PREDICTING THE FUTURE DEMAND FOR NURSES

THE CASE OF MUNICIPALITY HEALTH SERVICES IN NORWAY

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DECLARATION OF OATH

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27.07.2020 Lise Bull Svarva	28.7.2020
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Disclaimer

The original plan was to forecast future demand for full-time equivalent nurses for all Norwegian municipalities. This would, in turn, provide national numbers of future demand for full-time equivalent nurses within the Municipality Health Service. However, due to the Municipality Reform, initiated in 2014, several municipality changes took place in the period where our historical data was collected. By 2020, 428 municipalities were reduced to 356 municipalities and 19 counties where reduced to 11 counties. Due to these municipality changes, several municipalities had missing data. This led to exclusion of 54 municipalities.

Statistics Norway is in a process where they update their data to the new municipality structure. The population projections are assumed to be published by August 2020. When the data are converted to the new municipality structure, it becomes possible to provide a forecast of future demand for nurses for all municipalities, including national numbers.

Abstract

Background: The focus of this study is the future demand for nurses in Norway. Norway is expected to see strong growth in demand for health services. This is partly a result of strong growth in the number of elderly people.

The population growth and age-composition are expected to vary across municipalities towards 2040. As a result, we expect that demand for Municipality Health Services to differ between municipalities. Full-time equivalent nurses are an important part of the municipalities nursing and care services. The larger the nursing and care services, the larger the volume of full-time equivalent nurses becomes. Even when accounting for population demographics, it is still large varieties in the demand for nurses. This makes it interesting to forecast future demand for full-time equivalent nurses within the Municipality Health Service at the municipal level.

Under the assumption that utilisation rates stay constant when population size and composition changes, one may acquire a forecast of future demand for nurses. Such predictions give municipalities and the government the possibility to implement suitable measures that seek to meet the expected changes in demand.

Objective: The objective is to provide a forecast of the need for nurses in terms of full-time equivalents at the municipality level in 2040. This forecast focus on nurses employed in the Municipality Health Service.

Method: Linear regression model with municipality level fixed effects, and clustered municipalities is fitted to administrative data on full-time equivalent nurses and age-distribution in 369 Norwegian municipalities. The relationship between full-time equivalent nurses and the number of residents in three age groups is modelled by means of a constant return to scale Cobb-Douglas function.

Results: The results show a rising national demand for full-time equivalent nurses, however with municipality differences. Medium to large municipalities is expected to have rising demand, while several smaller municipalities are expected to have declining demand due to population fall. Our results indicate that smaller municipalities are expected to have the highest projected full-time equivalent nurses per capita.

The results depend on the assumptions made. This implies that the findings are associated with uncertainty and must be interpreted with caution.

Acknowledgements

This master thesis marks the end of a two-year master program at the European Master in Health Economics and Management.

Writing a master's thesis has been tough. It feels like an eternity project, and one is simply never satisfied with the result until the end. Looking back in retrospect, the process has been an enrichment. My interest for the subject has grown, thanks to fruitful and interesting discussions with my supervisor, Geir C. Godager.

This master thesis would never have been accomplished without Geir. His patient and sharing of knowledge have been extraordinary. I am very grateful for his guidance and support during this seven-month long journey.

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Table of contents

Tables and figures

Abbreviations

FTE	Full-time equivalent
FTEN	Full-time equivalent nurse
FTEN per capita	Full-time equivalent nurse per 1000 capita
HC-services	Health and care services
MHS	Municipality Health Service
SHS	Specialist Health Service
CRS	Constant return to scale
TDE	Time-dependent effect
MLE	Maximum Likelihood Estimation
WLS	Weighted Leased Squares
MSE	Mean Square Error

1.0 Introduction

The objective of the thesis is to forecast the relation between full-time equivalent nurses in the Municipality Health Service and the number of residents in three age groups in 369 municipalities in Norway. Forecasting is concerned with predicting the future as accurately as possible. Quantitative forecasts can be used when numerical information about the past is available, and when it is reasonable to believe that some aspects of the past will continue in the future (Hyndman & Athanasopoulos, 2013). Municipal demographics now and in the future will, therefore, be an important component of a model projecting future demand for labour (Godager et al., 2019).

The Norwegian Healthcare Sector is partly decentralised. The Specialist Health Service (SHS) has been the responsibility of the state since 2002. Four regional health authorities with multiple health trusts are responsible for (SHS) delivery. The Municipality Health Service (MHS) has the responsibility for primary, preventive, and long-term nursing care. The task division between SHS and MHS relate to the degree of service specialisation. Access to SHS is based on referrals from general practitioners in the MHS, which act as a gatekeeper for SHS (Ringard et al., 2013).

It exists a long tradition with a clear division of responsibilities between the two provider levels. Several reforms have prolonged and strengthened the task division. The latest reform, the Coordination Reform, was implemented in 2009. The objective of the Coordination Reform is a continuous improvement in responding to patients need of coordinated services. The key components are sustainable, high-quality health service, with more prevention and early intervention and health services close to the patient’s home. This will, in turn, ensure that the patient receives the proper treatment, at the right place and at the right time (Riksrevisjonen, 2016).

The thesis focuses on nurses employed in MHS. There are several reasons for restricting the forecast to MHS. The municipalities are obliged to provide necessary health and care services (HC-services) for its residents and for people staying in the municipality at the time of need (Helse- og omsorgstjenesteloven, 2011). This implies that people in need of HC-services must seek help from the municipality they are residents in or staying in at the time of need. This implies a relation between the characteristics of the population and the type and amount of services provided within each municipality. This is contrary to the policy within SHS. “Fritt behandlingsvalg”, implemented in 2015, gives the patient the right to choose where they want to be examined or treated in SHS. This means that patients are not restricted to be treated by a specific health trust (Helsenorge, 2017).

Another important reason for this restriction is the availability of good data of population and nursing demand at the municipal level. This enables to generate new knowledge using models based on "Small Area Variation" (SAV). SAV analysis can be used to describe the variation in health care utilisation rates over well-defined geographic areas, such as municipalities (Parchman, 1995). SAV allows illustrating how many full-time equivalent nurses (FTEN) that are demanded by the public depending on where people live (Ibáñez et al., 2009). By comparing the differences in demand for nurses, it is possible to draw a conclusion about the variability in future demand for nurses.

The population projections indicate a population growth and ageing of the population, however with municipality differences (Leknes, 2018). As a result, we expect that demand for MHS to differ substantially between municipalities. Even when controlling for population size and age-composition, we know that there are large varieties in demand for nurses. This makes it interesting to forecast future demand for full-time equivalent nurses (FTEN) within the MHS at the municipal level. Forecasting of FTEN at the municipal level is an important planning tool both locally and centrally.

Research question:

This leads us to one research question: How many full-time equivalents nurses (FTEN) in the Municipality Health Service (MHS) will the municipalities require in the future?

The research question can be divided into several sub-questions, but the focus of this thesis will concern four sub-questions:

- What is the expected number of full-time equivalent nurses for the ten most populated municipalities in 2040?

- Which municipalities is expected to have the largest and the lowest absolute change in full-time equivalent nurses between 2020 and 2040?
- Which municipalities is expected to have the largest and lowest relative (measured in per cent) change in full-time equivalent nurses between 2020 and 2040?
- Which municipalities is expected to have the highest and lowest number of full-time equivalent nurses per 1000 capita in 2040?

Overview of chapters

The theoretical framework describes the relation between population demographics and the need for HC-services. A summary of earlier forecasts is presented, which leads us to the motivation of forecasting FTEN within MHS at the municipal level. The chapter ends with the fundamentals in forecasting. Chapter three gives a description of the datasets and study setting. Chapter four describes the method and specification testing for the choice of model. Chapter five provides forecasting results. Following this, chapter six provides some limitations of the study, while chapter seven discusses other factors that are likely to affect the demand for FTEN and uncertainty factors for the forecasting results. The discussion also includes suggestions for further research. Chapter eight summarise the findings and concludes.

2.0 Theoretical framework

The prevalence of acute, chronic and multiple diseases increases with age. Several health problems are more common in older age groups, including, but not limited to, dementia, type 2 diabetes, chronic obstructive pulmonary disease (COPD) and cardiovascular diseases (Folkehelseinstituttet, 2014). Many of these diseases coincide, meaning that many older people have multimorbidities, implying two or more morbidities (Marengoni et al., 2008).

Population aging affects most countries in the world. Not only does the number of older people increase, but also the share of older people increases. This change is expected to have a considerable influence on most parts of society and the economy, impacting the demand and provision of HC-services (European Union, 2019). An increase in the proportion of the elderly population is, therefore associated with an increase in the prevalence of people with healthcare needs (Mafauzy, 2000). Illness and chronic disease restrain independence resulting in considerable resource needs in terms of practical assistance, follow-up consultations and treatments. This imposes a great challenge for future healthcare resources and increasing fiscal pressure (United Nations, 2019a).

There are several demographic factors that jointly explain ageing in Europe. The postwar baby-boom is reaching its retirement age, Europe has one of the lowest fertility rates, and people are living increasingly longer. As life expectancy continues to rise, and fertility rates simultaneously continue to decline, the share of elderly people increases. The ageing population and rising life expectancy is a result of several factors: declines in child mortality, increased awareness of healthy lifestyle, improved living conditions, innovations in medical technologies and in public health, have all led to rising life expectancy and declining mortality (European Union, 2019). As stated by the United Nations (2019, b. p.3) population ageing is a "triumph of public health, medical advancements, and economic and social development". Whether the increasing life expectancy is associated with last years of good health, is an important consideration. If the additional years of life are spent with disease and disabilities, this is likely to result in increased demand for healthcare and long-term services (European Union, 2019).

