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Urban Form, Sustainability and Health: The Case of Greater Oslo

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Abstract *Several studies have shown dense urban structures to be favourable in order to reduce greenhouse gas emissions from transport, limit energy consumption in buildings and protect farmland and natural areas in the surroundings of the city. There may, however, be some tensions between such a compact urban developmental strategy and considerations of public health in urban planning. This paper reviews findings from international research on the relationships between urban form and health and illustrates some of these effects by comparing statistics on life expectancy and the frequency of heart attacks among inhabitants of different urban districts in the Norwegian capital Oslo. Since we have only had access to aggregate figures at the level of urban districts, the results must be interpreted with caution. The currently available results do, however, suggest that the densification strategies often recommended for reducing the ecological footprints of cities might be encumbered with some important drawbacks, seen from a public health perspective. Based on the findings, some dilemmas and perspectives for sustainability- and health-oriented urban planning are discussed.*

1. Introduction

Sustainable development has been high on the agenda of urban planners for a quarter of a century, triggered by the publication of the United Nations' report "Our Common Future" (World Commission on Environment and Development, 1987). Important objectives of sustainable urban development in wealthy nations are to mitigate climate change, limit energy consumption, reduce pollution, protect natural areas and arable land and provide a safe and healthy environment for the citizenry, particularly the most vulnerable groups. There may, however, be some tensions between local health concerns and goals for reducing a city's negative impacts on the wider regional or global environment.

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Using the Norwegian capital Oslo as the main example, this paper will highlight some of these tensions. Oslo is interesting in this context since it has got a reputation as a forerunner of sustainable urban development and, in particular, for having successfully combated urban sprawl. Oslo was awarded the European Sustainable City prize in 2003 and has also obtained high rankings on the European Green City index.

The paper concentrates on environmental sustainability and health impacts caused by the spatial (physical/functional) urban form. Driving forces of the urban development will not be dealt with here, nor will barriers that might prevent the realization of spatial structures favourable from a sustainability perspective. I have discussed these issues elsewhere (Næss, 1993a, 2001, 2006a; Næss *et al*., 2011a, 2011b).

I will first briefly reiterate some key results from Norwegian and international research underpinning the compact city as a model for sustainable urban development. I will also mention some findings from the still-inconclusive research on the relationships between urban form and health. Mortality-based statistics on life expectancy and statistics on the frequency of heart attacks among inhabitants of different urban districts in Oslo will then be presented and discussed. In the final part of the paper, some dilemmas and perspectives for sustainability- and health-oriented urban planning will be discussed.

2. The Compact City as a Model for Urban Sustainability

Current urban development in many parts of the world requires a high rate of conversion of natural areas and farmland into urbanized land. This has serious negative effects on food security as well as on ecosystems and biodiversity. Habitat loss is a main cause of species extinction, and habitat loss and fragmentation are increasingly the direct results of urban development (Beatley, 2000). Low-density spatial expansion of cities also increases distances between the various facilities and functions of an urban region and, thus, increases the need for motorized travel (Næss, 1993b, 2006b; Næss *et al*., 1996; Newman & Kenworthy, 1999). Low-density development also makes it difficult and expensive to provide a high-class public transport system. Together with the road construction carried out to meet the expected future demands for road capacity, urban sprawl contributes to the creation of highly car-dependent cities. This involves high energy use for transportation and makes it difficult to reach greenhouse gas emission-reducing goals. Although a transition to more environmentally friendly vehicles is technically possible, growth of urban traffic ties up (possibly renewable) energy resources that could have been used with more positive effects in other sectors of society (such as energy use for lighting, heating, cooling and electric appliances in residential and commercial buildings and energy use for manufacturing). Moreover, urban driving entails a number of other environmental problems aside from energy use and emissions, such as noise, barrier effects, traffic accidents, congestion and the encroachment of urban transport infrastructure onto existing built environments and green areas.

Combating urban sprawl has, therefore, been high on the agenda of urban planners and researchers aiming to promote a more sustainable urban development (Westerink *et al*., 2012). In 1990, the European Commission advocated the "compact city" as the most sustainable model for urban development (Commission of the European Communities, 1990). Compared to low-density and sprawling cities as well as to the competing "green city" model of sustainable settlements, compact cities can promote sustainability by limiting the losses of surrounding natural and agricultural areas; reducing the amount of travel, car dependency and energy use for transport; reducing energy use in buildings; limiting

the consumption of building materials for infrastructure and buildings; and maintaining the diversity and possibilities for choice among workplaces, service facilities and social contacts (Næss, 1993a; Newman & Kenworthy, 1999; Blanco *et al*., 2009; Litman, 2012).

Densification, rather than urban sprawl, seems more favourable for the protection of natural landscapes, arable land and biodiversity (Beatley, 2000; Pinho *et al*., 2011). This is particularly the case if densification can incorporate "brownfield" sites, obsolete harbour areas and parking areas incompatible with a goal of reducing car traffic in the urban centre. The concentration of development in order to save nature, farmland and energy was a main message from the interdisciplinary Norwegian research project Environmentally Sound Urban Development (Norwegian acronym: NAMIT) in the late 1980s and early 1990s (Næss, 1993a; Høyer, 2002). Concentrated housing types (apartment buildings and row houses) require less heating energy per square metre than detached single-family houses (Høyer & Holden, 2001; Brown & Wolfe, 2007). A more-compact urban development also makes it possible to provide accessibility to facilities through proximity instead of by high-mobility means such as a car, and thus, combines important environmental and social aspects of sustainability.

