84.8%) of the current rural population had lived in regions with lower-than-average (good) economic dependency ratios, and the most current urban residents lived in dense (>100 inhabitants/km^2) residential areas (84.9%). A bigger proportion of rural residents had lived at distances farther than 2 km from local services (51.2% vs 25.8%) and within 300 m of green areas (48.3% vs 21.8%) than did urban residents. We also studied whether there was interaction between the urban and the rural status of residential areas and residential history characteristics in relation to perceived health, but found none.

Table 3
Residential area characteristic and changes in perceived health from ages 31–46, according to the multivariable logistic regression analysis. Numbers indicate crude and adjusted odds ratios (OR) and their 95% confidence intervals (CI) for change in perceived health.

	Perceived health good at age 31				Perceived health poor at age 31			
	Perceived health remained good vs. declined to poor				Perceived health remained poor vs. improved to good			
	Crude OR (95% CI)	Adj. SE OR (95% CI)	Adj. HB OR (95% CI)	Adj. All OR (95% CI)	Crude OR (95% CI)	Adj. SE OR (95% CI)	Adj. HB OR (95% CI)	Adj. All OR (95% CI)
RESIDENTIAL AREA								
Economic dependency ratio, ages 31–46								
Lower than average (good)	1	1	1	1	1	1	1	1
Varying	0.89 (0.73–1.08)	0.88 (0.72–1.08)	0.88 (0.72–1.08)	0.89 (0.72–1.09)	1.09 (0.85–1.39)	1.12 (0.87–1.45)	1.11 (0.86–1.43)	1.13 (0.87–1.47)
Higher than average (poor)	0.79 (0.57–1.10)	0.80 (0.57–1.11)	0.77 (0.55–1.07)	0.78 (0.56–1.10)	1.55 (1.00–2.40)	1.53 (0.98–2.39)	1.61 (1.02–2.54)	1.61 (1.01–2.57)
Population (inhabitants/km^2), ages 31–46								
Dense (>100)	1	1		1	1	1		1
Varying	1.24 (0.98–1.56)	1.23 (0.97–1.56)	1.21 (0.95–1.53)	1.19 (0.93–1.52)	0.80 (0.60–1.07)	0.83 (0.62–1.12)	0.80 (0.60–1.09)	0.83 (0.61–1.13)
Sparse (1–100)	1.28 (0.99–1.67)	1.24 (0.95–1.62)	1.28 (0.98–1.68)	1.22 (0.92–1.60)	0.90 (0.66–1.24)	0.86 (0.62–1.18)	0.97 (0.69–1.34)	0.94 (0.67–1.31)
Road distance to local services, ages 31–46								
≤2 km	1	1		1	1	1		1
Varying	0.99 (0.76–1.29)	1.00 (0.77–1.31)	0.95 (0.73–1.24)	0.97 (0.74–1.27)	0.94 (0.67–1.30)	0.95 (0.68–1.33)	0.96 (0.68–1.35)	0.97 (0.68–1.37)
>2 km	1.11 (0.84–1.46)	1.11 (0.84–1.47)	1.10 (0.83–1.45)	1.09 (0.82–1.45)	1.00 (0.71–1.40)	0.95 (0.67–1.34)	1.03 (0.73–1.47)	0.98 (0.69–1.40)
Distance to green area, ages 31–46								
≤300 m	1	1		1	1	1		1
Varying	0.99 (0.81–1.23)	1.00 (0.80–1.24)	0.98 (0.79–1.21)	1.00 (0.80–1.24)	1.01 (0.78–1.31)	1.05 (0.80–1.38)	0.99 (0.75–1.30)	1.03 (0.78–1.36)
>300 m	0.91 (0.69–1.19)	0.93 (0.71–1.23)	0.91 (0.69–1.19)	0.94 (0.71–1.24)	1.10 (0.79–1.53)	1.11 (0.80–1.56)	1.09 (0.77–1.53)	1.11 (0.78–1.57)

Table 4
Road distance to local services and distance to green area from ages 31–46 and change in perceived health for those reporting good perceived health at age 31, according to the multivariable logistic regression analysis. Numbers indicate crude and adjusted odds ratios (OR) and their 95% confidence intervals (CI) for good perceived health changing to poor. The analysis was conducted separately for women and men.