According to the European Union (2019), elderly people are defined as those aged 65 years and older. The ageing of the population has been prevalent in the EU for a longer period. Between 2008-2018, the share of older people within EU-28 increased with an average of 2.8% (Eurostat, 2019). In the coming three decades, the number of older people is expected to increase substantially. By 2050, the number of elderly people within EU-28 is estimated to reach 149.2 million inhabitants. This represents 28.5% of the total EU-28 population and an expected increase of 8.8% from 2018. The share of very old (≥ 85 years) is expected to grow faster than any other age-group. Between 2018-2050, the share of people aged 85 and above is estimated to increase with 130.3% from 2018 (European Union, 2019). The extent of the changes in demographics across countries is determined by the interaction between mortality, fertility and migration. The pace of these changes determines how advanced the population ageing will be. Some EU-countries are therefore expected to have a sharper population ageing than other countries (European Union, 2014).

By 2050, the average percentage share of people aged 55 and above is expected to reach 40.6% within the EU-28. Portugal is expected to have the highest share of people aged 55 years and above. The estimations suggest 47.1% of the Portuguese population will be 55 years and above, followed by Italy with 45%. Sweden is expected to have the lowest share, with just below 35%, followed by Luxembourg and United Kingdom with just above 35% (European Union, 2019).

While the Norwegian population is also expected to age, the degree of ageing in Norway is less severe than in many other countries. European Union (2019) suggests that the share of people aged 55 years and above will reach 37% by 2050. While other European countries are expected strong growth in the number of older people, combined with population decline and low birth rates, Norway is expected a population increase. By 2040, the population is expected to reach 6 million, representing an increase from 5.3 million in 2020 (Leknes, 2018) (Statistics Norway, 2020c). Population growth is, however decreasing. A tradition with immigration from new EU-member states is an important factor for the strong population growth over the last 15 years. However, there is expected a decline in immigration from these countries, which is a vital reason for the expected decline in population growth (Andersen e al., 2019). Fertility in Norway is expected to continue its decline, to just below 1.60 children per woman in the short term, before rising gradually to a long-term level of 1.76 children per woman (Tønnessen, 2018).

In the same way that there are differences in population ageing across countries, the demographic changes facing Norwegian municipalities vary substantially. Population growth will primarily occur in cities and larger municipalities that already have a relatively young population. Several municipalities already having a high share of older people are expected to have a population decline. As a consequence of low birth rates and lack of immigration from other municipalities or from abroad, ageing will, therefore, be strongest and occur fastest in the districts. By 2040, more than one in three residents in many district municipalities will be 65 years old and above (Helse- og omsorgsdepartementet, 2018).

Users of Municipality Health Services (MHS)

The use of HC- services increases with age and especially within the Municipality Health Services (MHS). Typical services provided by the MHS are home care services and nursing homes, services primarily demanded by the older generation. The following section describes the user characteristics of recipients of MHS in 2018. The numbers are based on statistics from the national Municipal Patient and User Registry in 2018 (Helsedirektoratet, 2018).

According to Helsedirektoratet (2018) there were 364 587 unique recipients of MHS in 2018, representing 6.8 % of the total population. A large share of the recipients received one or more HC-services within the year. The largest share of recipients was above 67 years, representing 59.7%. 26% of recipients were below 50 years, and 5% were below 18 years.

Among the total number of people in Norway, those aged 90 years and above represented the largest group of recipients. 89.7% of all people aged 90 years and above received one or more MHS, while decreasing to 49.6 % for those aged 80-89 years. 12.9% of people aged 67-79 received one or more MHS, while 4.8% among those aged 50-66 years received one or more MHS. The share was respectively 3.4 % and 1.5% for those aged 18-49 years and 0-17 years.

Even though recipients above 67 years are most prevalent among recipients of MHS, some services are more prevalent among users below 67 years. This includes practical assistance, help outside the institution and personal assistance. About 40 % of all recipients during 2018 were men. This proportion has increased since 2009, due to increasing life expectancy for men. In younger age groups (0-17 years), the proportion of recipients was higher among men, with 63% of the total share. For all other age groups, women use more MHS than men (Helsedirektoratet, 2018).

Forecasts of the Norwegian healthcare sector

Several reports have forecasted the future of the Norwegian health sector. A common measurement of personnel resources is full-time equivalents. Statistics Norway define full-time equivalents (FTE) as the sum of the number of full-time jobs and part-time jobs converted to full-time jobs. FTE is calculated as a percentage of a regular full-time position (37.5 hours per week). This is based on the agreed working hours at the reference week, which is the third week in November of the statistical year. This is assumed to be representative for the whole year (Holmøy et al., 2014).

Hjemås et al. (2019) forecasted the labour market for healthcare personnel in 2035. In addition to the ageing of the Norwegian population, they also recognised observed trends shifting demand in favour of higher educated personnel, leading to a higher demand for certain health personnel, such as nurses. Nurses are increasingly prioritised in favour of healthcare workers. The reference alternative assumes that 125 000 full-time equivalent nurses in the health sector are needed by 2035. Unless the provision of new nurses increases through education or the government enables to increase access in other ways, this could result in a shortage of 28 000 full-time equivalent nurses.

Leknes et al. (2019) projected regional demand for HC-services, measured in full-time equivalents, towards 2035. HC-services were divided into Specialist Health Service (SHS), and Municipality Health Services (MHS), where the latter was further divided into care services and health services. Due to the diversity of population growth and age-composition, the rising demand for HC-services is expected to distribute differently across the country. The combination of increasing population growth in the cities and population pattern that is becoming increasingly centralised indicates that the central areas will have the largest projected growth in demand for HC-services. The increase in projected demand is particularly large within the (municipality) care services. This is expected as (municipality) care service is more age-dependent then the other services. Between 2017 and 2035, (municipality) care services are expected to increase with 46%, SHS with 24% and (municipality) health services with 14%.

Holmøy, Kjelvik and Strøm (2014) made projections for the demand for labour within HC-services towards 2060. The key elements were realistic projections of gender-specific age profiles for the use of various HC-services. The report describes how uncertainties concerning future developments in demographics, health status among the elderly, informal care provided by family members, and service standards, defined as full-time equivalent per user, affect employment need in the health sector. One of the alternative projections assumes a constant service standard, constant age-specific state of health and provision of family care that increases at the same rate as public elderly care provision. With these assumptions, the employment requirement in the HC-sector in 2060 can be twice as large as they were in 2010. They find it, however, more realistic that service standards will continue to improve, while unrealistic that the informal care will grow proportionally with increased demand. In a scenario where they assume, i) 1% annual growth in service standards, ii) continuation of the 2010 level of informal care, and iii) an unchanged age-specific health status, measured by the user frequencies, full-time equivalent within the health sector could possibly account for more than one-third of all full-time equivalents in 2060. Given the 2010 level of part-time positions, the share of total employees will grow even stronger (Holmøy et al., 2014).

The projections by Hjemås et al. (2019), Leknes et al. (2019), Holmøy et al. (2014) have respectively estimated the future labour market for HC-workers, regional differences in demand for SHS and MHS, and lastly, the demand for full-time equivalents within the health sector, while taking account for several uncertainties. Based on this, we know that 125 000 full-time equivalent nurses are needed within the health sector in 2035. The growth in demand for healthcare services and personnel will be the largest in central areas and especially strong for (municipality) care services. Holmøy et al. (2014) illustrated the uncertainty in forecasting demand while taking account for factors such as family care, service standards and state of health.

Municipalities are expected to differ in population size and demographic composition. As a result, we expect that demand for MHS to differ substantially between municipalities. FTEN are an important part of the municipalities nursing and care services. The larger the nursing and care services the municipalities expect, the larger the volume of FTEN becomes. Even when accounting for population size and age-composition, we know that there are large varieties in demand for nurses. This makes it interesting to forecast future demand for FTEN within the MHS at the municipal level.

Forecast of FTEN at the municipal level can be an important planning tool both locally and centrally. It requires time and resources to meet the futures expected demand. Municipalities having a projected increase in demand for MHS may need to assess the need to build new nursing homes and hire nurses regularly. Municipalities with a projected decrease in demand for nurses, may, on the other hand, evaluate the current workforce, looking at, for instance, the number of nurses retiring within the next period and whether this is sufficient to meet the expected decrease in demand.

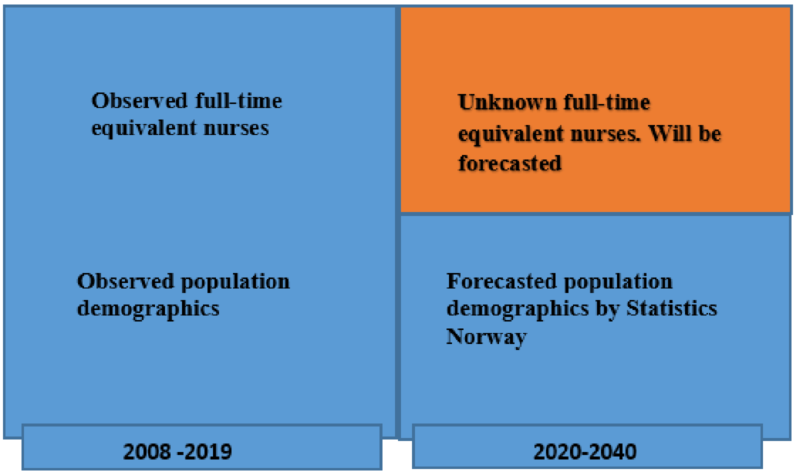
Forecasting of FTEN is also an important measure of central planning. Projections of the demand for MHS services are important when deciding on the capacity of the education system for nurses. The government must facilitate sufficient educational capacity and statutory nursing internships to ensure sufficient supply. Furthermore, there seems to be a problem with nurse dropout and high nurse absenteeism. A study among Norwegian nurses found that ten years after completing their education, 20 per cent did not work in the health sector (Beyrer et al., 2017). Statistics Norway (2019) registered nurse absenteeism of 8.3 % in 2018. This represented the fourth largest absence among the 122 professions included. To make the deviation between expected demand and supply as small as possible, the government needs to implement measures to reduce nurse dropouts and absenteeism.

