NORDGREEN

Access to green space, socio-demography, and health in six Nordic municipalities participating in the NORDGREEN project

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Abstract

In this paper, we aim to provide an overview of access to green space, socio-demographic status, and health for the following municipalities in the Nordic region; Espoo, Ii (Finland), Stavanger (Norway), Täby and Vilhelmina (Sweden), and Aarhus (Denmark).

To map access to green space within each municipality several data sources were used. Land-cover and land-use maps were obtained to identify parks, cemeteries, and forests. Then, we computed the total area of these green space types in each municipality and their neighbourhoods. Moreover, we computed the total area of green space per inhabitant, and the mean distance between the dwellings and each green space type. Additionally, we used Urban Atlas to compute the total green area, and vegetation coverage was measured using satellite images. All green space measures were computed using geographical information systems (GIS). Data on socio-demography and health outcomes were identified and downloaded from the national statistics of each country. Relevant socio-demographic variables were age, education, immigration status, and median household income. Health outcomes of interest were life expectancy, depressive symptoms, cardiovascular health, perceived health, physical activity, and obesity. Data have been summarized and analysed using descriptive and analytical statistics. For total green area, we compared the figures with the recommended distance of 300-meter to the nearest green space suggested by the World Health Organization (WHO).

Our main finding is that all municipalities have a high proportion of green area, and 95% of all dwellings have less than 300-meters to the nearest green space. Taking a glance at the sociodemographic and health data, Täby municipality stands out from the rest of the municipalities on several aspects, such as highest proportion of inhabitants with a university degree, highest life expectancy and lowest proportion of obesity. Variation in socio-demographic characteristics and health variables was observed across the different neighborhoods within the municipalities.

We suggest that this type of data can be used to map potential inequalities in access to green space for different groups of the population. Moreover, statistical analyses can be conducted to assess associations between access to green space and health outcomes on a neighborhood level. This can provide valuable input to the planning process and help understanding the dynamic of how green space influences health and well-being among inhabitants in the municipalities.

Introduction

This paper is the first output from work package 1 in the NORDGREEN-project. The work package focuses on the empirical link between characteristics of urban green space and its impact on human health in the Nordic context, and the following paper gives an overview of access to green space, socio-demographic status, and health for the following municipalities Espoo and Ii (Finland), Stavanger (Norway), Täby and Vilhelmina (Sweden), and Aarhus (Denmark).

During the last 20-30 years research has revealed vast knowledge about the mechanisms explaining the relationship between nature and health. These mechanisms include possibilities for physical activity, reduced stress, improved air quality and reduced levels of noise, and facilitating social cohesion (Markevych et al., 2017, Hartig et al., 2014, Remme et al., 2021). Better access to nature have been found to be positively related to a range of health outcomes. Common diseases and outcomes which are investigated include mental health (Min et al., 2017, Qiao et al., 2021), cardiovascular diseases and type II diabetes (Astell-Burt et al., 2021), and birthweight (Hu et al., 2021). Rojas-Rueda et al. (2019) reviewed several studies examining the relationships between exposure to nature and mortality. They found evidence for a significant reduction in mortality with increased amount of neighborhood green area.

There exists a range of ways to measure access to nature (Ekkel and de Vries, 2017, Nordbø et al., 2018). In this paper, we will use land-cover, land-use and vegetation cover maps to compute green space measures using geographical information systems (GIS). The World Health Organization (WHO) suggests a recommendation for minimum distance to nearest green space for citizens (WHO, 2016). We will discuss and compare our findings from the case municipalities with this recommendation. Moreover, we will provide an overview of sociodemographic and health data for all case municipalities. Such knowledge is relevant for many reasons. First, to provide an overview of inhabitant's access to green space and their health status. Second, to compare access to nature within the municipalities, between municipalities, and in relation to the WHO's recommendation. Third, to investigate the relationship between access to green space and health in the Nordic region. Fourth, to initiate measures to promote fair distribution of green access resources.

The paper can be used as a data source for the municipalities from where they can obtain relevant information about access to green space, socio-demography, and health. First, we present the methods and data sources used. Then, socio-demographic characteristics and health data for each municipality are displayed. This is followed by an overview of variables capturing access to green space and results describing some associations between distance to green space, socio-demography, and health. Lastly, some suggestions and final recommendations to practice are provided.