	Good perceived health at age 31. ORs and 95% CIs for perceived health remaining good vs. declining to poor							
	Women				Men			
Road distance to local services, ages 31–46	Crude OR (95% CI)	Adj. SE OR (95% CI)	Adj. HB OR (95% CI)	Adj. All OR (95% CI)	Crude OR (95% CI)	Adj. SE OR (95% CI)	Adj. HB OR (95% CI)	Adj. All OR (95% CI)
≤2 km	1	1	1	1	1	1	1	1
Varying	0.77 (0.55–1.09)	0.76 (0.54–1.08)	0.76 (0.54–1.08)	0.75 (0.53–1.07)	1.39 (0.91–2.11)	1.49 (0.97–2.29)	1.31 (0.85–2.02)	1.43 (0.92–2.23)
>2 km	0,84 (0.59–1.20)	0.81 (0.56–1.17)	0.85 (0.59–1.21)	0.81 (0.56–1.18)	1.63 (1.05–2.51)	1.69 (1.08–2.64)	1.60 (1.02–2.50)	1.64 (1.03–2.60)
Distance to green area, ages 31–46								
≤300 m	1	1	1	1	1	1	1	1
Varying	1.20 (0.90–1.61)	1.22 (0.90–1.65)	1.19 (0.89–1.60)	1.21 (0.89–1.65)	0.80 (0.59–1.08)	0.81 (0.60–1.11)	0.77 (0.57–1.06)	0.80 (0.58–1.11)
>300 m	1.22 (0.86–1.75)	1.33 (0.92–1.92)	1.22 (0.85–1.75)	1.32 (0.91–1.92)	0.63 (0.42–0.95)	0.61 (0.41–0.92)	0.63 (0.42–0.96)	0.62 (0.41–0.96)

Crude: no adjustments.
Adj. SE: Adjusted with changes in marital status and employment status.
Adj. HB: Adjusted with changes in alcohol use and leisure time physical activity.
Adj. All: Adjusted with changes in marital status, employment status, alcohol use and leisure time physical activity.
Good perceived health: very good/good; poor perceived health: fair/poor/very poor.

Table 5
Residential history of urban and rural populations at age 46.

	Residential area of the Northern Finland Birth Cohort 1966 Study members at age 46		
	Urban N (%)	Rural N (%)	P-value
Economic dependency ratio, ages 31–46	2452 (100.0)	1513 (100.0)	<0.001
Lower than average (good)	754 (30.8)	1283 (84.8)	
Varying	1326 (54.1)	217 (14.3)	
Higher than average (poor)	372 (15.2)	13 (9.7)	
Population (inhabitants/km^2), ages 31–46	2452 (100.0)	1506 (100.0)	<0.001
Dense (>100)	2081 (84.9)	494 (32.8)	
Varying	323 (13.2)	470 (31.2)	
Sparse (1–100)	48 (2.0)	542 (36.0)	
Road distance to local services, ages 31–46	2452 (100.0)	1513 (100.0)	<0.001
≤2 km	458 (18.7)	212 (14,0)	
Varying	1361 (55,5)	527 (34.8)	
>2 km	633 (25.8)	774 (51.2)	
Distance to green area, ages 31–46	2452 (100.0)	1513 (100.0)	<0.001
≤300 m	535 (21.8)	731 (48.3)	
Varying	1365 (55.7)	561 (37.1)	
>300 m	552 (22.5)	221 (14.6)	

Urban: Inner urban area, outer urban area, peri-urban area; rural: local centres in rural areas, rural areas close to urban areas, rural heartland areas, sparsely populated rural areas.
P-value from the χ^2 test for the difference between urban and rural populations at age 46.