Fundamentals in forecasting

Two elements are needed to forecast future demand for nurses: Historical data of both the dependent and the independent variables and assumed future values of the regressors. Historical data enables the estimation of the relationship between the dependent and independent variables in the period covered by the historical data. Next, by using the assumed future values of the regressors in combination with estimation results, one may predict the future values of the dependent variable (West & Harrison, 2006) (Godager et al., 2018).

The time period considered for the historical data ranges from 2008-2019. With this data, it is possible to estimate the relationship between the need for nurses by the number of residents in three age groups. The next step is to use these patterns to forecast future values. Given assumed future values of the population size and composition, provided by Statistics Norway, it is possible to replace the x-variables from the period 2008-2019 with x-variables for 2020-2040 (Statistics Norway, 2020a). This gives a forecasting horizon 2020- 2040, which refers to the range of periods the forecasting intends to cover. According to Soyiri & Reidpath (2013) and Godager et al., (2018), the respective periods represent a long-range forecast horizon.

Figure 1 Fundamentals of forecasting



This statistical technique is based on the assumption that existing patterns will continue into the future (Chambers et al., 1971) implying overall stability of the model and no noteworthy changes in either the market or demand. This implies that the unobserved effect within each municipality remains constant across time. This is, however, a strong assumption. There are several factors within each municipality that may change over time, which can contradict this assumption. Furthermore, the age-specific utilisation rates are assumed to be constant, meaning the relationship between the three age-groups and demand for nurses, is the same in the future as it is today. These age-specific utilisation rates may, however, change with time. Furthermore, there are several other factors than population demographics that can impact the future demand for nurses, as illustrated by Holmøy et al. (2014). All these factors represent uncertainties in the forecasting model. I will return to the impacts of these in the discussion.

The future demand for nurses is forecasted with municipality population projections and constant age-specific utilisation rates. The projections thus show what can happen under certain conditions. The results cannot be interpreted as accurate forecasts of future demand for nurses (Hjemås et al., 2019). However, if the future population, given by sex and age, can be predicted relatively well, a model based on historical data of FTEN will provide more reliable predictions than direct speculations. Although the population development cannot be fully accurately predicted, alternative population projections can adjust this uncertainty. The projections of future demand on FTEN will be forecasted with three alternative population projections: low, moderate and high (L, M, H) population growth. To take account for the unobserved growth in demand for FTEN, each of these three alternatives will be forecasted with fixed and increasing time-dependent effects.

3.0 Data

3.1 Datasets

Three sets of data have been collected from Statistics Norway. Dataset 1 & 2 give information about municipality population size and demographic composition. These data provide the basis for the independent variables in the dataset. Dataset 3 involves data on FTE of three nurse occupations and provides the foundation for the dependent variable.

- Dataset 1) Municipality age and gender population projections 2020-2040[1]
- Dataset 2) Municipality age and gender composition 2008-2019[2].
- Dataset 3) Full-time equivalents for nurses, midwives and public health nurse at the municipality level 2008-2019[3]

Dataset 1 involves population forecast, specified by age and gender, towards 2040. A population forecast is a calculation of future population size and composition (Leknes, 2018). The population projections are based on the BEFREG model. In BEFREG, Norway is divided into 108 projection regions. The population is then summed up to counties and then distributed to municipalities (Leknes et al., 2016). BEFREG use the cohort-component method for forecasting. The model projects one year at a time, where each year builds on the previous year. For each year, the number of births and immigrants are added, while the number of deaths and emigrants are subtracted. The model applies one-year age- and gender-specific assumptions concerning four demographic components: fertility, life expectancy, migration and immigration (Syse, 2016). The model assumes that the patterns of the demographic components from the last ten years will continue in the future (Leknes et al., 2016)

Based on these demographic components, three alternative population forecasts are computed. This is given by high (HHMH), moderate (MMMM) and low (LLML) growth in the demographic components. All three forecasting alternatives assume moderate growth in

[1] Table 11668 (Statistics Norway, 2018a)
[2] Table 07459 (Statistics Norway, 2020a)
[3] Table 07944 (Statistics Norway, 2020b)

migration (Syse et al.,2018). The 2020-2040 projections have used the municipality structure of 2018-2019. Age (0-100+) have been decomposed into to 5-years age intervals.

Dataset 2 provides one of two datasets for historical data. Dataset 2 has the same structure as Dataset 1, only with observed population demographics from 2008-2019. During the period 2008-2019, there were several changes in the municipality structure. This led to missing data on a number of municipalities. The missing data raised concern about the robustness of estimation results. To address this, all municipalities who had missing data between 2008-2019 were dropped. This led to the exclusion of 54 municipalities. Detailed information can be found in attachment A in the appendix.

The third dataset provides the second dataset for historical data. The dataset has information about contracted full-time equivalent nurses at the municipality level between 2008-2019. The same 369 municipalities and the municipality structure are applied.

The initial dataset made a distinction between nurses (with a bachelor's degree) as one category and public health nurse and midwives as a second combined category. For this thesis, we have merged these three groups into one group. FTEN, therefore, contain FTE for nurses, midwives and public health nurses.

Municipality Health Service (MHS) is not included as a specific sector. Instead, Kommuneforvaltningen or local government is included. Kommuneforvaltningen consists of municipalities, county municipalities and non-market-oriented municipal enterprises. The municipalities have the responsibilities for, among other things, tasks within health, nursing and care (Borgås, 2007).

Several of the tasks and responsibilities within the county municipalities have been transferred to the state. In 2002, the state received the responsibility for all public hospitals (SHS), and from 2004 the state also received the responsibility for the area of children and family protection and substance abuse. The activity in the municipalities, on the other hand, has increased through reforms such as the 6-year reform and the strengthening of the elderly care and the day-care sector (Borgås, 2007). Due to this clear division of responsibilities of health and elderly care, it is possible to use data of Kommuneforvaltningen to illustrate the future demand for nurses within MHS.

3.2 Variables

The dependent variable consists of merged numbers of nurses, midwives and public health nurse, measured in full-time equivalents (FTEN). Three continuous independent variables explain the demand for FTEN. The dependent variables are based only on age, ranging from 0-100+ year. Children are defined as residents between 0-19 years, adults are defined as residents between 20-64 years, and older adults are defined as residents between 65-100+.

The independent variables are composed of together 21 age groups. Each of the variables is composed of a different number of age groups, making the variables differ in term of size. An overview is given in attachment B in the appendix. Future demand for nurses is forecasted with all three population projection alternatives (L, M, H). This addresses some of the uncertainty in population projections.

Table 1 variable definition and data source

Variable	Definition	Source
FTEN	FTEN in the municipality	Statistics Norway Table no: 07944
	Number of residents in the municipality in age group:	Statistics Norway Observed year: 2008-2019
Children	0-19	Table no: 07459
Adults	20-64	Forecast year: 2020-2040
Older adults	65-100+	Table no: 11668

Data preparation

In order for the data to be analysed, Excel and Stata were used to merge the three datasets. The first step was to make Dataset 1 and 2 have the same design and format. The next step was to import Dataset 1 and 2, one by one, and replace each five-age-interval with age-group, giving a total of 21 age groups. Dataset 1 and 2 were merged and saved as a file. The following step was to combine each of the population alternatives (L, M, H) to each of the 21 age-groups for men and women.

The next step was to merge the two groups of nurse professions into one group and replace all cell suppressions (used to anonymize municipalities with only one or two FTEN nurses), with one FTEN. This file was then merged with the file for population numbers for 2008 to 2040. The final dataset includes information about population size and composition for 369 municipalities between 2008-2040, where observed population numbers exist from 2008-2019 and projected population numbers occur from 2020-2040. Observed information of FTEN exists from 2008-2019, where the aim of the thesis is to project FTEN for 2020-2040.

The final dataset is a panel dataset, also called longitudinal data. In a panel data set, the data consist of multiple observations of units at different points in time. The data includes observations of n entities (cross-sectional units) in T time-periods. The particular observations are denoted with two subscripts *i* and *t*, where *i* refer to the municipality and *t* refer to the year. Y_{it} is then the demand for FTEN in municipality *i* in year *t*.

3.3 Description of municipalities

Norway has a two-tier government system, composed of municipalities and counties. This thesis has forecasted future demand for FTEN in 369 municipalities. The municipalities vary considerably in terms of population size and demographics. This makes the demand for FTEN to vary across municipalities. In the following, an overview of FTEN and demographic composition is given for 2008 and 2019, and demographic composition for 2020 and 2040. An overview is given in table 2.

Municipalities are divided into three groups based on population size: Small municipalities (0-4 999 inhabitants), medium-sized municipalities (5 000-19 999 inhabitants) and large municipalities (>=20 000 inhabitants) (Kringlebotten et al., 2020).

In 2008, it was 4 158 623 inhabitants within the 369 municipalities. The number of residents ranged from 212 in Utsira to 560 484 inhabitants in Oslo. The municipality with the median number of inhabitants had 4 503 inhabitants. This indicates that at least half of the 369 municipalities were regarded as small municipalities (≤4 999). The share of children (0-19 years) ranged from 18.8% in Nesseby to 33.2% in Gjesdal. The median municipality had 25.7% of children. The share of adults (20-64) ranged from 50.4% in Kvitsøy to 66% in Oslo, while the median municipality had a share of 57.1%. Older adults (65-100+) ranged from 8.3 % in Gjesdal to 27.6% in Ibestad, while the median municipality had a share of 17% of older adults.