Methodological framework

Health data and socio-demographic data

Health data and socio-demographic characteristics from 2021 were downloaded from Statistics Denmark, Statistics Finland, Statistics Norway, Statistics Sweden for the six municipalities both at the municipal level and the neighborhood level (except for Vilhelmina and Ii from which we could not obtain neighborhood level data). The size of the neighbourhoods and correspondingly the number of neighbourhoods within each municipality differed between the countries. Aarhus consists of 24 districts, Täby of 38 demographic areas (DeSO), Espoo of 7 districts, and Stavanger of 9 districts.

We downloaded data on health variables such as life expectancy for both genders, proportion of the population being physically active more than 150 minutes per week, proportion of the population with obesity (BMI > 30 kg/m2), perceived health, and incidence rates of hearth attack and stroke (per 100 000 inhabitants). Socio-demographic information, such as age-distribution, educational level, immigrants, and median household income in Euro, was retrieved for all municipalities. For a full list of variables see Table 1 and Table 2.

Measures of access to green space

Several measures of access to green space were computed using GIS based on some key definitions of green space (see Table 1 for definitions). These measures were based on two sets of maps: 1) land-cover and land-use maps and 2) vegetation cover maps. In the Nordic countries national land-cover and land-use maps are available from the national depositories (Kortforsyningen in Denmark, National land survey in Finland, Lantmäteriet in Sweden, and GeoNorge in Norway). Municipalities also have their own maps at local depositories such as Aarhus in Denmark (webkort.aarhuskommune.dk/spatialmap). These maps consist of defined categories of land-use and land-cover, which were used in the computations.

Based on land-cover and land-use maps, we identified parks, cemeteries, and forests, and the union (sum) of these green space types. The union (sum) was named total green space. We computed the total area of these green space types in each municipality and their neighbourhoods. Moreover, we computed the total area of green space per inhabitant, and the mean distance between the dwellings and each green space type. In Figure 1, we show a map section from Espoo with different land-use categories. The figure portrays the

Table 1. Definitions of green space applied in this working paper.

Measure	Definition
Total green space	Includes parks, forests and cemeteries (our definition)
Green area	Includes Urban Atlas categories (WHO, 2016, Barboza et al., 2021): green urban areas, sport and leisure facilities, arable land, crops, pastures, cultivation patterns, forests, herbaceous vegetation, and wetlands

shortest distance from a dwelling (yellow point) to the nearest forest (green area) represented by a black arrow.

We also used two datasets from the European Union's Earth observation programme Copernicus (www.copernicus.eu). The CORINE dataset was used to compute a measure describing landscape diversity. The Urban Atlas dataset was used to compute the total green area which includes the categories urban parks, forests, cemeteries, arable land, pastures or grassland, and wetlands (see Figure 2 for an example from Espoo). The measure of total green area has been used in several studies and is applicable for making comparisons across cities.

Statistical analyses and visualization of the data

Simple statistical tools were used to analyse the data and present descriptive statistics. We also produced boxplots and bar charts to visualise the distribution of socio-demographic characteristics, health outcomes and access to green space across and within the municipalities.

Figure 1. Different categories representing green space are merged to one common variable green area (represented with green colour). The shortest distance from a dwelling (yellow point) to the nearest forest (green area) is represented by the black arrow.