4. Discussion

4.1. Main findings

According to the univariate model, those whose residential history comprised densely populated areas more likely reported good health 15 years later compared with those who had resided in sparsely populated areas during the follow-up. Furthermore, being in a relationship, employed, not using alcohol excessively and being physically active were associated with reporting good perceived health at ages 31 and 46. The multivariable analysis indicated that residential history in areas with poor economic dependency ratios was associated with increased odds of reporting good health 15 years later if perceived health had been poor at age 31. Among men, continuous living farther than 2 km from local services was associated with higher odds of reporting poor health, but continuously living farther than 300 m form green areas lowered odds of reporting poor health at age 46 if health had been perceived as good at age 31. The residential environment's urban/rural characteristics may be one factor contributing to the findings.

4.2. Associations between residential area characteristics and changes in perceived health

Our finding that residential history in areas with poor economic dependency ratios was associated with increased odds of reporting good health 15 years later if perceived health at age 31 had been poor is not consistent with several other findings that indicate that residential history in socioeconomically disadvantaged areas is associated with worse health outcomes. Residential or non-residential contextual exposure to disadvantage has been associated independently with a higher likelihood of reporting poor health (Sharp et al., 2015). Sharp et al. (2015) also found that individuals who live, work, shop, worship and seek health care in neighbourhoods with a higher proportion of disadvantaged and vulnerable people are more likely to perceive themselves as being in poor health. Glymour et al. (2010) reported that among US adults ages 55–65, neighbourhood disadvantage predicted the onset of poor perceived health in a longitudinal context. Furthermore, a study by Godhwani et al. (2019) stated that area deprivation later in life may maintain inequities in self-rated health, and a study by Yang and South (2020) stated that any fairly sustained exposure to high neighbourhood poverty between adolescence or young adulthood and middle adulthood, regardless of whether this exposure occurs early or later in life, may compromise individual health and exert consistent and adverse effects on physical and perceived health.

The poor economic dependency ratio used in our study indicates that the number of people who ares unemployed or outside of labour force is much larger than the number of employed people, which potentially can have implication at to what extent a municipality can provide services and other amenities to its residents. While adjusting for individual socioeconomic variables did remove the association between poor health and the likelihood of this perception changing to good among those whose residential history was in disadvantaged areas, adjusting individual health behaviour further strengthened the association, indicating complex processes behind the associations. When we examined the residential histories of 46-year-old cohort members in urban and rural areas, we found that most rural residents have been living in municipalities with good economic dependency ratios, perhaps on the urban fringes of large cities, whereas most of those whose residential history comprised municipalities with poor economic dependency ratios, often were urban residents. Thus, the association between increased odds of reporting good perceived health and the residential area's economic dependency ratio being poor, actually is derived from current urban residents. Clarke et al. (2014) and Morenoff et al. (2006) have formulated that long-term residence in disadvantaged neighbourhoods may discourage positive health behaviours that get reinforced over time through local norms and attitudes towards fitness, eating nutritious foods, tolerance for substance use and views about when and where to seek health care. It may be that in our sample, the residents in socioeconomically poor areas have had other amenities in urban areas where they live, that have allowed them to overcome effects of poor socioeconomic situations in larger regions. The effects of poor economic dependency ratios in municipalities probably would be reflected more in rural and other more remote areas than in urbanised areas, e.g., reduced access to services. Defining the socioeconomic variables from smaller neighbourhood units potentially could have resulted in different findings, as associations with contextual variables and health can depend on how contextual units are delineated (e.g. Kwan, 2012).

Associations between poor perceived health and residential area deprivation also have been related to selective mobility, rather than causal neighbourhood effects (Jokela, 2014, 2015). In the Moving to Opportunity (MTO) studies, the families who moved from high-poverty areas to low poverty areas experienced improved health outcomes (Graif et al., 2016; Sampson et al., 2002). In our study, we were interested in residential area characteristics remaining the same over the years. Thus, in our study, those whose residential area had not changed were people who have not moved and whose residential area circumstances have not changed, or people who have moved, but to similar kinds of residential environments during the 15-year follow-up period. It is possible that self-selection of people in certain kinds of environments already has happened before age 31, and after that, people with certain health status have remained in similar kinds of environments. However, those who have experienced a decline in health status may have wanted to stay or move in areas with readily available services or other amenities that they perceive to be beneficial for their health.