The above-mentioned relationships between urban form and transportation have also been found in Oslo (Næss *et al*., 1995; Næss and Sandberg, 1996; Hjorthol, 1998; Røe, 2001; Holden, 2007). Based on the experience from the studies in Oslo as well as three Danish cities, Figure 1 shows how the average daily travelling distance by motorized modes of travel has been found to vary with the distance from the dwelling to the city centre. In Figure 1, the effects of residential location have been controlled for socioeconomic and demographic variables (and in the metropolitan area of Copenhagen also for

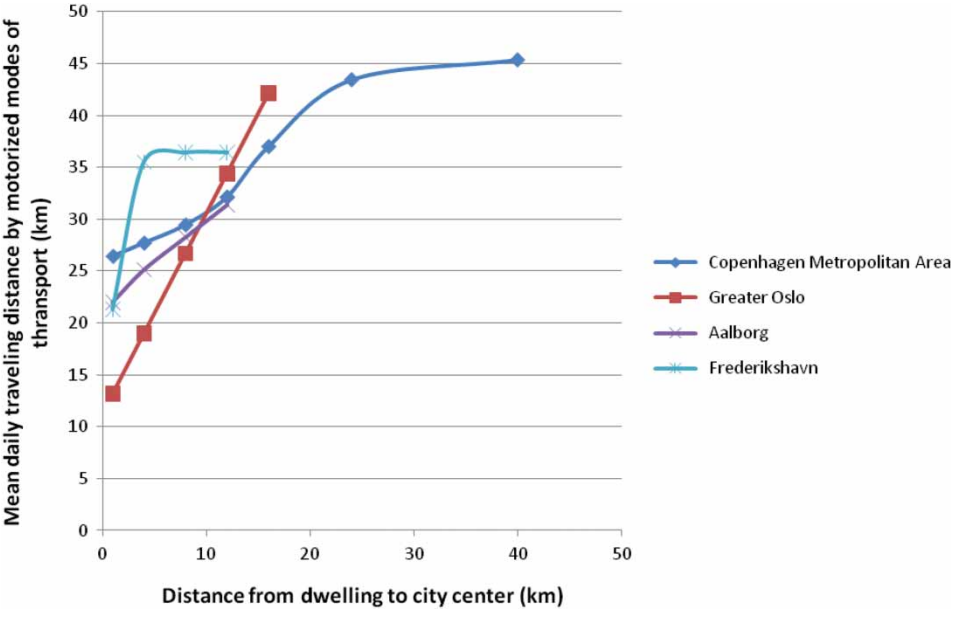

Figure 1. Relationships between residential location and travelling distance by motorized modes found in four urban regions.
Sources: Nielsen (2002) (Aalborg); and data files from studies published in Næss (2009) (Copenhagen Metropolitan Area); Næss *et al*. (1995) (Greater Oslo); and Næss and Jensen (2004) (Frederikshavn).

transport-related residential preferences). The curves reflect the different sizes of the four cities, where the continuous urban area stretches considerably further out from the city centre in a big city like Copenhagen (1.2 million inhabitants within the continuous urban area and 1.8 million within the metropolitan area) than in a small town like Frederikshavn (25,000 inhabitants within the continuous urban area and 35,000 within the entire municipality). There are, of course, a number of individual characteristics influencing the travel behaviour apart from the location of the residence. Individual lifestyles are, however, conditioned by structural constraints and opportunities, which are reflected in the observed geographical differences in the travel behaviour. Controlling for a number of socioeconomic variables, energy usage for intra-metropolitan transportation in Oslo was nearly four times higher among respondents living on the urban periphery than among those respondents living closest to the city centre.

The proportion of travel to and from the workplace via car is considerably lower among employees at workplaces located close to Oslo's city centre than for those at suburban workplaces. In the Oslo metropolitan area (like in most European cities), the inner city has the greatest level of accessibility by public transport and the lowest level of accessibility by car, due to congested streets and scarce parking. Of six workplaces studied in Greater Oslo, only about 10–15% of the employees of the inner-city workplaces commuted by car, compared to 70–90% in the outer suburbs (Næss & Sandberg, 1996). Similar results have been found in several other cities, including Trondheim, Copenhagen and Amsterdam (Verroen *et al*., 1990; Hartoft-Nielsen, 1997; Strømmen, 2001).

Some planners believe that the lower use of cars for daily commuting to central workplaces would be compensated by shorter travelling distances to decentralized workplaces interspersed throughout suburban residential areas. In the contemporary highly specialized and high-mobility society, however, people do not necessarily choose workplaces (or recruit employees) from within their local neighbourhood. In the above-mentioned study, employees at the outermost workplaces had the longest average commuting distances (albeit not necessarily travel times) among the whole sample. Combined with the effect of location on the choice of travel modes, energy use for commuting was thus found to be, on average, three times higher for employees at peripheral locations than for employees at central locations (Næss & Sandberg, 1996).

As can be seen above, urban densification seems clearly preferable to outward urban expansion if the aim is to mitigate climate change, protect biodiversity and natural landscapes and provide accessibility to facilities without being highly dependent on the car travel. In line with these insights, Oslo has pursued a pronounced densification policy since the mid-1980s (Næss *et al*., 2011a). As a result, the population density within the continuous urban area (comprising 907,000 inhabitants in 2011) increased by as much as 27% over the period 1985–2011. The population density increase has been especially high in the central parts of Oslo. Within the so-called Inner Zone, the number of inhabitants grew by from 132.700 in 1989 to 184.500 in 2010, with no increase in the urbanized land, representing a population density increase of 39%. There may, however, be some tensions between such a compact urban developmental strategy and considerations of public health in urban planning.

3. Urban Structure and Health

Improving health and hygiene conditions in cities has, for more than a century, been an important part of the rationale for urban planning. Characteristics of the built

environments in cities can, to a varying degree, expose people to health risks in the form of pollution, lack of proper hygiene, risk of accidents, etc., in the environments where they live, work, go to school and carry out other daily or regular activities. Built environment characteristics may also facilitate or discourage activities that are considered favourable from a health viewpoint, notably those activities involving physical exercise.

Planning and developing urban structures encouraging the population to engage in healthy physical exercise, while at the same time reducing their exposure to noise, pollution and accidents, can thus play an important role in public health policy. Urban planning as a public health measure is a part of what the nineteenth-century pioneer of social medicine, Rudolf Virchow, termed "social prophylaxis", where the preventive treatment of population groups is obtained through political intervention (Jensen, 1986). Such disease prevention partly involves the protection of population groups against involuntary exposure to harmful conditions such as air pollution, noise or polluted drinking water. It also partly involves facilitating "self-care" in the form of making healthy practices more convenient and affordable for the population.

Improving public health through urban development and renewal is also an important part of the sustainable development concept. The need for a healthy urban environment is emphasized in the Brundtland Commission's report, Chapter 9 in particular (WCED, 1987). Although the most urgent problems are in some Third World cities, pollution, traffic accidents and other unhealthy conditions are serious problems for cities in affluent countries as well.