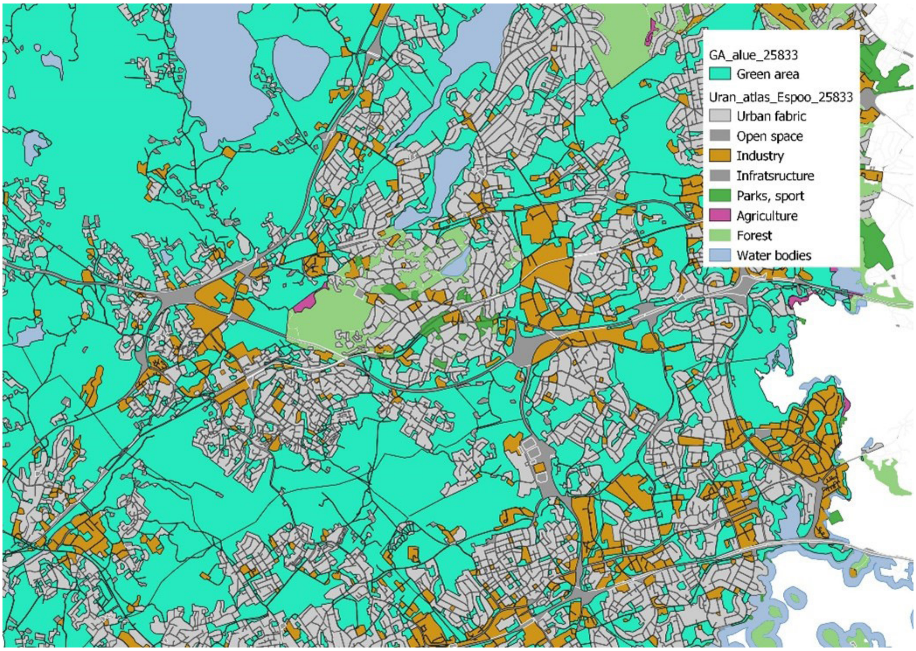


Figure 2. Urban atlas was used to identify different land-use and land-cover qualities. The figure shows different land-cover categories in Espoo.

The second set of maps used were based on satellite images. These images are used to map vegetation cover. The idea behind the vegetation cover maps is that different surfaces reflect red and near-infrared light in different ways. Green living plants tend to absorb near infrared light, and it is possible to separate green surfaces from non-green surfaces. The vegetation cover maps show greenness within a pixel. Based on the greenness values within a pixel, the Normalised Difference Vegetation Index (NDVI) were calculated. In Figure 3, we show vegetation cover scores calculated based on satellite images from Espoo, where water bodies are identified as black pixels and urban fabric is presented as darker pixels. Figure 4 presents the land-cover and land-use categories from the Urban Atlas maps.

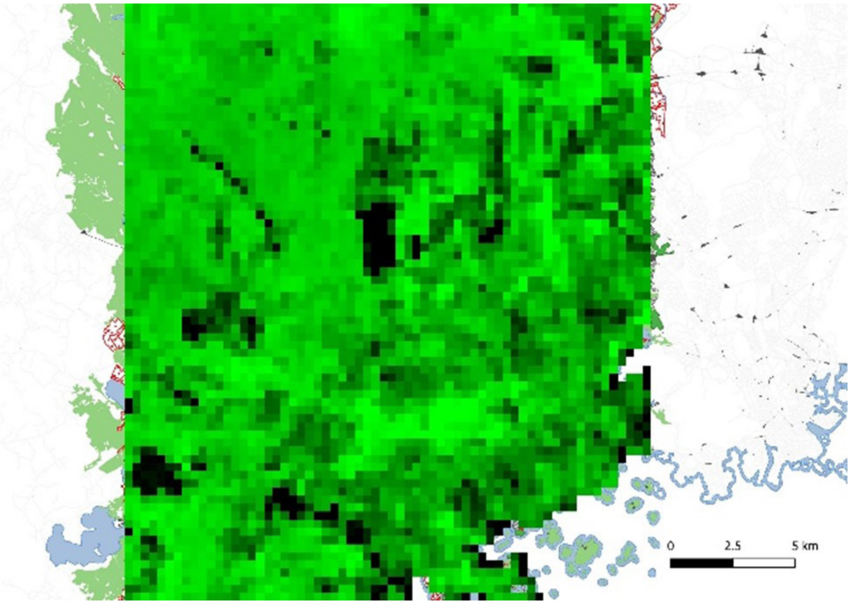


Figure 3. Satellite image displaying vegetation coverage (NDVI scores) in Espoo.