It was a total of 22 793 FTEN in 2008. The number of FTEN ranged from 3 FTEN in Røst to 1 746 in Oslo. The median municipality had 30 FTEN. The national average number of FTEN per capita in 2008 was 5.5. FTEN per capita ranged from 3.1 FTEN per capita in Eidsvoll to 18.6 FTEN per capita in Modalen. The median municipality had 7.2 FTEN per capita.

In 2019, the number of people increased to 4 687 876. Utsira had the lowest number of residents, with 196 inhabitants, while Oslo had the highest number of residents with 681 071. The municipality with the median number of inhabitants had 4 671 inhabitants. The share of children ranged from 15.5% in Loppa to 29.6% in Rennesøy. The median municipality had 22.9% of children. The share of adults ranged from 49.7% in Fjaler to 66.2% in Oslo. The median municipality had a share of 56.1%. The share of older adults ranged from 11.2% in Gjesdal to 31.3% in Ibestad. The median share of older adults increased to 20.9%.

In 2019, it was a total of 34 078. FTEN ranged from 3 FTEN in Træna to 2 802 FTEN in Oslo. The municipality with the median FTEN had 43 FTEN. The national average FTEN per capita was 7.3 FTEN per capita while ranging from 4.1 FTEN per capita in Oslo to 25.3 FTEN per capita in Modalen. Median FTEN per capita was 9.6.

According to the reference alternative, with a moderate population growth (M), the population is expected to reach 4 722 373 inhabitants in 2020. Population size is expected to range from 211 inhabitants in Utsira to 687 326 inhabitants in Oslo. The median municipality is expected to have 4 690 inhabitants. The share of children is expected to range from 14.6% in Loppa to

29.4% in Gjesdal, while the median municipality has a share of 22.6%. Adults are expected to range from 48.6% in Fedje to 66% in Oslo. The median municipality has a share of 56% adults. Older adults are expected to range from 11.6% in Gjesdal to 32.5% in Ibestad. The median municipality has a share of 17% older adults.

By 2040, the population size is expected to reach 5 338 553 inhabitants, according to the reference alternative (M). The number of inhabitants is expected to range from 212 in Utsira to 815 514 inhabitants in Oslo. The median municipality is expected to have 4 661 inhabitants. The share of children is expected to range from 11.1% in Loppa to 43.9% in Fjaler. The median municipality has an expected share of 20.7 % of children. The share of adults is expected to range from 34.9% in Fjaler to 62.5% in Oslo. The median municipality has an expected share of 50.9%. The share of older adults is expected to range from 14.7% in Ås, while Røst is expected to have 52.4% older adults. The median municipality has an expected share of 27.9%.

The population projections provided by Statistics Norway show a shift in the demographic composition. The share of children and adults are expected to decline, while older adults are expected to increase. The demographic shift is, however, distributed differently across municipalities. The combination of continuous centralisation and most pronounced ageing in the districts will reinforce the age-distribution in three ways. Centralisation occurs mainly among young people of fertile age. This makes central areas to have a higher projected number of younger people. Secondly, the centralisation makes children born by migrants settle in central areas, reinforcing the first point. Lastly, the elderly is commonly not subject to migration and therefore remain in the districts. By 2040, more than every third inhabitant in some municipalities are 70 years or older (Leknes et al., 2018).

Table 2 Description of FTEN and demographic composition for selected years. N=369

	Variable	Min	Max	Median
FTEN 2008 & 2019	FTEN 2008	3	1 746	30
	FTEN 2019	3	2 802	43
	FTEN per capita 2008	3.1	18.6	7.2
	FTEN per capita 2019	4.1	25.3	9.6
POP 2008 & 2019	POP 2008	212	560 484	4 503
	POP 2019	196	681 071	4 671
	Children % 2008	18.8	33.2	25.7
	Adults % 2008	50.4	66.0	57.1
	Older adults % 2008	8.3	27.6	17.0
	Children % 2019	15.5	29.6	22.9
	Adults % 2019	49.7	66.2	56.1
	Older adults % 2019	11.2	31.3	20.9
POP 2020 & 2040	POP 2020	211	687 326	4 690
	Pop 2040	212	815 514	4 661
	Children % 2020	14.6	29.4	22.6
	Adults % 2020	48.6	66.0	56.0
	Older adults % 2020	11.6	32.5	17.0
	Children % 2040	11.1	43.9	20.7
	Adults % 2040	34.9	62.5	50.9
	Older adults % 2040	14.7	52.4	27.9

4.0 Method

4.1 Theory: Cobb Douglas and constant return to scale

We now present our model of how FTEN relates to population size and demographic composition. We assume that the need for FTEN is given by a Cobb-Douglas function with a constant return to scale, where the parameter assigned to each of the age-groups are assumed to sum to unity. By implication, this functional form ensures that FTEN demand rises proportionally with respect to population size.

The generalised Cobb-Douglas production function with n inputs is given by

$$\tilde{Y}_{it} = \tilde{B}_i \, \tilde{X}_{Cit}^{\beta_C} \, \tilde{X}_{Ait}^{\beta_A} \, \tilde{X}_{Oit}^{\beta_O} \, \tilde{\varepsilon}_{it} \qquad \beta_C + \beta_A + \beta_O = 1 \quad \text{(Eq.1)}$$

Where indices are defined as follows:

i = municipality

t= year

C=children

A=Adults

O=Older adults

$\tilde{Y}_{it}$ is the number of FTEN in municipality *i* in year *t*. $\tilde{X}_{Cit}$ is the explanatory variable for children. $\tilde{X}_{Ait}$ is the explanatory variable for adults, while $\tilde{X}_{Oit}$ is the explanatory variable for older adults. $\tilde{B}_i$ is the municipality specific intercept. The model has n different intercepts, one for each municipality. β_C, β_A and β_O are unknown parameters of children, adults and older adults, taking a value between 0 and 1. $\tilde{\varepsilon}_{it}$ is random noise (Baltagi, 2005).

The hypothesis of constant return to scale (CRS) implies that the coefficients sum to one (Greene, 2002). CRS occurs when β_C + β_A+ β_O = 1.

The exponents represent output elasticities. Output elasticities represent the percentage change in output for every one per cent change in the quantity of input. When the input factors are increased with a factor b, the output or production level will be increased with the same factor b (Godager et al., 2018). The assumption of CRS implies that a simultaneous increase in all three age groups produces a one-one increase in demand for nurses. A given percentage increase or decrease in the number of residents requires the same proportional change in the number of nurses.

A large amount of literature exists whether or not to log transform (Lo & Andrews, 2015). Answering this is beyond the scope of the thesis.

4.2 Empirical model and specification testing

The Cobb-Douglas function can be expressed as a log-log functional form of input by applying logarithms on both sides of the equation. To perform a logarithmic transformation to a variable, the observed values must be greater than zero (Hyndman & Athanasopoulos, 2013). Since neither the number of nurses nor the number of people in age groups can be negative, this condition is satisfied.

The logarithmic transformation is given as

$$Y_{it} = B_i + \beta_C X_{Cit} + \beta_A X_{Ait} + \beta_0 X_{Oit} + \varepsilon_{it} \qquad \text{(Eq.2)}$$

Where the definition below is used

Y_{it} = ln ($\tilde{Y}_{it}$)

B_i = ln ($\tilde{B}_i$)

X_{Cit} =ln ($\tilde{X}_{Cit}$)

X_{Ait} = ln ($\tilde{X}_{Ait}$)

X_{Oit} = ln ($\tilde{X}_{Oit}$)

ε_{it} = ln ($\tilde{\epsilon}_{it}$)

The double log transforms the non-linear Cobb-Douglas function (Eq.1) to a linear-in-parameter function (Eq.2) (Hyndman & Athanasopoulos, 2013). This allows the production function to be estimated empirically with linear regression (Woolridge, 2016). Greene (2002) states that forecasting is one of the major functions of the linear regression model. This makes estimation results from regression models to commonly be used for forecasting, where it computes predictions of the dependent variable, given assumed future values of the independent variables. The relationship between population size and demand for nurses is assumed to follow a linear relationship, as increasing population size requires more nurses. This assumption is captured by CRS.

Maximum likelihood estimation (MLE) is a common method for parameter estimation and interpretation in statistics (Myung, 2013). The method searches over different possible population values and selects the parameter estimates that are most likely, given the specified functional form and the data sample (Eliason, 1993). Maximising the likelihood provides parameter values where the observed sample is most likely to have been generated. This means that the parameter values correspond most closely with the observed data (Devore & Berk, 2012).

Multiple linear regression predicts future values of y, given estimated regression coefficients of the independent variables. The predicted values for equation (2) then becomes

$$\hat{Y}_{it} = \hat{B}_i + \hat{\beta}_C X_{Cit} + \hat{\beta}_A X_{Ait} + \hat{\beta}_O X_{Oit} \qquad \text{(Eq.3)}$$

Where $\hat{Y}_{it}$ is the predicted value of FTEN in municipality *i* in year *t*. $\hat{\beta}_C$, $\hat{\beta}_A$ and $\hat{\beta}_O$ are the estimates and $\hat{B}_i$ is the predicted municipality specific intercept. The coefficient of X_{Cit} measures the change in $\hat{Y}_{it}$for a one-unit increase in X_{Cit}, while holding the other independent variables fixed. By holding the other variables fixed, we control for X_{Ait} and X_{Oit} when estimating the impact of X_{Cit} on $\hat{Y}_{it}$. The same applies to the estimation of $\hat{\beta}_A$ and $\hat{\beta}_O$ on $\hat{Y}_{it}$ (Woolridge, 2016).