The urban developmental strategies and measures that can be pursued in order to promote different aspects of public health may, to some extent, be in conflict with each other. On the one hand, opportunities for gardening and outdoor recreation in close proximity to one's home appear to be highest in low-density suburban environments. This applies to avoiding exposure to heavily trafficked streets as well. On the other hand, however, the possibility of having a high proportion of non-motorized travel appears to be highest in dense, inner-city settings. These different aspects of health are emphasized to a different extent among proponents of an "anti-urban" and a "pro-urban" strand in urban planning, and by proponents of the "green" and "compact" models for sustainable cities, respectively.

The anti-urban professional ideology among urban planners is to a high extent based on assumptions about rural life as being healthy and life in large cities to be unwholesome in a somatic and moral sense (Jacobs, 1961; Cohen, 2004). The roots of this belief can be traced back to at least two centuries to writings by the American president Thomas Jefferson, who in 1800 described large cities as "pestilential to the morals, the health and the liberties of man". The late nineteenth-century institutions for restoring somatic and mental health (tuberculosis sanatoriums and mental hospitals, in particular) were usually located in rural surroundings at safe distance from unwholesome urban life. Today, too, some researchers emphasize gardening and contact with nature as important contributors to mental health (Grahn, 1993). Urban densification may be a threat to green areas—often a minimum factor in already densely built urban areas—thus reducing access to natural playgrounds and close neighbourhood recreation areas. Additionally, being distinct from suburban settings where buffer zones around heavily trafficked roads can more easily be established, dense urban environments are often more exposed to noise and local pollution from traffic.

A considerable body of international literature has demonstrated that residents living in inner-city districts tend to be more exposed to air pollution, noise and traffic accidents than their suburban counterparts (Goldstein *et al*., 1986). A study of inner-city residents of the Gamlebyen and Vålerenga districts in Oslo showed that a high proportion of respondents felt that nuisances from road traffic impacted negatively on their health, well-being and daily activities (Kolbenstvedt & Hjorthol, 1987). Similarly, in a study of Kristiansand, Røe and Jones (1997) found considerably higher risks of traffic accidents among inner-city residents than among suburbanites.

Most professionals in the preventative health field agree that regular physical exercise contributes to better health. Several studies have shown that a short distance from homes to green recreational areas stimulates residents to walk, jog or bike more frequently in these areas (Grahn, 1993; Næss, 2006c). Swedish investigations indicate that the proportion of residents actively using green recreational areas is halved when the trip by foot or bike to the area takes more than 8 or 10 minutes (Grahn, 1993). In a Danish survey, Nielsen and Hansen (2007) found that access to a garden or short distances to green areas from home are associated with less stress and a lower likelihood of obesity. The number of visits to such areas could not, however, explain the health effects of proximity to green areas. Instead, a general conduciveness to outdoor activities and a non-motorized travel in the districts with high accessibility to green areas were pointed out as possible explanations.

In the inner districts of Oslo, the availability of local green areas close to the residence is considerably lower than in the suburbs (Guttu *et al*., 1997; Municipality of Oslo, 2009). Together with a high exposure to noise, air pollution and traffic accidents, these circumstances could be expected to lead to higher health risks among inner-city residents. Although exposure from pollution and noise from industrial activities have been reduced considerably over several decades in Oslo—as well as most other European cities—due to a combination of environmental regulations, technological improvements and relocation of manufacturing industries to suburban or exurban locations domestically or overseas, inner-city areas in many respects still seem to offer a less-healthy environment than the suburbs. For this reason, arguments made by Howard (1902) and subsequent garden-city proponents about the health merits of "town-country" environments rather than purely urban environments are, apparently, still valid.

There are also several scholars, however, who warn of the negative health impacts of low-density urban development (Frumkin, 2002; Fan & Song, 2009). In contemporary health discourse among urban planners, there is a pronounced strand warning against the negative health impacts of a dispersed and car-based urban development. Obesity has become a dominant public health problem, particularly in the US, with 26% of the adult population characterized as "severely overweight" (having a body mass index, or BMI, above 30), with the associated increased risks of heart disease, diabetes, stroke and musculoskeletal diseases. Obesity levels are rising in Europe as well, with shares of 8%, 10% and 23% of the population "severely overweight" as of 2005 in Norway, Denmark and England, respectively. According to the World Health Organization, 60–70% of all Europeans will be severely overweight by 2030 if current trends continue (Danish National Institute of Public Health, 2007). The role of urban development and transport infrastructure in facilitating physically active or sedate lifestyles has been increasingly addressed, and despite the normally lower availability of local green areas in the inner cities, criticism about obesity-generating urban structures has most often been pointing at low-density suburban development as the culprit. According to these

debaters, increased density, especially around urban nodes, will lead to a healthier transport pattern, since a greater part of the population will use public transport, walk and bike.

The effect of residential locations on the use of green areas for physical exercise and mental relaxation, and on the use of non-motorized modes of transportation may thus seem to pull in opposite directions, seen from a health perspective. Living far away from the closest green recreational area, however, does not necessarily imply that residents eschew physical exercise for solely this reason. Their exercise can instead take other forms, such as walking or jogging along streets and paths, or some form of indoor exercise. A study in the Copenhagen metropolitan area (Næss, 2006c) indicates that a reduced frequency of walks and bike trips in natural areas by inner-city residents is largely balanced by a higher frequency of other types of physical exercises, such as in gyms or sports centres.

In a study of the US city of Atlanta, Frank *et al*. (2004) found mixed patterns of urban land use, typically found in dense inner-city settings, to be strongly associated with lower frequencies of obesity. Conversely, Ewing *et al*. (2006) found higher frequencies of obesity among American youth living in counties with a sprawling pattern of development, compared to their counterparts living in counties with more concentrated developmental patterns. A similar tendency was found in a study of inhabitants of different Canadian metropolitan areas (Ross *et al*., 2007). Although some studies (Lopez & Hynes, 2006) hold that the jury is still out regarding the impact of residential location on obesity-related diseases, most authors seem to agree that car-dependent suburbs are more likely than dense urban environments to produce daily travelling habits characterized by relative physical inactivity (Frank *et al*., 2004; Ewing *et al*., 2006; Ross *et al*., 2007; Boarnet *et al*., 2008; Ewing & Cervero, 2010; Næss, 2010, 2012; Joh *et al*., 2012) although some of the effects of urban form characteristics on physical activity in the neighbourhood may be compensated by physical activity outside the local environment (Troped *et al*., 2010). The possible negative health consequences resulting from lower availability of outdoor recreation areas in the proximity of inner-city dwellings must, therefore, be compared to the positive health impacts of inner-city residents' more frequent walks to and from public transport stops, and a higher number of trips by foot and bicycle.