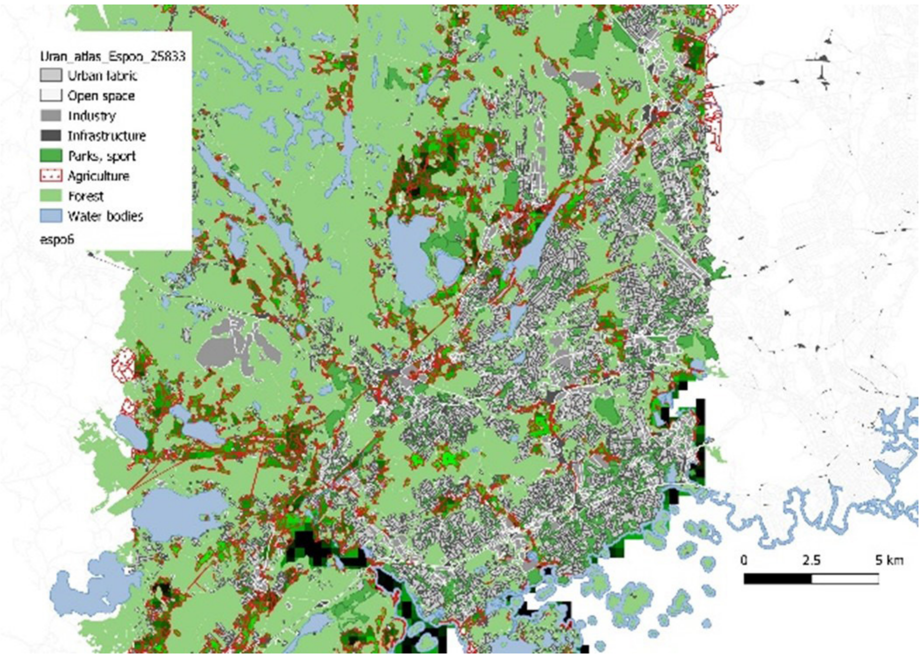


Figure 4. Green area derived from Urban Atlas from Espoo. Green spaces are visualized in green colour, while urban fabric, water bodies and transportation are in other colours.

Results from the municipalities in the NORDGREEN project

Health data

Health data for the six municipalities are shown in Table 1. By using data from each municipality, we can compare the data with neighbouring municipalities, municipalities with approximately the same socio-demographic characteristics, or the country as a whole. As an example, life expectancy in Finland in 2021 was 79.0 years for men and 84.6 years for women compared to 80.9 years for men and 85.3 years for women in Espoo. The percentage of obese inhabitants in Finland is 27%, which is higher than in Espoo (16.8%).

Comparing the data for the municipalities in NORDGREEN project, we observed that Täby has highest life expectancy for both women and men. We also found that residents in Espoo are most satisfied with their neighborhoods and feel most safe. Crime rates, such as number of offences and violence per 1000 inhabitants, are highest in Vilhelmina. The residents in Täby are most physically active, whereas Vilhelmina has the highest proportion of obese residents. Despite average scores on life expectancy and neighborhood satisfaction and safety, the residents in Aarhus score highest on perceived health compared to the other municipalities (see Table 2).

Variation in health variables was observed across the different neighborhoods within the municipalities. In Figure 5, we show an example of how life expectancy varies across neighbourhoods in Stavanger. Finnøy and Rennsøy are the neighbourhoods with highest life expectancy among women. Similarly, men from the same neighbourhoods live longer than average. Another interesting example is the difference in perceived health across the neighbourhoods in Espoo. In both Stor-Alberga and Stor-Hagalund, nearly as much as 80% of the inhabitant's report they have good or very good health compared to lowest proportion of 67% in Norra Espoo.

Table 2. Health and well-being variables from the municipalities in the NORDGREEN project.

	Espoo	Stavanger	Täby	Aarhus	Vilhelmina	Ii
Life expectancy for men	80.9	81.2	**83.0**	81.6	78.8	
Life expectancy for women	85.3	84.8	**86.4**	81.6	84.1	
Neighbourhood satisfaction	**84.4**	78.0	71.0	79.0		
Perceived neighbourhood safety	**93.0**	84.0	81.0	87.0		
Offences per 1000 inhabitants	91.4	67.4	83.3	76.6	98.4	**119.4**
Violence per 1000 inhabitants	5.5	**8.0**	5.8	4.4	5.7	4.9
Physical activity	30.8	24.0	**73.0**		67.0	
Obesity	16.8	14.0	9.0		**22.0**	
Perceived health	75.2	78.0	76.0	**86.0**	63.0	
Incidence heart attack		220.0	193.5		**313.5**	
Incidence stroke		190.0	218.3		**299.3**	