The classic linear regression model places a set of assumptions. The first assumption concerns linearity, implying that the model is linear in the parameters. The second assumption requires the absence of perfect multicollinearity. This implies that the independent variables are not perfect correlated with each other. The third assumption concerns the exogeneity of the independent variables. The assumption of exogeneity states that the independent variables are uncorrelated with the error term. The fourth assumption requires that the error term is constant for over the range of observations**.** This makes the error term homoscedastic. The last assumption assumes normality of the error distribution (Greene, 2002).

Specification testing

To find the model that provided the best fit, specification tests were applied to two competing sets of models: Models based on the logarithmic transformation and maximum likelihood estimation, and models where FTEN per capita was estimated by means of Weighted Least Squares (WLS). After the selection of the two alternatives with specification testing, we compared Mean Squared Error (MSE) from the MLE model and the WLS model. The model based on MLE and log-transformed data provided a lower MSE. We, therefore, proceeded with the MLE and log transformation. Specification testing for the WLS can be found in attachment C in the appendix.

The initial assumption was unequal gender effect on demand for nurse services. We proceeded with three age-groups: children (0-19), adults (20-64) and older adults (65-100+) per male and female, giving a total of six variables. The following specification tests were based on these six explanatory variables.

Hausman test: Fixed effects or random effects?

Panel data offers a way to mitigate the effects of omitted variable bias, either by fixed effects (FE) or random effects (RE). The Hausman test evaluates whether the unique errors are uncorrelated to the regressors (H0) or correlated (H1) (Greene, 2002). If the unique errors are uncorrelated, FE and RE are both consistent, but FE is inconsistent. If the unique errors are correlated to the explanatory variables, FE is consistent, and RE is inconsistent (Woolridge, 2016). The result is significant (p-value 0,00), implying that we reject the null hypothesis in favour of a fixed-effect model.

Municipality fixed effects account for unobservable heterogeneity across municipalities. By including municipality-dummies, we get an analysis with fixed effect (FE). Each dummy-variable absorb the effect of the omitted variables that vary from one municipality to another while being constant over time within the same municipality (Stock & Watson, 2006). This allows us to compare the municipalities and utilize the variation within each municipality over time (Hagen, 2016).

Year dummies or linear trend (with or without squared term)

The initial dataset included year-dummies for each year between 2009 and 2019, where 2008 was excluded to avoid perfect collinearity. Year-dummies are essential to control for year effect and to capture the influence of aggregate trends (Lee & Parks, 2010). Year-dummies provides information about the unexplained changes in FTEN that are not attributed to changes in the age composition of the population. A year-dummy equals one for a given year and 0 for all other years. An alternative to year-dummies is a linear trend. A linear trend shows the overall trend in the period. It can be interpreted as the direction of the outcomes across time. A linear year trend can be complemented with a squared term. Squared or quadratic terms are applied on a continuous variable to take account for the non-linearities in the outcome trends (Neelsen & Stratmann, 2011).

The likelihood ratio test (lrtest) can guide our decision to use year-dummies or linear trend, and if a linear trend provides better explanatory power with or without a squared term. The lrtest assumes that one model is nested in the other, meaning that one model is a subset of another model (Stata, n.d.a)

The null hypothesis states that the model with the linear trend (which is the restricted model, nested in the model with year dummies) does not reduce explanatory power, while the alternative hypothesis states that the model with year dummies (which is the less restrictive model) have more explanatory power. The results indicate that we cannot reject the model with a linear trend with a squared term in favour of the model with year dummies (p-value 0,0605). We also tested whether a linear trend with squared term provides better explanatory power than a linear trend without squared term. Here, the model without the squared term is nested in the model with a squared term. The results indicated that a model with squared term provides better explanatory power (p-value 0,00). We proceeded with linear trend and a squared term.

Clusters

The fixed effects account for the unobserved heterogeneity between municipalities. However, some observations within each municipality may not be independently and identically distributed. This means that some unexplained variation in the outcome is correlated across time. Failure to control for errors that are correlated over time within a municipality would lead to misleadingly small standard error and consequently, small confidence intervals and low p-values (Cameron & Miller, 2015). By clustering municipalities, we obtain robust standard errors. The municipalities are group into clusters, giving a total of 369 clusters, with 12 observations within each cluster, and the Huber/White/sandwich estimator of coefficient's standard error is computed (Stata, n.d.b).

Gender effects

Under the assumption of gender-specific effects, the number of independent variables becomes six in total, with three age groups per gender. After clustering and adding a linear trend with squared year, the regression results revealed that the confidence intervals for men and women overlapped for each age-group. This implies that the difference between each age-group is not statistically significant, which gives reasons to test the assumption of equal gender effects.

Due to clustered municipalities, the log-likelihood test can no longer be used. Instead, the Wald test was used. We ran a simultaneous test on the assumption of equal gender effects across all three age groups (H_0) over the alternative of unequal gender effects (H_1). The p-values (Children: 0.0484. Adults: 0.3714. Older adults: 0.0734) are consistently so high that we cannot reject the null hypothesis of equal gender effects for the three age groups. The conclusion of the Wald test is that we may assume equal gender effects for all three age groups, thereby reducing the number of independent variables from six to three.

Time-dependent effects

Forecasting with MLE and log transformation can be applied in two ways. One were we assume that the time-dependent effect (TDE) provided by the linear trend are fixed at 2019 level. Alternatively, one may assume that the historical time-dependent effects, will continue towards

2040. Fixed TDE is these calculations implies that the forecast of FTEN is based only on demographic development. The impact of increasing TED is an additional increase in FTEN that are not attributable to changes in the population composition. Future FTEN will be a product of both population composition and increasing TDE.

TDE can be described as the additional number of FTEN that is not attributed to the user demographics. This is closely related to service standards, which is defined as FTE per user. Increasing service standards is a result of higher requirements and expectations by the public. The requirements and expectations are increasing in line with income growth and standard of living for the average resident (Helse- og omsorgsdepartementet, 2016). This suggests that people will demand an increase in service standards in the future. This translates into more FTE than what is strictly needed based on demographic composition.

5.0 Results

5.1 Estimation results

Based on the specification testing, we proceed with our log-log regression model. The coefficients in our model represent the elasticity of the dependent variable with respect to each of the independent variables. Coefficients are constrained to sum to unity in our maximum likelihood estimation, thereby reflecting our assumption that the function is homogenous of degree one.

The estimation results are given in table 3 below. The interpretation of our estimation results is when the number of children increases by 1%, demand for FTEN is expected to increase with 0.26%. Further, a 1% increase in the number of adults is expected to increase demand for FTEN by 0.42%. A 1%increase in the number of older adults is expected to increase demand for nurses by 0.32%. Adults and older adults are significant at 1% level, while children are significant at 5% level.

When comparing the coefficients for the three groups, it is important to keep in mind the fact that the number of people in each age category in a given municipality differs substantially.

The *Adult* category, for example, comprises many people because it is defined by a broad age-span. Hence, a 1 % increase in the number of *Older Adults* will correspond to a smaller increase in the absolute number of people as compared to a 1 % increase in the larger group *Adults*. The coefficient on *Adult* being bigger than the coefficient on *Older Adult* does not mean that *Older Adult* is a "less important" driver of FTEN demand than *Adult*.

The year and year squared coefficients capture the unexplained changes in demand that are not attributed to changes in the age composition, population size, or municipality specific unobservables. The interpretation with a positive year (0.05) and negative year squared (-0.0008), is that the unobserved factors increase at a decreasing rate. Both year and year squared are significant at 1% level.

Table 3 Estimation results from Maximum likelihood estimation.

Variable	**Coefficient**	**Robust† Std. Err.**	**P-value**	**[95% Conf. Interval]**
Children	0.26	0.10	**	[0.05 0.46]
Adults	0.42	0,11	***	[0.21 0.64]
Older Adults	0.32	0.09	***	[0.15 0.49]
Year	0.05	0.01	***	[0.03 0.06]
Year squared	-0.0008	0.0002	***	[-0.0012 -0.0004]

† Standard errors are clustered at the level of the municipality

N= 369 municipalities, T=12 years, NT=4428 observations.

The dataset is a balanced panel (Greene, 2002) of 369 municipalities over a period of 12 years, from 2008 to 2019. The total number of observations amount to 369 x 12=4428. The unique number of observations is 369.

A comparison between the observed FTEN and predicted estimation results of FTEN at a national level in 2008-2019 can be found in attachment D in the appendix.

5.2 Forecast results of future demand for full-time equivalent nurses

Combining estimation results and demographic forecast allows producing forecasts for the demand of FTEN. In the following, a brief overview of the forecasts at a national level will be given. It is important to have in mind that these forecasts are based on the aggregated numbers of 369 municipalities. Since 54 municipalities are excluded from the dataset, it is not possible to provide adequate numbers for future FTEN at the national level. They will still be referred to as “national forecasts”[4]. The second section describes the forecasting results with reference to the sub-research-questions.

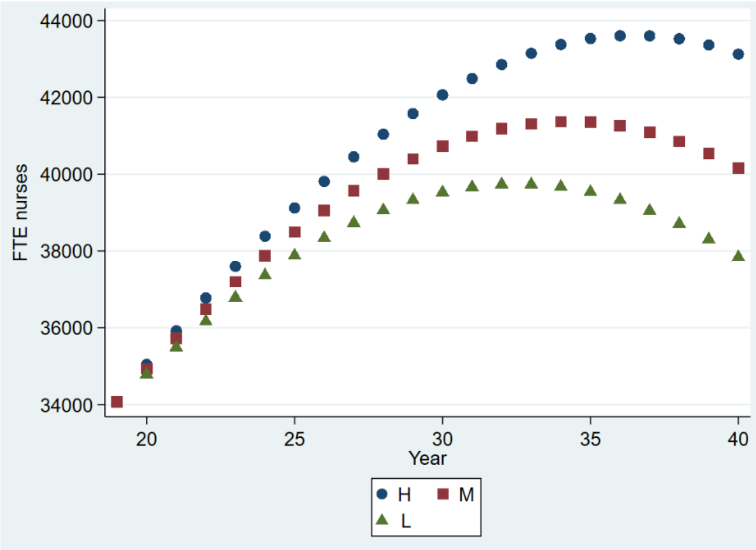
The predicted development of FTEN in this text reflects net changes. This net changes in FTEN reflect the change in FTEN demand in each municipality, ignoring nurse turnover caused by retirement, nurses relocating or nurses resigning. If the annual growth in demand is, for instance, 0.69% and x% nurses leave the profession for various reasons each year, 0.69% + x% nurses are needed to cover the drop-out and the increased demand. As the thesis only forecasts future demand, we are not able to provide numbers taking account for this deviation.