As mentioned above, high urban density contributes to reducing the overall levels of vehicle emissions by reducing average travelling distances and the relative proportion of car trips. On the other hand, dense and concentrated urban patterns of development most often mean that a higher proportion of transportation takes place within a limited geographical area. Seen in isolation, this increases the concentration of pollution. The same applies, to a high extent, to traffic accidents. An overall reduced amount of travel in dense cities contributes to reducing the number of accidents (Røe & Jones, 1997); however, even though a high population density for the city as a whole appears to reduce rather than increasing the number of traffic accidents causing personal injuries, the risk of accidents is still higher among inhabitants of central urban districts than among suburban residents. This paradox is highlighted by Fan and Song (2009), who, based on a study of the Portland metropolitan area of the US state of Oregon, found that health threats imposed by sprawl affect inner-city residents disproportionately compared to suburban residents, and that efforts to curb sprawl can mitigate urban–suburban health disparities.

As can be seen from above, urban structural conditions can possibly influence residents' health in many different and highly complex ways. Identifying these various mechanisms,

and finding urban developmental strategies to counter unhealthy tendencies while promoting those conducive to better health, is an important topic for further research. It is important, however, to investigate the combined effects of several mechanisms emanating from some typical urban-structural situations. In light of the debate surrounding urban densification as a strategy for sustainable urban development, comparing the health impacts of inner-city living to those impacting suburbanites stands out as a particularly relevant issue. In a study of Oslo, Næss *et al*. (2008) found clear effects of residential location on mortality caused by heart disease and psychiatric factors, but this study did not take characteristics of residential areas into consideration. In order to better inform health-oriented urban planning, however, it is precisely the spatial and other characteristics of residential areas that are of primary interest.

In Section 4, preliminary research results from Oslo will be used to shed light on some dilemmas that need to be resolved between policies aiming to reduce urban consumption of energy and land, and policies aiming to promote public health through urban planning.

4. Preliminary Empirical Data from Oslo

So far, we have not had the opportunity to carry out in-depth research into the existence and strength of the various mechanisms through which urban structural conditions may influence health in the context of the city of Oslo. Such research would probably need to involve both quantitative and qualitative methods, with statistical analyses of disaggregate health data (e.g. from the HUBRO files of the National Public Health Institute), socioeconomic characteristics and health-relevant lifestyle indicators for individuals living at different residential addresses, combined with qualitative medical history interviews of people living in typical inner-city and suburban neighbourhoods. The collected data would need to cover not only the present situation, but also information about previous diseases, health-related habits and prior residential addresses (Næss *et al*., 2008). Unfortunately, we have so far not been able to obtain funding for such a thorough study.

Available statistics on mortality and disease incidences within the 15 administrative districts of the municipality of Oslo can, however, give some preliminary indications about the combined results of these mechanisms. At this stage, we have only had access to aggregate figures at the level of urban districts for selected health and mortality variables, as well as for socioeconomic characteristics. Bearing in mind the danger of committing "the ecological fallacy" when making inferences about phenomena occurring at the individual level based on aggregate-level data, the following comparison of Oslo's urban districts must be interpreted with great caution. Spatial differentiations in mean life expectancy and frequency of cardiac infarctions still suggest that there may be some important tensions between urban developmental strategies favourable to the protection of nature and the environment, and concerns for a healthy local environment for the urban population. Careful interdisciplinary analyses will be necessary to identify urban developmental principles simultaneously contributing to environmental sustainability and improved public health.

Figure 2 shows the locations of the 15 administrative districts of the municipality of Oslo. Some key urban structural, socioeconomic and health indicators for each district are given in Table 1.