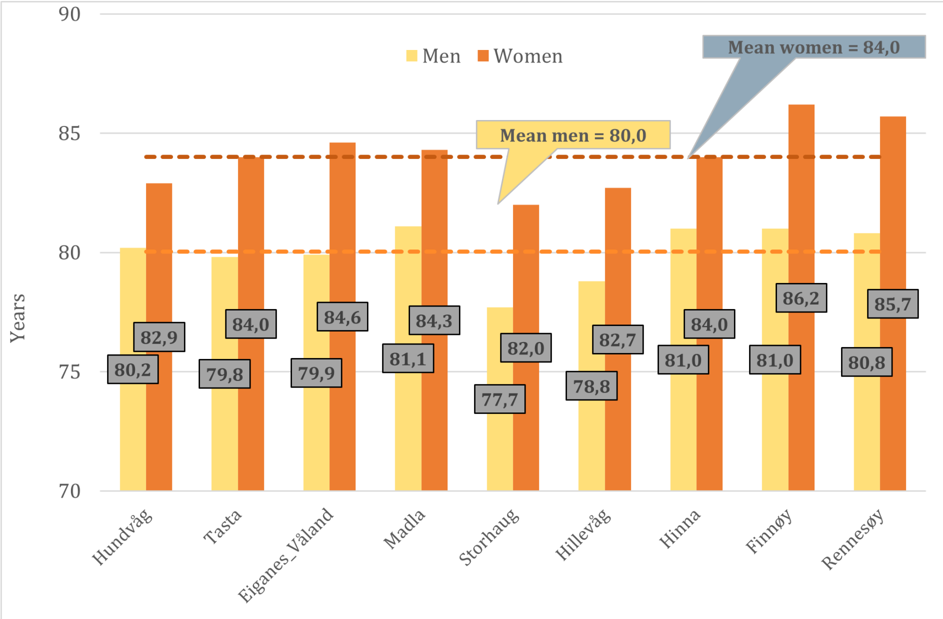


Figure 5. Life expectancy by neighbourhood in Stavanger.

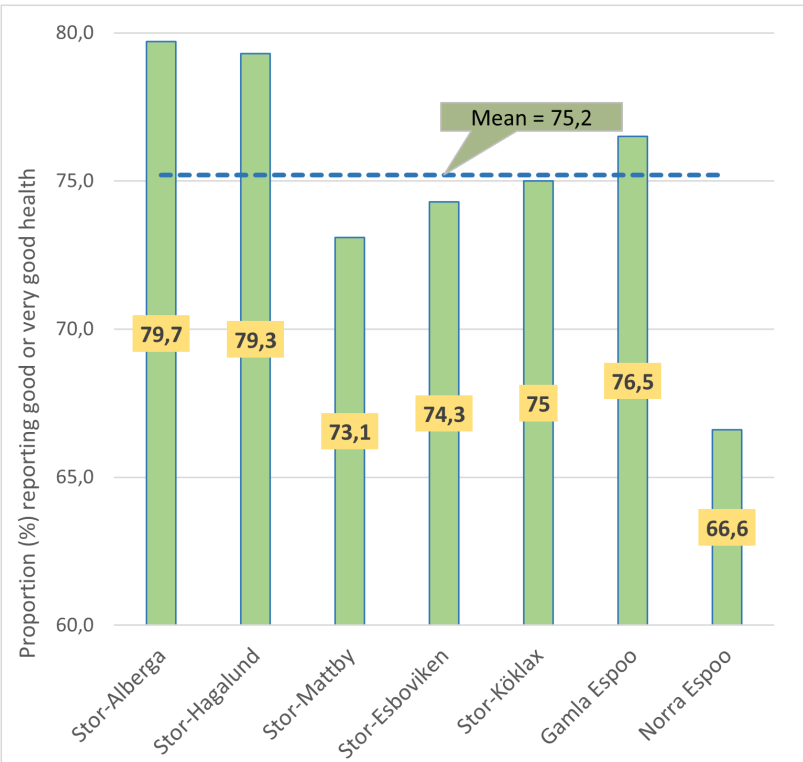


Figure 6. Self-reported health by neighborhood in Espoo.

Socio-demographic data

Socio-demographic data are presented in Table 3. These variables help to understand how the population in each municipality (or neighbourhood) can be described. Many socio-demographic characteristics are also important health determinants such as age, gender, and education. Again, the data can be compared with national data. As an example, 20.6% of the population in Norway is below 18 years of age, and 4.4% of the population is 80 years or older (data from Statistics Norway) compared to 22.3% and 3.3% in Stavanger, respectively. In the same way, 18.5% of the population in Norway has immigration background compared to 23.4% in Stavanger. The distribution of inhabitants with primary, high school, and university level education is 24.8%, 39.9%, and 35.3% respectively in the Norwegian population, compared to 17.0%, 26.0%, and 47.0% in Stavanger.

Comparing socio-demographic data for the municipalities in NORDGREEN project, the two rural municipalities Vilhelmina and Ii have the highest proportions of elderly inhabitants and the lowest proportions of both immigrants and residents with university education. Of the four urban municipalities, Täby stands out from the rest on several aspects, such as highest proportion of immigrants and inhabitants with a university degree.