5.2.1 National forecasting

Graph 2 and Graph 3 present the forecast for the expected number of FTEN in Norway towards 2040. Each of the graphs includes forecasts of FTEN based on low (L), moderate (M) and high (H) population growth[5]. The graphs differ in terms of whether it is an increasing or fixed time-dependent effect (TDE).

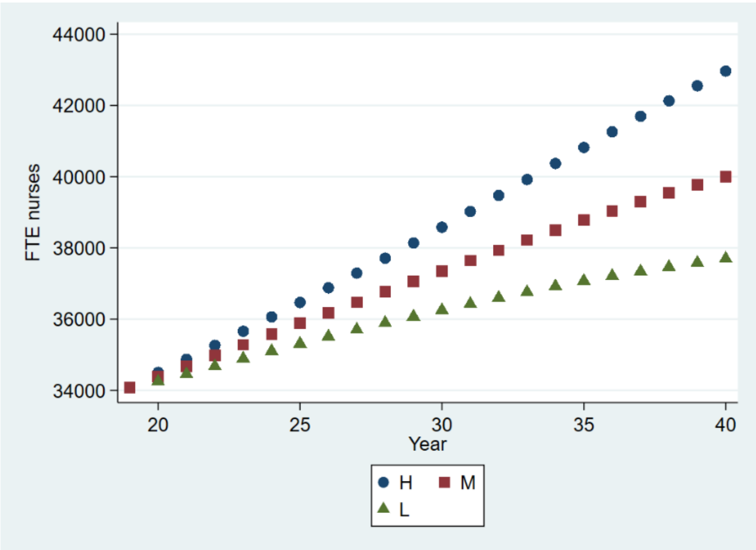
[4] National forecast can easily be produced in the near future, as soon as Statistics Norway provide updated demographic forecasts that reflect the new municipality structure in Norway.
[5] Each alternative (low, medium and high) is described by four letters in the following order: fertility, life expectancy, internal migration and immigration. Where L= LLML M= MMMM H=HHMH.

Figure 2 National FTEN forecast with L, M and H pop. growth. Increasing TDE. N=369



Graph 2 presents forecasted FTEN when assuming increasing time-dependent effect (TDE). In 2040, the 369 municipalities are expected to require 37 838 FTEN (L), 40 154 FTEN (M) or 43 124 FTEN (H). This represents an absolute growth of 3 050 (L), 5 220 (M) and 8 077 (H) FTEN from 2020. Expressed in relative terms, the relative increase over the forecast window is 8.8 % for alternative L, 14.9 % for alternative M and 23 % for alternative H. This equals an annual growth in FTEN of 0.42% for L, 0.70% for M and 1.04% for H. An overview is given in table 4.

Figure 3 National FTEN forecast with L, M and H pop. growth. Fixed TDE. N=369



Graph 3 presents expected FTEN when we assume fixed TDE at the 2019 level. The results indicate an expected demand for FTEN in 2040 of 37 698 FTEN (L), 40 005 FTEN (M) or 42 964 FTEN (H). This represents an absolute growth of 3 446 (L), 5 609 (M) and 8 457 (H) FTE from 2020. This equals a relative percentage growth from 2020 of 10.1 % (L), 16.3 % (M) and 24.5 % (H). Expressed in annual terms, this amount to a yearly increase of 0.48% for L, 0.76% for L and 1.10% for H.

The graphs differ in terms of whether it is increasing or fixed TDE. Graph 2 includes the unexplained changes in demand in addition to demographical changes. Recalling the positive year coefficient and negative year squared coefficient, the unexplained growth increases at a decreasing rate. The negative sign of its coefficient produces a concave graph with a maximum within our forecasting window. Graph 3, on the other hand, takes only into account the demographical changes in demand for FTEN. The impact of these assumptions is already apparent from 2020. The demand for FTEN is consequently higher when assuming increasing time-dependent effect. This makes Graph 2 start at a higher point already from 2020.

The two graphs illustrate the uncertainties and potential impact of TDE. Graph 2 tries to take into account the unobservable growth we have seen in the past; a growth which was increasing, at a decreasing rate. In the short run, Graph 2 provides more reliable results, as it includes both TDE and population demographics. When including this negative squared term, FTEN would over time, reach zero, which does not appear plausible. One may, therefore, argue that Graph 3, where TDE is fixed to the 2019 level, provides more plausible long-run forecast.

Table 4 National FTEN forecast for 2020 and 2040 for L, M and H pop. growth with increasing and fixed TDE. N=369

	Demographic projection	FTEN 2020	FTEN 2040	Growth FTEN No.	Growth FTEN (%)
Increasing time-dependent effect	L	34 788	37 838	3 050	8.8
	M	34 934	40 154	5 220	14.9
	H	35 047	43 124	8 077	23
Fixed time-dependent effect	L	34 252	37 698	3 446	10.1
	M	34 396	40 005	5 609	16.3
	H	34 507	42 964	8 457	24.5

5.2.2 Municipality projections

While there are many alternative combinations of population forecasts and model assumptions that could potentially be described, we have to focus on a subset. Leknes et al., (2018) consider the alternative with moderate growth (M) closest to a population prognosis, and we, therefore, focus on this alternative when presenting the forecasts at the municipality level. We also limit our focus to forecasts where the unobservable time-dependent effect is fixed to 2019 level.

In the following section, a detailed description of a set of municipalities is given. We will emphasise changes in population size as it is a basic precondition for how the demand for FTEN will degenerate in 2040. In cases where there are noteworthy changes in the age composition, this will be highlighted. An overview of the municipalities demographic composition in 2020 and 2040 can be found in attachment E in the appendix. A selection of graphs illustrating expected growth in FTEN is presented in attachment G in the appendix.

The results are based on the 369 municipalities included in the dataset. If all 423 municipalities were included, the results could differ.

An Excel file with the complete forecasting results for all 369 municipalities and all six forecast alternatives is available as a separate attachment (not included in the appendix).

Description of forecasting results at the municipality level

In the following, a brief overview is given of the forecasting results for the reference alternative (M) with fixed TDE. An overview for all population alternatives, with fixed and increasing TDE, can be found in attachment F in the appendix.

The demand for FTEN in 2020 is expected to range from 3 to 2 839 FTE, with a median value of 42 FTEN. By 2040, our forecasting results indicate that the lowest number of FTEN will decline to 2 FTEN, while the municipality with the highest demand will require 3 587 FTEN. It is the same two municipalities in both years: Røst (3/2) and Oslo (2 839/3 587). The median municipality in 2040 is expected to demand 47 FTEN.

The absolute change in demand for FTEN over the two decades is expected to range from -9 to 748 FTEN. The median municipality is expected to experience an increase in demand of 3 FTEN. The relative change is expected to range from -39 % to 64.5%, with a median value of 8% FTEN. 123 of 369 municipalities are expected to experience a decline in FTEN between 2020-2040.

In 2020, the full-time equivalent per 1000 capita (FTEN per capita) is expected to range from 4.1 in Oslo to 25.3 in Modalen. The municipality with the median FTEN per capita is expected to have a coverage of 9.7. By 2040, FTEN per capita is expected to increase to 4.4 and 26.6. It is the same two municipalities in 2040, Oslo and Modalen. The median FTEN per capita increases to 9.8. The national average FTEN per capita in 2020 is expected to be 7.3, while 7.5 in 2040.

5.2.2.1 Sub-question 1: FTEN forecast for the ten most populated municipalities in 2040

The population projections indicate that the ten most populated municipalities in 2040 is expected to be Oslo, Bergen, Bærum, Stavanger, Kristiansand, Fredrikstad, Sandnes, Tromsø, Drammen and Asker. By 2040, the number of inhabitants is expected to range from 68 364 to 815 514, making them all large municipalities (≥20 000). The forecasting results indicate that these municipalities are expected to represent 28.5% of the total FTEN in 2040. Among the ten largest municipalities, the demand for FTEN is expected to range from 317 FTEN to 3 587

FTEN, as seen in table 5. FTEN per capita is expected to range from 4.4 to 8.3 in 2040, as seen in table 6. Compared to many other municipalities, the demographic shift is relatively modest. Tromsø is expected the have the largest percentage change in the share of older adults, increasing with 7.7%.

The population projections indicate that Oslo, the capital of Norway, is expected to have the highest population size in 2040, reaching 815 514 inhabitants. This represents the highest absolute growth in population size, increasing with 128 188 inhabitants from 2020. With the increasing population size, a simultaneous increase in demand for FTEN is expected. The forecasting results indicate that Oslo is expected to have the highest projected demand for FTEN with 3 587 FTEN in 2040. This gives Oslo the highest absolute growth in FTEN from 2020. The expected relative increase in FTEN of 26.3% translates into an annual growth of 1.17% per year. Despite the large increase in FTEN, Oslo is expected to have the overall lowest FTEN per capita in both 2020 and 2040, with respectively 4.1 and 4.4 FTEN per capita.