Residential history in densely populated residential areas (>100 inhabitants/km^2), also was associated with reporting good perceived health at age 46 more often than if residential history had comprised sparsely populated areas. However, this association disappeared after adjusting with socioeconomic and health behaviour variables. In densely populated residential areas, the association with health likely was derived via possibilities to seek official and unofficial care and support, as well as better access to amenities, which also encourages health promoting behaviours, e.g. walking and cycling. In our sample, those who had a residential history in dense residential areas mainly were urban residents.

A finding that also might be related to this was that men who had continuously lived farther than 2 km from local services had greater odds of reporting poor health than men who lived near services. Residential areas nearby services provide better access to amenities and enable integration of physical activity into daily activities that may in turn promote good health. According to Finnish studies, walking and cycling are most common for trips under 2 km and, after 3–5 km, the proportion of those walking and cycling drops substantially (Finnish Transport Agency 2018). Detrimental health consequences for residents who live in areas that they perceive as poorly connected – with inadequate facilities and services, and a lack of social opportunities – also have been attributed to exposure to chronic environmental stressors (Gidlow et al., 2010). In a study by Spring (2018), long-term exposure to built environments that lack health supportive services – e.g., physicians, pharmacies, grocery stores and recreational facilities – increased the risk of poor health compared with more average neighbourhoods. She states, that this may be because of when these services are near, it is easier to obtain medical care or purchase health-related goods; thus this access to services may influence health-related behaviour, and neighbourhood social processes. Residential history within 2 km of local services was more typical for urban than rural residents in our sample, while rural residents most often had lived the whole follow-up time farther than 2 km from services. However, why this association was detected specifically among men is more difficult to explain and warrants more studies. Perhaps men can take advantage of living near services better than women, possibly due to gendered constraints, e.g., childcare or household tasks. Some studies also have reported gender differences in active travel and particularly cycling patterns, motivators and constraints for recreational and transportation cycling (Goel et al., 2022; Heesch et al., 2012).

We also found that among men, residential history in areas farther than 300 m from green area was associated with lower odds of reporting poor health 15 years later if perceived health at age 31 had been good. As such, our results do not seem to correspond with longitudinal studies that have found that exposure to greenness, or a higher percentage of tree canopy is associated with lower incidence of fair to poor general health (e.g., Astell-Burt and Feng 2019). It may be that our variable (urban green areas or forests' proximity) actually represents more general associations of perceived health and rural and urban environments, and distance to services, considering that in sparsely populated and more distant areas one is more likely to live near green areas. Those who had lived in areas farther than 300 m from green areas, were more likely to be residents living in urban areas at age 46. Also, green area availability is relatively high in Finnish cities (Kabisch et al., 2016), which may make our variable too coarse, and more thorough analysis of residential area green space type and quality might be needed (Gonzales-Inca et al., 2022; Nguyen et al., 2021). Also, why the association was detected with men, but not women, is difficult to determine, though the explanation may be similar to the aforementioned distance to services aspect. Some other health-supporting factors might be related to closeness of services and unofficial help from other people who prevail when living in more urbanised environments and simultaneously in areas more distant from green areas. Also, the Working Paper of the Finnish Forest Research Institute stated that women spent more time outdoors within their residential areas than men (Sievänen and Neuvonen, 2011), so other factors aside from nearby green area may be important for men's perceived health. However, some studies have found that green space measures are not associated with self-reported health (Dunstan et al., 2013). A Picavet et al. (2016) study found that depending on whether it is a rural or urban type of green the association with different health indicators went in opposite directions, and no association was found between higher longstanding green and better health outcomes. However, we could not find evidence that the associations with distance to green area and changes in perceived health would have been different among urban and rural residents. Usability of greenspaces has been raised as an important aspect in achieving better health outcomes (Carter and Horwitz, 2014), but we did not have information about the actual usability of nearby urban green areas and forests. Although the 'Every man's rights' in Finland enable all residents to use green areas for recreation, not all green areas may be perceived equally pleasant to use.

Furthermore, poor individual socioeconomic and health behaviour characteristics were associated consistently with declining perceived health. These findings correspond with those of other studies (Abu-Omar et al., 2004; Kasmel et al., 2004), with the potential pathway being through health problems to the functional consequences that they inflict.