Table 3. Socio-demographic variables from the municipalities in the NORDGREEN project.

	Espoo	Stavanger	Täby	Aarhus	Vilhelmina	Ii
Total population	292 796	144 147	72 755	**352 348**	**6 539**	9 848
Below 18 years (%)	22.3	21.8	24.0	**18.3**	18.7	**27.0**
Above 80 years (%)	**3.3**	3.4	5.4	3.5	**7.5**	5.6
Working population (%)	66.8	67.9	61.6	**70.5**	59.6	**57.2**
Immigrants (%)	19.1	23.4	**23.7**	16.9	9.2	**1.0**
Primary school (%)	18.2	17.0	**5.6**	12.5	12.6	**23.1**
High school (%)	**27.4**	36.0	31.2	37.0	**62.2**	51.0
University level (%)	54.5	47.0	**63.2**	50.5	**25.2**	26.0
Median household income (€)	43 054	**56 244**	55 921	40 025	**29 375**	35 727

Green space variables for each municipality

The different green space variables are displayed in Table 4. Detailed land-cover and land-use maps were not available for Vilhelmina and Ii, and therefore only a limited set of variables were computed for these two municipalities. The distances between the dwellings and parks, cemeteries, and forests are commonly used to measure access to green space. The mean distance from dwellings to parks was shortest for inhabitants in Täby. Moreover, the total park area per inhabitants were highest for inhabitants in Täby. The mean distance from the dwellings to the nearest parks was only 278 meters in Täby compared to compared to 2.4 km in Aarhus.

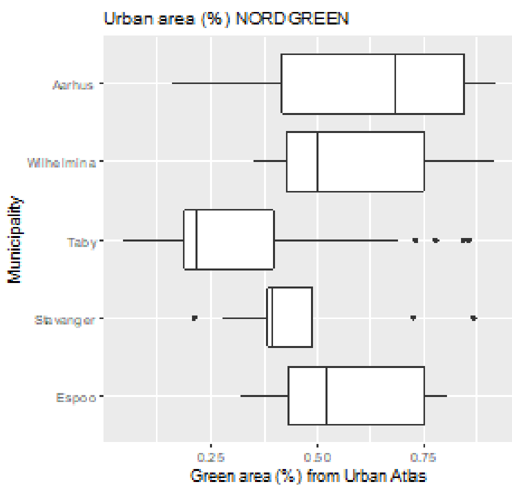
Table 4. Variables of access to green space from the municipalities in the NORDGREEN project.

	Variables	Espoo	Stavanger	Täby	Aarhus	Vilhelmina	Ii
Euclidian distance	Total green space	**68.2**	134.7	89.8	109.5		
	Parks	431.5	1377.9	**277.9**	2444.8		
	Cemeteries	4799.8	1613.3	4582.6	**858.2**		
	Forests	**85.6**	173.0	118.2	118.1		
Total area (ha)	Total green space	**1649.5**	325.3	71.9	220.0		
	Parks	27.4	3.3	4.4	**45.5**		
	Cemeteries	**15.8**	3.2	0.2	4.3		
	Forests	**1606.4**	318.9	67.4	170.9		
Network distance to green structure		90.3	210.7	**89.8**			
Percentage with distance < 150 m		87.2 %	**55.0 %**	89.3 %			
Percentage coverage	Total green space	**45.3 %**	31.9 %	32.4 %	12.0 %		
	Parks	0.5 %	0.1 %	**2.3 %**	1.3 %		
	Cemeteries	**0.3 %**	0.1 %	0.1 %	0.2 %		
	Forests	**44.5 %**	31.8 %	30.0 %	10.5 %		
Area (m2) per inhabitant	Total green space	1725.5	**10202.8**	1146.3	479.0		
	Parks	5.5	0.6	**24.3**	10.6		
	Cemeteries	**8.2**	1.5	3.2	2.8		
	Forests	1711.7	**10200.7**	1118.8	465.8		
	NDVI	0.788	**0.799**	0.707	**0.799**	0.766	0.792
	Green area (GA%)	65.5 %	67.3 %	52.5 %	70.6 %	92.1 %	**95.2 %**
Shannon's diversity index (SDI)		**1.19**	0.93	1.02	0.79	0.36	0.24
Shannon's evenness index (SEI)		0.70	0.76	0.72	0.78	0.80	**1.39**

Below we compare two of the measures reported in Table 4 with the recommended distance from dwellings to the nearest green space (WHO, 2016). We used total green space (union of parks, cemeteries, and forests) in this comparison. More than 95% of all dwellings in our municipalities are located within this recommendation. As a Nordic alternative, we computed the percentages of dwellings located less than 150 meters from a green space of any type (see Table 4). The proportion of dwellings with less than 150 meters to the closest green space of any type was highest in Täby (89.3%) and lowest in Stavanger (55.0%).