The population projections indicate that Bergen, part of Hordaland county, is expected to reach 310 648 inhabitants in 2040, giving Bergen the second-highest population size in 2040. The expected increase represents the second-largest growth in population size. Our projections indicate that Bergen will require the second highest FTEN in 2040, with 1 949 FTEN. The increase of 278 FTEN from 2020 constitutes the second-highest absolute growth in FTEN. The calculations suggest that Bergen will have 6.3 FTEN per capita in 2040.

Bærum, part of Akershus county, is expected to have the third-largest population size in 2040 with 143 673 inhabitants. The expected increase from 2020 represents the fourth largest absolute growth in population size. Our forecasting results indicate that Bærum will require the third-largest number of FTEN in 2040, with 1 045 FTEN. The increased demand of 166 FTEN from 2020 constitutes the fifth-largest absolute growth in FTEN. FTEN per capita is expected to increase from 6.9 in 2020 to 7.3 in 2040.

The demographic forecast indicates that Stavanger, part of Rogaland county, will have the fourth largest population size in 2040 with 138 410 inhabitants. This is a relatively modest increase from 2020, increasing with 4.7%. The FTEN forecast suggests that Stavanger will require the fifth largest number of FTEN in 2040, with 904 FTEN. The additional 98 FTE from 2020 represents a percentage increase of 12.2%. While the annual growth in population size increases with 0.23% a year, demand for FTEN is expected to increase with 0.58% annually. The FTEN per capita is expected to increase from 6.1 in 2020 to 6.5 in 2040

Kristiansand, a municipality in Western Norway, have a forecasted population size of 109 797 inhabitants in 2040. The forecasts results indicate that Kristiansand is anticipated to have both the fourth-largest number of FTEN in 2040 and the fourth-largest absolute growth in FTEN. The results indicate that Kristiansand will require an additional 169 FTEN by 2040, reaching 909 FTEN. This suggests that Kristiansand will have 8.3 FTEN per capita in 2040.

The population projections indicate that population size in Fredrikstad in Østfold county will reach 98 074 inhabitants by 2040. This makes Fredrikstad the sixth-largest municipality in Norway in 2040. The population growth from 2020 represents the fifth largest absolute increase. The forecasting results indicate that Fredrikstad will require 810 FTEN in 2040. This represents a percentage increase in FTEN of 23.4%. This translates into increased demand for additional 153 FTE. This indicates that FTEN per capita will increase from 7.9 in 2020 to 8.2 in 2040.

The results from the population projections suggest that Sandnes in Rogaland County will have the third-highest absolute growth in population size, increasing with 18 653 inhabitants. By 2040, Sandnes is expected to have 96 383 inhabitants in 2040. This gives Sandnes the potential of having the seventh-largest number of inhabitants in 2040. Our results indicate that Sandnes will require 678 FTEN by 2040. This indicates that Sandnes will have the third-highest absolute growth in demand for FTEN, increasing with 170 FTEN. Bases on this, the population in Sandnes is expected to have 7 FTEN per capita in 2040.

Tromsø municipality in Troms county is expected to have the seventh-highest population size in 2040. By 2040, the population size is expected to reach 82 086. The forecasting results indicate that an additional 76 FTEN is needed by 2040, suggesting a demand of 573 FTEN in 2040. This makes Tromsø have a potential of 7 FTEN per capita 2040.

Drammen in Buskerud county has an expected population size of 12 011 inhabitants in 2040. This makes Drammen the ninth-largest municipality in 2040. In terms of FTEN, Drammen is expected to have the eight greatest demand for FTEN in 2040, with an estimated demand of 646 FTEN. This represents a percentage increase of 21.4% from 2020. From 2020 to 2040, FTEN per capita is expected to increase from 7.6 to 7.9 FTEN per capita.

The tenth-largest municipality in 2040 is expected to be Asker in Buskerud county. The population projections indicate that Asker will reach 68 364 inhabitants by 2040. Our forecast results indicate that Asker will require 317 FTEN by 2040. This equals an estimated percentage increase of 17.5% FTEN from 2020. Compared to the population size, the estimations suggest that Asker is expected to have the third overall lowest FTEN per capita across all municipalities in 2040, with 4.6 FTEN per capita.

Table 5 FTEN - and demographic forecast for the ten most populated municipalities in 2040. N=10

	FTEN forecast			**Demographic forecast**		
Municipality	**FTEN 2020**	**FTEN 2040**	**Growth FTEN No. (%)**	**POP 2020**	**POP 2040**	**Growth POP No. (%)**
Oslo	2 839	3 587	748 (26.3)	687 326	815 514	128 188(18.7)
Bergen	1 672	1 949	278 (16.6)	281 450	310 648	29 198 (10.4)
Bærum	879	1 045	166 (18.8)	126 769	143 673	16 904 (13.3)
Stavanger	806	904	98 (12.2)	132 135	138 410	6 275 (4.7)
Kristiansand	740	909	169 (22.8)	94 807	109 797	14 990 (5.8)
Fredrikstad	656	810	153 (23.4)	82 612	98 074	15 462 (18.7)
Sandnes	508	678	170 (33.4)	77 730	96 383	18 653 (24)
Tromsø	497	573	76 (15.3)	76 880	82 086	5 206 (6.8)
Drammen	532	646	114 (21.4)	70 035	82 046	12 011 (17.2)
Asker	270	317	47 (17.5)	61 494	68 364	6 870 (11.2)

Table 6 FTEN per capita for the ten most populated municipalities in 2040. N=10

Municipality	**FTEN per capita 2020**	**FTEN per capita 2040**
Oslo	4.10	4.40
Bergen	5.90	6.30
Bærum	6.90	7.30
Stavanger	6.10	6.50
Kristiansand	7.80	8.30
Fredrikstad	7.90	8.20
Sandnes	6.50	7.00
Tromsø	6.50	7.00
Drammen	7.60	7.90
Asker	4.40	4.60

5.2.2.2 Sub-question 2: Absolute change in full-time equivalent nurses (FTEN) between 2020 and 2040

Municipalities with the greatest absolute increase in demand for FTEN between 2020-2040

The five municipalities with the greatest absolute growth (2020-2040) in FTEN are among the ten municipalities with the largest anticipated population size. The forecasting results indicate that Oslo, Bergen, Sandnes, Kristiansand and Bærum will have the greatest absolute growth in FTEN. Since these municipalities have already been described in the section above, we will only give a brief overview.

The absolute growth among these five municipalities is expected to range from 166 FTEN to 748 FTEN. Demand in Oslo is expected to increase with 748 FTEN and Bergen with 278 FTEN. Only between Oslo and Bergen, there is a difference of 470 FTEN. Sandnes is expected to increase with 170 FTEN, closely followed by Kristiansand with 169. Bærum is expected to increase with 166 FTEN. Between Oslo and Bærum, there is a difference of 582 FTEN.

Municipalities with the largest absolute decline in demand for FTEN between 2020-2040

Several municipalities are expected to experience a decline in the number of FTEN between 2020-2040. The five municipalities with the largest decline are Vanylven, Kvinnherad, Årdal, Saltdal and Meløy. The absolute decline ranges from -7 to -9 FTEN, however, representing a relative decline in FTEN up to -31.4%. A simultaneous relative decline in population size, ranging from -7.3 % to -29.5%, is expected. While taking account for population size in 2040, the FTEN per capita is expected to range from 9.1 to 13.6 FTEN per capita. An overview of findings is presented in table 7 and table 8.

The demographic shift is quite apparent in these municipalities. The percentage of older adults in these municipalities are already quite high today and will increase at an even higher rate in the future. The share of older adults is expected to range from 22%-29.7% today. In 2040, the share of older adults is expected to range from 32.1%-45.3% of the inhabitants. An overview is given in attachment E in the appendix.

Vanylven, a small municipality in Møre og Romsdal, is expected to experience the largest absolute decline of -9 FTEN. The results suggest a decline from 29 FTEN in 2020 to 20 FTEN in 2040. This represents a relative decline of -31.4% or an annual decline of -1.37% FTEN. A simultaneous decline in population is expected. Vanylven is expected to have both the fourth largest absolute and relative decline in population size. By 2040, the population is expected to decline with -29.5%, representing a population decline of -901 inhabitants. In 2040, Vanylven is expected to have 2 156 inhabitants. This suggests that Vanylven will have 9.3 FTEN per capita in 2040. The population projections indicate that older adults will account for the largest share of the population, representing 45.3% in 2040.

The projections indicate that Kvinnherad, a medium-sized municipality in Western Norway, will have the second-largest decline in the number of FTEN. Between 2020 and 2040, demand for FTEN is expected to decline from 166 FTEN to 158 FTEN, representing a decline of -8

FTEN. The population projections show a simultaneous decline in population size. Population size is expected to decline from 13 043 to 12 095, representing the highest absolute population decline among all 369 municipalities. With these projections in mind, Kvinnherad is expected to have 13 FTEN per capita.

Our forecast results suggest that Årdal, a municipality in Sogn & Fjordane county, will have the third-highest decline in the number of FTEN between 2020-2040. The results indicate that FTEN is likely to decline from 47 in 2020 to 39 in 2040, representing a decline of -8 FTEN. Similar, we see a simultaneous decline in population size. The population is estimated to decline from 5 171 in 2020 to 4 252 in 2040. This represents the second-highest absolute decline in population size. The results indicate that Årdal is expected to have 9.1 FTEN per capita. If this population decline actually happens, Årdal will go from being a medium-sized municipality to a small municipality by 2040. The largest decline is expected to be among adults, declining with -11.4%, while older adults are expected to increase with 15.3% between the two decades.