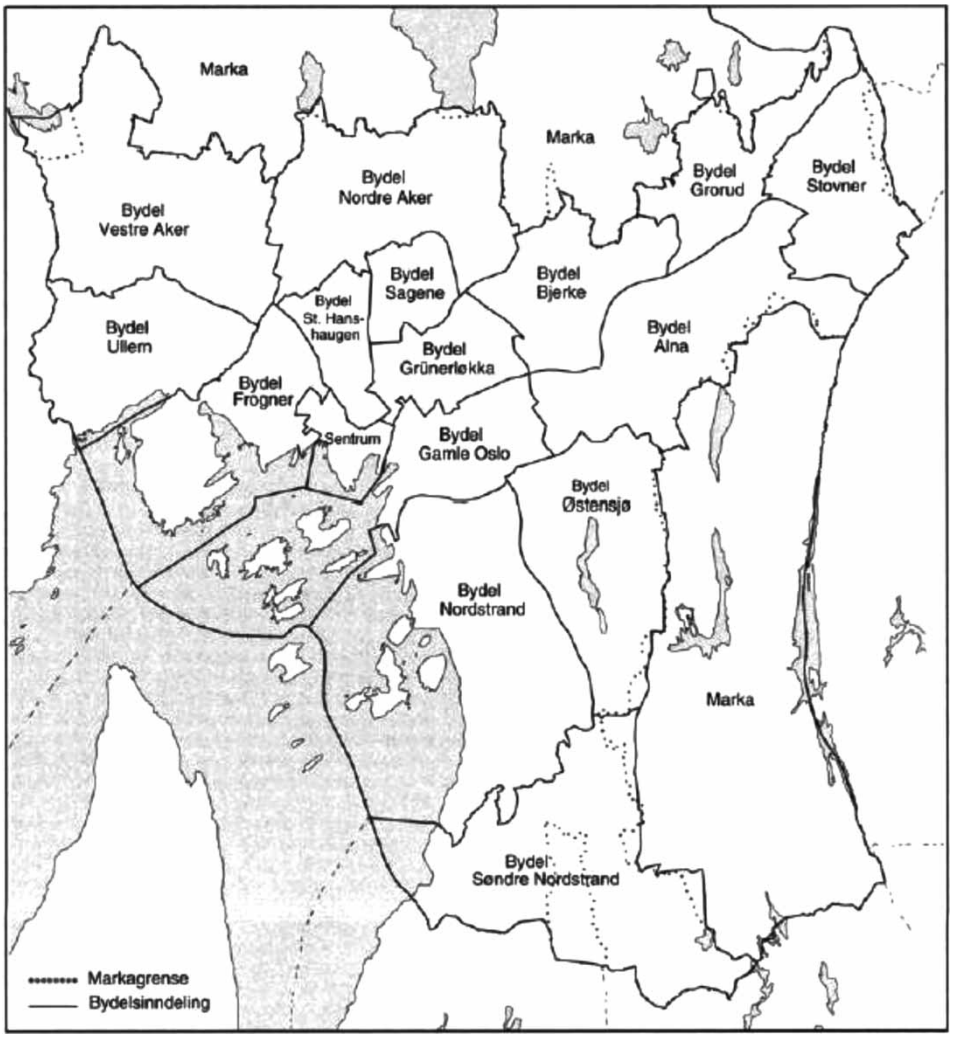

Figure 2. The 15 administrative districts of the municipality of Oslo. The downtown area is approximately equal to the district named Sentrum. "Marka" is the name of the continuous forest areas surrounding the city.

With only 15 units of analysis, the basis for assessing the separate influences of different urban structural and socioeconomic variables on health and mortality by means of multivariate statistical analyses is poor. We shall, therefore, only show a few graphs where the urban districts have been sorted, based on a binary classification into inner-city and suburban districts. The districts have also been classified as low- or high-income districts. The health-related variables are the mean number of expected remaining years of life[1] among men and women at 20 and 50 years of age, respectively (Statistics Norway, 2010a, 2010b), and the number of patients per 10,000 inhabitants aged 50–79 treated for acute heart attack (coronary infarction) in 2008 (Municipality of Oslo, 2009).

Table 1. Key urban structural, socioeconomic and health indicators for the 15 administrative districts of the municipality of Oslo[a]

District	Dist. from down-town (km)	Density (pers./ ha)	% intra-urban green areas	Border-ing sur-rounding forests	Median gross personal income (1000 NOK)	Median gross fortune liable to tax (1000 NOK)	% with high educa-tion	% above 40 years of age	% un-employ-ed	% living in over-popula-ted dwel-lings	% exposed to noise	Cardiac infarcts per 10,000 inhabitants 50–79 year	Mean number of expected remaining life-years among:			
													20-year-old males	20-year-old females	50-year-old males	50-year-old females
Alna	11.2	34.0	15.4	Yes	279	221	23.7	44.3	6.1	4.7	7.6	113	56.6	60.8	28.6	32
Bjerke	4.7	35.9	8.9	Yes	287	211	31.9	42.0	5.8	6.5	8.7	81	57.2	61.9	28.9	33.3
Frogner	2.1	60.7	6.9	No	323	186	53.5	42.0	3.8	13.0	4.8	51	57.9	63.4	29.4	34.2
Gamle Oslo	1.7	56.8	22.9	No	280	113	43.0	31.1	5.6	10.6	14.0	91	53.1	57.8	25	29.2
Grorud	9.9	31.8	16.6	Yes	270	202	20.9	44.6	6.3	5.7	7.8	108	55.3	60.1	27.2	31.6
Grünerløkka	1.8	95.1	15.5	No	291	106	48.0	29.9	5.4	8.9	12.9	142	53.7	59.4	25	30.5
Nordre Aker	4.7	34.0	11.0	Yes	338	301	53.8	44.3	3.2	4.8	5.0	42	59.7	63.4	30.8	34.5
Nordstrand	8.1	27.5	22.3	No	324	304	40.5	49.2	2.8	5.5	3.8	53	58.1	62.6	29.2	33.7
Sagene	2.3	110.6	20.0	No	306	127	52.1	32.0	5.6	6.4	12.7	71	49.8	58.7	22.8	30.3
St.Hanshaugen	1.9	89.6	10.8	No	311	129	55.7	31.3	3.5	10.5	6.9	145	55.7	61.2	27.6	32.3
Stovner	13.3	36.3	24.1	Yes	268	229	18.2	46.0	6.4	3.5	7.2	123	55.5	61.1	27.9	31.9
South Nordstr.	11.7	19.4	19.5	Yes	272	199	28.1	39.4	6.3	1.4	6.7	59	58.8	62	29.8	33.1
Ullern	3.9	32.2	13.4	No	376	469	56.8	50.3	2.8	3.0	3.7	68	58.1	63.4	30	33.7
Vestre Aker	6.4	26.2	15.3	Yes	365	478	56.6	48.9	2.7	4.1	3.1	71	60.8	63.5	32.4	34.6
Østensjø	4.8	37.4	21.1	Yes	272	255	31.9	48.2	3.6	6.1	5.4	67	56.4	61.4	28.4	32.9

Sources: Municipality of Oslo (2009) and Statistics Norway (2010a, 2010b).

[a]Distances from downtown are measured, as the crow flies, from the address of the urban district administration to the Parliamentary Building. Densities, proportions of green areas and socioeconomic data refer to 2009, except income and fortune, where the data refer to 2007, and the proportions living in overpopulated dwellings, where the data refer to 2001. Data on cardiac infarctions refer to 2008 and the figures on life expectancy are based on mortality rates for the years 2002–2004.

When comparing districts varying in their density and location relative to the city centre, the immediate impression is that tendencies contributing to better health among suburbanites (cleaner air, less noise, higher availability of green areas, etc.) seem to outweigh the tendencies that inner-city living opportunities might have to promote better health (better opportunity for reaching daily activities by walking or biking). As given in Table 1, the average expected remaining years of life for 50-year-old men is nearly 10 years longer in one of the low-density suburban districts (Vestre Aker) than in the most densely populated urban district (Sagene).[2] Among females aged 50 years, the remaining years of life are also higher in the low-density districts than in the high-density districts, but the pattern is less pronounced than among men, and the difference in expected remaining years of life between Vestre Aker and Sagene is only four and a half years (but with a difference of five and a half years when comparing Vestre Aker with another high-density district, Gamle Oslo). A similar pattern was found when comparing the number of expected remaining years of life among 20-year-olds. Here, we found an even larger difference between the low-density Vestre Aker and high-density Sagene among men (11 years), whereas the corresponding difference among 20-year-old women is 5 years (and a difference of 6 years when comparing Vestre Aker with Gamle Oslo, the district with the lowest life expectancy). The high-density districts are all located close to downtown, with their local public administration offices situated, at most, 2.3 km from the Oslo city centre. The above-mentioned differences in life expectancy are therefore to a great extent a result of differences between the inner city and the suburbs.