Researchers such as Barboza et al. (2021) have transformed the 300-meter limit to a percentage of green area based on analyses of associations between the two measures. They suggest that the 300-meter limit corresponds to 25% of green area. As seen in the third lowest row in Table 4, the values range from 52.5% (Täby) to 70.6% (Aarhus) for the urban municipalities.

The distribution of the different green space variables within the municipalities is also of interest. Below we present the distribution of two of these variables. In Figure 7, boxplots of green area (%GA) for the different municipalities are displayed. This figure illustrates that among the neighborhoods of each municipality the percentage of green area varies. We found neighbourhoods with less than 25% green area in Aarhus, Täby, and Stavanger. In Figure 8, we show



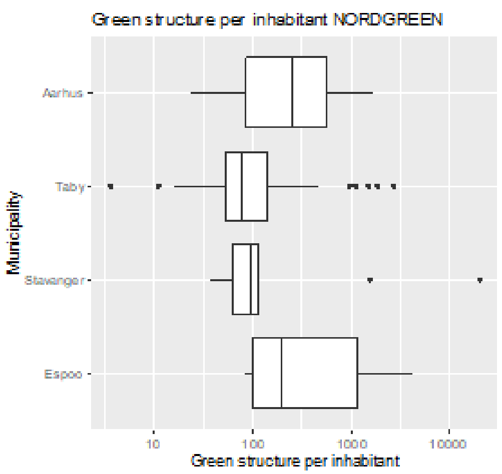


Figure 7 (left). Boxplot of the percentage of green area derived from Urban Atlas.
Figure 8 (right). Boxplot of total green space per inhabitant for the different municipalities. Note the log-scale for the x-axis in this diagram.

corresponding boxplots for total green space per inhabitant (note the log-scale for the x-axis). Some neighborhoods are outliers, such as the rural Finnøy and Rennesøy in Stavanger, which have far more green space (mainly forests) per inhabitant than then the rest of the neighborhoods in Stavanger.

Suggestions and final recommendations

The analyses of the six Nordic municipalities show that access to green space corresponds to what is recommended by WHO. However, some neighbourhoods within the municipalities have percentages of green area less than 25%. The data that we collected for the municipalities and the neighbourhoods is valuable material to assess the distribution of green space and socio-demographic variables. A next step will be to investigate the access to green space among different socio-demographic groups. This will be reported as a scientific output of the NORDGREEN project.

For municipalities that would like to undertake similar analyses and obtain an overview of health and well-being status, we recommend using a variety of physical and mental health outcome as well as well-being measures. Examples of, but not limited to, are measure that were applied in this paper, which often are openly accessible through national statistics in each of the Nordic countries. Additionally, we have noticed that some municipalities have available health data on a neighbourhood level based on national registers and local surveys. With such local data it is possible to conduct more in-depth analysis of associations between access to green space, socio-demography and health.

In this study, we computed a large set of measures to capture access to green space. We suggest using the following variables: 1) distance to different types of green spaces (parks, forests, cemeteries), 2) proportion of green area based on Urban Atlas, 3) vegetation cover (NDVI), 4) total area of green space (parks, cemeteries, forests) per inhabitant, and 5) percentage of total green space within the neighbourhood. The first two measures are relatively easy to compute, and the measures can be applied to validate citizens' access to green space according to WHO's recommendations. Moreover, these measures are commonly used in research on green space and health (Brownson et al., 2009, Nordbø et al., 2018).

A limitation of the analyses and results presented in this paper is the varying size of the municipalities and particularly neighbourhoods. Moreover, the population size varies substantially between the municipalities in our study. Lastly, there are other built environment qualities not discussed in this paper, such as distance to sport facilities and neighbourhood walkability and bikeability. These measures are indirectly linked to access to green space and may contribute to promote health and well-being in different ways. Nevertheless, the data and analyses presented in this working paper can provide valuable input to planners and decision makers on challenges related to green space access, socio-demography and health that need to be dealt with in the planning processes.

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