4.3. Strengths and limitations

One of our study strengths is the large population-based birth cohort sample, with its extensive data for health and wellbeing characteristics at different ages, and the coordinate-based geographical information on cohort members' residential locations during their lifetimes. We acouted for the full residential histories of study subjects between ages 31 and 46, and the high temporal and spatial coverage of the objectively measured residential area characteristics, thereby allowing us to link residential area and cohort data with high accuracy. We distinguished between those who had been living from ages 31 to 46 in one type of residential environment and those whose residential environment had changed. However, the use of static areas and distances centred in cohort members' places of residence, may have introduced some bias, because even though certain residential area characteristics would be present within the defined boundaries from home, the individuals may have been exposed to these characteristics differently, as people have very different areas where they conduct their everyday living (Hasanzadeh et al., 2018; Kwan, 2012).We had no information on individuals' everyday contextual changes (e.g., Sharp et al., 2015). With a longitudinal study design, looking back over a 15-year time period with such a large study sample, and trying to define personalised activity areas (e.g. Hasanzadeh et al., 2018) for each individual would not have been feasible.

Although longitudinal studies can help overcome issues related to self-selection, we cannot rule out the possibility that the individuals in this study already decided to live in certain kinds of places, for health-related reasons, before the 31-year survey period. We do not have any information on whether the individuals are living in certain residential areas of their own free will or out of necessity; thus, there is possibile that residential area implications for health would be different for these groups. We also do not have data on how the cohort members perceived their social environments, which would have strengthened our study (e.g., Gidlow et al., 2010). However, Godhwani et al. (2019) found no support for the idea that change in poor health over time would vary based on neighbourhood dissatisfaction. Also, althought our data contained a rich set of variables associated with perceived health and residential areas, we cannot rule out the possibility that omitted variables would remove the detected associations.

The use of a straight-line distance, instead of a road network, to analyse of distance to green areas can be viewed as a limitation, but using the road network also can include some bias, because it is imperfect and does not include unofficial paths or shortcuts that people may use in their residential area to reach green areas. The green area variable may include some discrepancies as well. Although the forest data in CORINE Land Cover can be viewed as reliable, the class 'green urban area' may have some limitations, as it may include some areas that are not urban parks per se, and some maintained urban parks may be missing. Another limitation is the subjectivity of perceived health, as well as the 15-year 'gap' between the two measurements because we cannot ascertain when exactly the health status changed. However, perceived health has been demonstrated to correlate with morbidity, predict mortality (Benyamini and Burns, 2020; Gallagher et al., 2016; Goldberg et al., 2001; Jylhä, 2009), and reflect both early life, as well as cumulative and contemporary circumstances (Hertzman et al., 2001). The categories of perceived health may not mean the same for everyone but reclassifying it to only two categories may have lessened this problem.

The cohort population's attrition rate has been reported in Nordström et al. (2021). For the 31-year follow-up, 75.3% answered the postal questionnaire, and 70.7% participated in clinical examination, whereas the respective figures in the 46-year follow up were 69.2% and 56.5%. At both time points, the participants more often were women, employed, from higher social classes, were married and had children than initially. Thus, the current cohort population may not fully represent the most disadvantaged segment of the population. Furthermore, the results might be generalizable to other Nordic countries or areas with a similar residential and built-environment characteristics.

5. Conclusion

The results of this population-based study indicate that having a residential history in urban areas near services potentially is associated with maintaining good perceived health, particularly among men. However, having a residential history in areas with poor economic dependency ratios was associated with increased odds of reporting good health 15 years later among middle-age adults with poor health at age 31. The findings likely are related to the urban/rural context of the residential area's characteristics. People with a long-term residential history in remote areas should be supported in maintaining good health. Also, being employed and having a healthy and active lifestyle may protect against declining health and foster improvement in perceived health. The results also point to the importance of considering the residential area's characteristics, e.g., access to services, as well as residence duration under these conditions, as potential determinants of health, which either may promote or impair health during one's lifetime.

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Declaration of competing interest

None.

Data availability

The authors do not have permission to share data.

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