Obviously, a host of other conditions aside from the urban structural situation of a dwelling are likely to influence people's health. We have, therefore, checked whether the geographical differences in life expectancy are still present when adjustments are made to include factors such as income, wealth, education level, unemployment, age distribution in the district and the proportion of the population living in small, overpopulated dwellings.[3] Because our data on life expectancy, residential locations and socioeconomic characteristics are on an aggregate level with only 15 administrative districts analysed, it has only been possible to check for one socioeconomic variable at a time. These comparisons do, however, suggest that the observed differences in life expectancy between the inner and outer districts cannot be explained solely by socioeconomic variables. The location of the residence also seems to matter. Figure 3 shows the mean expected remaining number of years of life among inner-city and suburban districts with income levels above or below the median value for the 15 districts. Income was chosen as the control variable in Figure 3 because income can theoretically be expected to be correlated with a number of lifestyle characteristics influencing health (Elstad, 2000). Among our socioeconomic variables, income was also among the ones showing strong co-variation with life expectancy. As can be seen from Figure 3, however, there is still a considerable difference in the number of expected remaining years of life among 50-year-old people when comparing inner-city and suburban districts with similar income levels. This applies equally to men and women.

Similar patterns are found when comparing life expectancy among 20-year-old people within similar income groups across different residential locations. The differences in life expectancies between suburbanites and inner-city dwellers also persist when comparing districts with similar education levels, wealth, unemployment levels and shares of crowded dwellings.

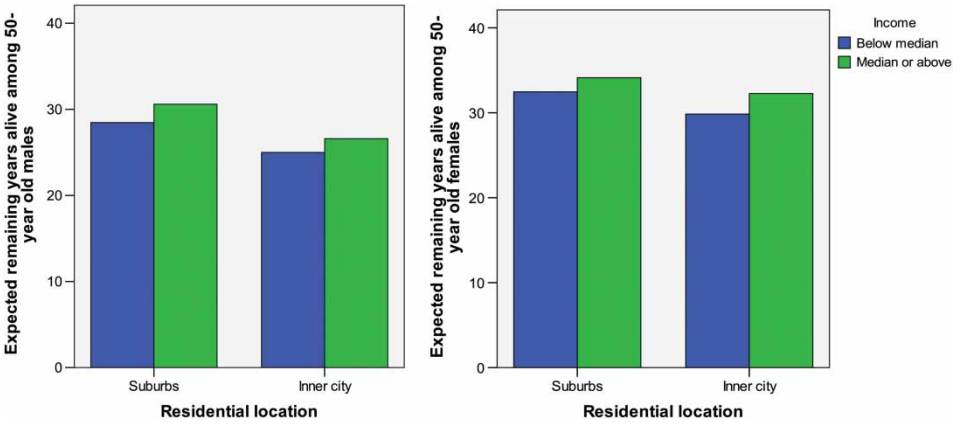

Figure 3. Expected remaining years of life among 50-year-old men (left) and women (right) within administrative districts of Oslo, with different income levels and different locations in the urban structure.
Sources: Municipality of Oslo (2009) and Statistics Norway (2010a, 2010b).

Based on theoretical considerations, one could perhaps expect inner-city living to reduce the risk of heart disease, since the higher possibility of reaching daily destinations by non-motorized modes of travel might provide better opportunities for regular physical exercise. Statistics on the frequency of coronary infarctions suggest, however, that any such positive effects are outweighed by other aspects of inner-city living that contribute to an increased risk of heart disease. Controlling for income, we find considerably higher frequencies of coronary infarctions among inner-city residents than among suburbanites (Figure 4). Similar to the patterns found for life expectancy, the higher frequency of heart attacks among inner-city dwellers persists when comparing districts with similar education levels, wealth, unemployment levels and shares of overpopulated dwellings, though the difference is quite small when controlling for the proportions of overpopulated dwellings. It is, however, difficult to identify any causal mechanisms by which living in a small dwelling with more residents than rooms in itself produces a higher risk of heart attack. Plausibly, a high proportion of overpopulated dwellings acts as a proxy variable (or indicator) for a number of social and urban structural conditions that may put strain on people's health, such as low income, low availability of outdoor space, little influx of sun and high exposure to traffic noise and air pollution.

In the view of Dybendahl and Skiri (2005), much of the explanation for the low levels of life expectancy in the inner-city districts of Sagene, Gamle Oslo and Grünerløkka must be sought in the fact that these districts (especially Sagene) have many municipal rental dwellings and/or healthcare institutions; moreover, it is a well-established fact that those who move into these categories of dwellings have, at the outset, poorer prospects for longevity compared to residents who own their homes.

These circumstances are hardly sufficient, however, to explain the higher mortality rates and frequency of coronary infarctions among residents of Oslo's inner districts. Local environmental factors most likely also play a role. Among inhabitants in the inner city of Oslo, 10.1% were characterized as "strongly affected" by noise from road traffic, compared to 4.6% among the municipality's remaining inhabitants (Municipality of

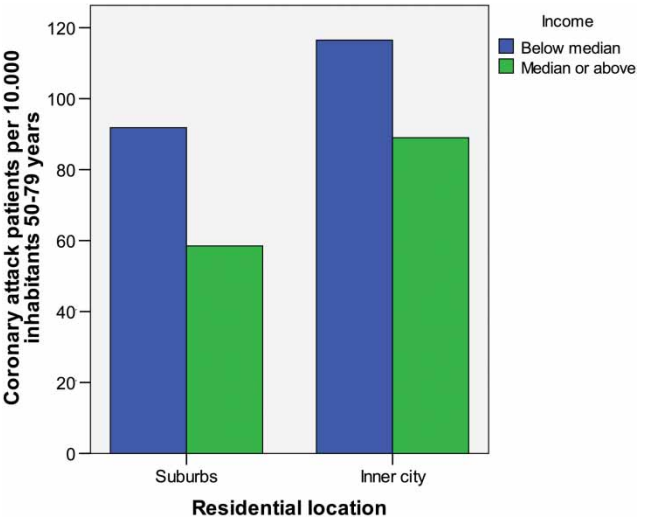

Figure 4. Number of patients per 10,000 inhabitants aged 50–79 years old treated for acute coronary infarctions in 2008 within the administrative districts of Oslo, having different income levels and different locations in the urban structure.
Source: Municipality of Oslo (2009).

Oslo, 2009). Inner-city residents are also generally more exposed to pollutants such as suspended particulates, sulphur dioxide, nitrogen oxides and carbon monoxide than their suburban counterparts, except those suburbanites living close to the main highways leading out of the city. Oslo's geographical setting in a "bowl" between surrounding hills makes the inner city especially vulnerable to smog on calm winter days (Figure 5).

The inner city, and especially its eastern parts, is also characterized by high provision of fast-food bars where the purchase of high-fat meals is offered as a convenient and cheap way of satisfying one's hunger. The latter is pointed out by Piro (2008) as a possible contributing explanation of the low scores of Oslo's inner eastern districts on health indicators. Piro also points at the perceived risk of crime as a factor preventing some residents of these districts, particularly among the older generation, from engaging in healthy activities such as walking in the neighbourhood. Such lack of outdoor activity in the local area may in its turn have a self-enforcing effect, since the going for a walk in the neighbourhood appears as less of a "normal" activity among inner-city East-Enders than among their counterparts living in districts with low crime rates and lower levels of traffic in the streets.

More research is obviously needed in order to gain a better insight into the mechanisms by which urban structural conditions influence the inhabitants' health, and how these mechanisms add up to overall patterns of relationships between residential area characteristics and health. Studies so far, including the above results from Oslo, do not provide a base for firm conclusions (Mead *et al.*, 2006). The currently available results do, however, suggest that the densification strategies often recommended for reducing urban energy use, greenhouse gas emissions and encroachment on natural areas and farmland might be encumbered with some important drawbacks, seen from a public health perspective. In Section 5, environmental sustainability merits and possible negative

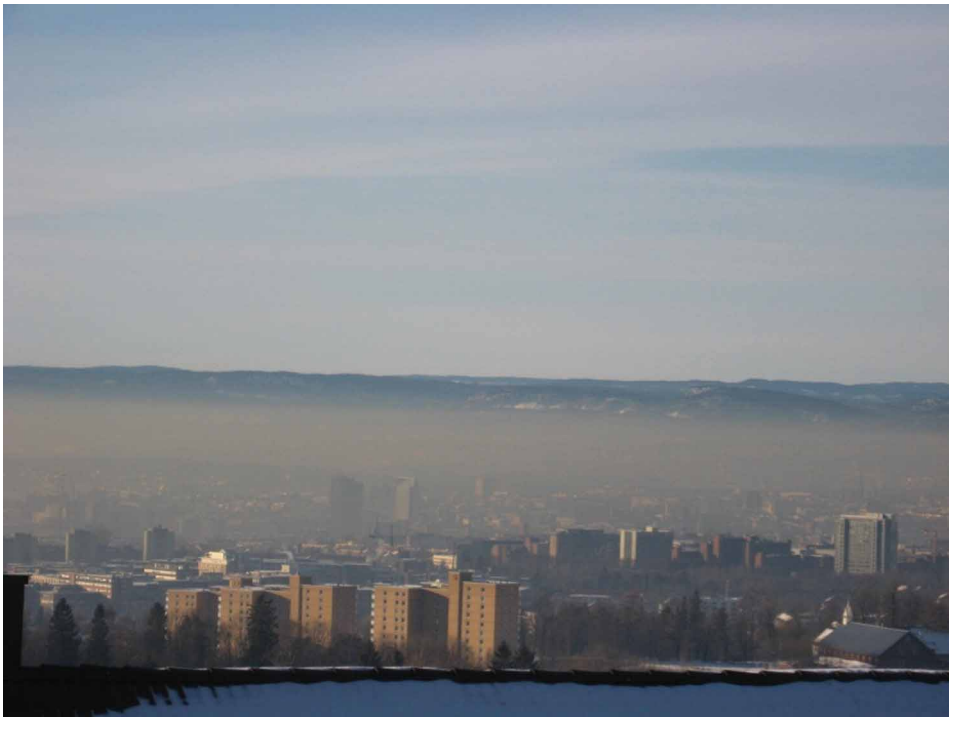

Figure 5. Smog covering the inner districts of Oslo on a calm winter day in 2011. Photograph by the author.

health-related side effects of the spatial development of Greater Oslo during recent decades will be described and discussed.

5. Discussion

The higher levels of mortality and coronary infarctions among inner-city residents in Oslo present some important dilemmas in urban planning aimed at sustainable development. On the one hand, a sprawling, car-dependent urban development is clearly not in line with environmental sustainability; but on the other hand, urban densification runs the risk of exposing more inhabitants to living conditions that seem unfavourable to their health. To some extent, these dilemmas represent conflicts of interests between present and future generations, and between local and global environmental concerns. The impact of urban development, in terms of greenhouse gas emissions, is long term and will have global effects, independent of their sources. Densification resulting in unhealthy urban neighbourhoods affects local residents, but the effects are not restricted to the short term, as the permanence of urban built structures makes it likely that future residents' health will also be affected by conditions resulting from today's urban planning.

The distributive ethical questions involved are, however, not only restricted to the local–global and the present–future dimensions. Regarding traffic accidents, noise and local pollution, the location of developmental areas impacts the distribution of burdens

and benefits among the city's inhabitants. If development takes place in the outer parts of the urban area, those who move into the new houses will benefit from a local neighbourhood safer from traffic and less polluted than the urban average, while inadvertently contributing to an increased overall amount of traffic for residents living closer to downtown, with increased through-traffic, pollution and accident risk. Correspondingly, people moving to infill developments in the inner city will, on average, create only a small amount of traffic and pollution while being exposed to the nuisance of car traffic originating mainly in the outer parts of the urban area.

Residential development in the form of outward urban expansion thus contributes to an increased polarization by worsening conditions among residents already experiencing the least satisfactory local traffic conditions, while providing a sheltered situation for residents of the new peripheral dwellings. Comparatively, inner-city densification contributes to a higher degree of equalization of traffic-related environmental nuisances, besides reducing the overall amount of travel and its related pollution and injuries.

As an early response to air pollution in industrial cities, taller smokestacks were built; dilution was seen as a solution to industrial pollution. In the contemporary post-industrial cities typical of many European countries, traffic has replaced industry as the main source of pollution, noise and other environmental nuisances, and non-local environmental problems—such as climate change—have revealed that the belief in dilution as a solution to pollution was an illusion. Whereas high urban density reduces the overall amount of traffic and the city's contribution to air pollution, when compared to a more-dispersed urban structure, high density still concentrates the traffic volume and its related environmental nuisances. Therefore, while dilution cannot do away with environmental problems, the concentration of local air pollution and noise in dense inner-city districts calls for policy measures that can bring about a stronger reduction in local traffic volumes than is achievable by urban concentration alone. In order to prevent inner-city residents from having to resign themselves to lower quality outdoor areas and a high environmental load from traffic, stronger measures to regulate urban driving will be required than current regulations in Oslo and most other European cities.

Buildings are seldom, if ever, constructed with environmental protection as a main purpose. Instead, construction takes place to accommodate growth in the number of households, jobs, etc., and in the floor space per resident or employee. Increases in the building stock are at best environmentally friendly in a relative sense, but not in absolute terms (Høyer & Næss, 2001). In order to make an omelette, you have to crack eggs, and so also for the construction of the built environment: the most environmentally friendly building is arguably the one never built. As shown earlier in this paper, fewer environmental "eggs" will usually be cracked if urban development takes place as densification rather than as urban sprawl. Still, densification has its own negative health and environmental impacts. Today, the idea of limiting the growth of building stock for environmental reasons has minimal political support. The challenge for sustainability-oriented urban planning practices under current conditions will be to minimize the negative impacts of this growth, while trying to repair some of the environmental damage done by prior urban development.

Instead of resorting to the dominant post-World War II planning principles characterized by low-density suburban growth, the strengths of the compact urban model should be maintained while avoiding its pitfalls. Several authors have tried to develop such alternatives, including Newman and Kenworthy (1999), Frey (1999) and Barton (2000).

None of these authors believe that the city should be compact right through without green wedges or parks. Densities at neighbourhood and district levels should, however, be high enough to facilitate local services and public transportation, and to reduce the need for new "greenfield" development. In order to limit travelling distances, residences should not be located too far away from the concentration of workplaces, administration centres, specialized services and cultural facilities usually found in the downtown area.

Translated to the situation in Oslo, this speaks in favour of maintaining the development border against the surrounding forests. From pure energy considerations, the most favourable outcome would probably be to locate as high a share of the development—residences as well as workplaces—as possible, as close to the Oslo city centre as possible. In a broader urban planning perspective, where considerations are given to housing quality, green structures, heritage buildings, climate change adaptation, and, not the least, public health concerns, such extreme residential densification would not be desirable. For existing and new inner-city housing areas, more efforts should be taken to ensure green courtyards that provide opportunities for outdoor recreation and play in a traffic-safe environment (Sonne, 2009). By planting rows of trees along sidewalks, establishing "green roofs", and by converting asphalt areas into lawns, bushes or other vegetation-covered areas, the negative urban heat-island effect of high density development could be reduced significantly. Traffic calming measures—beyond the measures undertaken as part of the government-led urban renewal programme in the 1970s and 1980s—are also important for relieving inner-city residents of the health and safety risks to which many centrally located dwellings are currently exposed. From an equity perspective, such measures would be highly justified, since inner-city residents are, on average, responsible for only a low proportion of the city's traffic-related environmental problems.

Apart from the new dwellings that can be added to the inner-city housing stock in an environmentally sound way, the potential for densification could be increased considerably by extending Oslo's present zone of dense urban fabric westward and northward. A similar rise in the allowed plot ratio around local centres along urban rail and streetcar lines in Oslo would also be beneficial. Improving urban environments in the industry-dominated Grorud Valley in the north-east is an obvious task, where better site utilization of industrial areas, reduction of road capacity, upgrading public transportation services and establishing continuous green corridors and bike paths could facilitate density increases along with providing better outdoor recreation opportunities. In addition to densification around public transport nodes within the city of Oslo, concentrated, high-density residential development close to the main centres in the neighbouring county of Akershus would be favourable from an energy standpoint.

Office development does not require the same standards as housing in terms of outdoor space, greenery and sunshine. At the same time, from a perspective of transportation minimization, a high concentration of office workplaces and services would be particularly recommendable in the parts of Oslo with the highest levels of public transportation accessibility. Although a mix of dwellings, services and workplaces in the inner city is generally preferable for environmental and liveability reasons, priority should perhaps be given to compact and high-density non-residential development in the areas immediately adjacent to Oslo's main rail stations.

Many of the above land-use strategies are already incorporated in the Oslo municipal plan and the county plan for the neighbouring county of Akershus. The main problem, seen from a sustainability perspective, is the lack of willingness to implement measures

to effectively reduce urban driving. As long as public transportation improvements are outweighed by road capacity increases, the likelihood of achieving the goal of increasing public and non-motorized travel while reducing car travel seems remote. The recently adopted Oslo Package 3 for road construction, public transport improvement and increased road tolls represents a continuation of this ambiguous strategy, which could be characterized as being similar to stepping on the accelerator and the brake at the same time (Næss *et al*., 2011a). If climate change mitigation concerns and public health considerations in urban planning are to be reconciled, however, it seems crucial to replace facilitation of growth in car traffic with much stronger restrictions on the freedom to drive in the city.

Notes

1. The average expected remaining years of life have been calculated for each district based on actual mortality rates among men and women for each one-year-age class during the period 2000–2004. This method of estimating remaining life expectancies is encumbered with several sources of error and uncertainty, particularly due to the fact that people move between different places of residence, but also because of an uneven distribution of nursing and old people's homes, and the fact that some immigrants move abroad without reporting (Dybendahl & Skiri, 2005). We still consider these data relevant for the present preliminary study.
2. Controlling simultaneously for income, property, age and unemployment, we find a difference of 6.5 years in the number of expected remaining life years among 50-year-old males between the districts with the highest and lowest population densities (sig. = 0.005).
3. Defined as one- and two-room dwellings inhabited by more than one or two persons, respectively, in 2001. (Municipality of Oslo, 2009).

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