The FTEN forecast results indicate that Saltdal, a medium-sized municipality in Northern Norway, will have the fourth largest absolute decline in FTEN between 2020-2040. The projections indicate that FTEN will decline from 63 to 55 FTEN. This represents an absolute decline of -8 FTE or a relative decline of -12.2%. The population projections indicate that the population will decline from 4 651 inhabitants to 4048 inhabitants. This represents a potential decline in population size of -13%. Among the municipalities mentioned, Saltdal is expected to have the highest coverage in 2040, with 13.6 FTEN per capita

Meløy in Northern Norway is expected to experience the fifth-largest decline in FTEN, declining with -7 FTEN. The forecasting results indicate a decline from 60 FTEN in 2020 to 52 FTEN in 2040. This equals a percentage decline of -12.3%. The demographic forecast suggests that the population will decline to 5 368 inhabitants in 2040. The projected population decline of -905 inhabitants represents the third-largest absolute decline. By 2040, Meløy is expected to have 9.8 FTEN per capita.

Table 7 FTEN- and demographic forecast for the municipalities with the largest absolute decline in FTEN. N=5

	FTEN forecast			Demographic forecast		
Municipality	**FTEN 2020**	**FTEN 2040**	**Growth FTE No. (%)**	**POP 2020**	**POP 2040**	**Growth POP No. (%)**
Vanylven	29	20	-9 (-31.4)	3 057	2 156	-901 (-29.5)
Kvinnherad	166	158	-8 (-5.1)	13 043	12 095	-948 (-7.3)
Årdal	47	39	-8 (-17.1)	5 171	4 252	-919 (-17.8)
Saltdal	63	55	-8 (-12.2)	4 651	4 048	-603 (-13)
Meløy	60	52	-7 (-12.3)	6 273	5 369	-905 (-14.4)

Table 8 FTEN per capita in the municipalities largest absolute decline in FTEN. N=5

Municipality	**FTEN per capita 2020**	**FTEN per capita 2040**
Vanylven	9.6	9.3
Kvinnherad	12.7	13.0
Årdal	9.0	9.1
Saltdal	13.5	13.6
Meløy	9.5	9.8

5.2.2.3 Relative (measured in per cent) change in FTEN between 2020 and 2040

Municipalities with the greatest relative increase in FTEN between 2020-2040

The five municipalities with the greatest expected relative change in FTEN are all located in Eastern Norway: Ås, Våler, Hobøl, Hemsedal and Ullensaker. The expected relative growth in FTEN ranges from 46.2% to 64.5%. Together, these five municipalities are expected to increase with 245 FTEN from 2020-2040. FTEN per capita is expected to range from 5 to 7.6. An overview of results these results are presented in table 9 and table 10. The population projections indicate a strong relative population increase for the five municipalities. Large changes in the age-composition among the municipalities are not expected.

Ås municipality, part of Akershus county, is expected to have both the greatest relative growth in FTEN and in population size by 2040. Our forecast results indicate that Ås is expected to experience a relative growth in demand for FTEN of 64.5% FTEN. For each year between 2020-2040, demand for FTEN is expected to increase with 2.52%. This indicates that Ås is expected to have a demand of 231 FTEN in 2040. Furthermore, Ås has an expected relative population growth of 60.6 %. This translates into an annual population growth of 2.39%. By 2040, Ås is expected to have 34 029 inhabitants. The demographic forecast indicates that Ås is expected to have the overall lowest share of older adults in 2040, representing only 14.7% of the inhabitants. By 2040, Ås is expected to have 6.8 FTEN per capita in 2040.

Our forecast results indicate that Våler in Østfold is expected to have the second-highest relative growth in FTEN. Våler is expected to increase their demand for FTEN from 42 FTEN in 2020 to 67 FTEN by 2040, representing a relative increase of 58.7%. The demographic forecasts indicate that Våler is also expected to have the second-highest relative population increase, where the results suggest an increase of 52.9%. This implies that Våler is expected to reach 8 823 inhabitants in 2040. Based on these results, Våler is expected to have 7.6 FTEN per capita.

Hobøl in Østfold is expected to have a relative increase in demand of 49.9% FTEN between 2020-2040. This makes Hobøl the municipality with the third-highest relative growth in FTEN. By 2040, Hobøl is expected to have a demand of 42 FTEN. This represents an increase of 14 FTEN from 2020. Hobøl is furthermore the municipality with the fourth highest relative growth in population size. From 2020 to 2040, the population in Hobøl is expected to increase to 8 333, representing a relative increase of 43.4 %. Based on these numbers, Hobøl is expected to have 5 FTEN per capita in 2040.

Demand for FTEN in Hemsedal in Buskerud county is expected to increase from 17 FTEN in 2020 to 26 FTEN in 2040. The relative increase of 49.9% represents the fourth greatest relative change in FTEN. This translates into an annual increase in demand of 2.04%. The expected relative increase in population size of 45.7% represents the third-largest increase from 2020. By 2040, the population is expected to reach 3 669 inhabitants. Based on this, Hemsedal is expected to have 7.1 FTEN per capita in 2040.

The municipality with the fifth largest relative increase in FTEN is expected to be Ullensaker, a municipality in Akershus county. Our forecast results indicate a relative increase in FTEN of 46.2%, representing an absolute growth of 107 FTE since 2020. This suggests that Ullensaker will require 338 FTEN in 2040. Ullensaker is not among the five municipalities with the highest expected relative increase in population size. A rise of 36.5 %, makes Ullensaker the municipality with the seventh-highest relative population increase. By 2040, Ullensaker is expected to reach 53 040 inhabitants. This suggests that Ullensaker will have 6.4 FTEN per capita in 2040.

Table 9 FTEN- and demographic forecast for the municipalities with the greatest relative growth in FTEN. N=5

	FTEN forecast			**Demographic forecast**		
Municipality	**FTEN 2020**	**FTEN 2040**	**Growth FTE No. (%)**	**POP 2020**	**POP 2040**	**Growth POP No. (%)**
Ås	141	231	91 (64.5)	21 191	34 029	12 838 (60.6)
Våler	42	67	25 (58.7)	5 769	8 823	3 054 (52.9)
Hobøl	28	42	14 (49.9)	5 812	8 333	2 521 (43.4)
Hemsedal	17	26	9 (49.9)	2 518	3 669	1 151 (45.7)
Ullensaker	232	338	107 (46.2)	38 843	53 040	14 197 (36.5)

Table 10 FTEN per capita for the municipalities with the greatest relative growth in FTEN. N=5

Municipality	**FTEN per capita 2020**	**FTEN per capita 2040**
Ås	6.6	6.8
Våler	7.3	7.6
Hobøl	4.8	5.0
Hemsedal	6.9	7.1
Ullensaker	6.0	6.4

Municipalities with the largest relative decline in FTEN between 2020-2040

Several municipalities are expected a decline in FTEN between 2020-2040. Taking account for the initial number of FTEN, Loppa, Røst, Kvalsund, Vanylven and Engerdal are expected to have the largest relative decline in demand for FTEN. The relative change in demand ranges from -27.3% to -39%. Together, these municipalities will go from having a demand of 68 FTEN in 2020 to 46 FTEN in 2040. FTEN per capita is also expected to decrease between 2020-2040. The population projections indicate a decline in population size, ranging from -36.3% to -25.3%. An overview of results is given in table 11 and table 12. The municipalities show a trend with a steep decrease in children and adults, with a sharp increase in the share of older adults. Older adults are expected to account for the largest share of the population in four out of five municipalities. By 2040, the share of older adults is expected to range from 43.4%-52.5%. The changing demographics can be related to internal migration, typically where young adults with children move, and the older adults remain in the districts.

Loppa municipality in Finnmark county is expected to have the largest relative decline in FTEN with -39%. This translates into an annual decline in demand of -1.66%. The forecasting results suggest a decline from 10 FTEN in 2020 to 6 FTEN in 2040. It is expected a simultaneous decline in population size. A population decline of -36.3% represents the highest relative decline across all 369 municipalities. By 2040, the population is expected to reach 587 inhabitants. The results indicate that FTEN per capita will decline from 2020 to 2040. In 2020

Loppa is expected to have 10.9 FTEN per capita, while 10.4 FTEN per capita in 2040. In 2040, the largest share of the population is expected to be older adults, representing 45.7% of the population. This is an increase of 15.5% from 2020. Loppa is expected to have the overall lowest share of children across all municipalities, representing 11.1% in 2040.

Røst municipality in Nordland county is expected to have the second-largest relative decline in FTEN. The forecasting results indicate a decline of -37.2%, translating into an annual decline of -1.59%. Røst municipality is expected to have the overall lowest FTEN in both 2020 and 2040, with respectively 3 FTEN and 2 FTEN. The population projections indicate that Røst will have the second-highest relative decline in population size, declining with -32.5%. This suggests that Røst will have 347 inhabitants in 2040, making Røst the second smallest municipality in 2040. Similar to Loppa, Røst is expected to have a decline in FTEN per capita, declining from 6.5 in 2020 to 6 in 2040. By 2040, older adults are expected to account for 52.5% of the inhabitants. This is the overall highest share of older adults across all municipalities in 2040.

Our FTEN forecast results indicate that Kvalsund in Finnmark county is expected to have the third-largest percentage decline in FTEN between 2020-2040. Our results indicate a relative decline of -34.4%. This indicates a decline from 12 FTEN in 2020 to 8 FTEN in 2040. Røst is expected to have the third-largest relative decline in population size, declining with -30.6%. By 2040, the population is expected to reach 700 inhabitants in 2040. This suggests that Kvalsund is expected to have 11 FTEN per capita in 2040. This represents a decline from 2020, where Kvalsund is expected to have 11.6 FTEN per capita. A slower increase in the share of older adults is seen in Kvalsund. Older adults are expected to increase their share with 12.5% and will still represent the second largest age group in 2040.

In addition to having the lowest absolute growth in FTEN, the results indicate that Vanylven is also expected to have the fourth highest relative decline in FTEN with -31.4%, as already mentioned in section 5.2.2.1.

The results indicate that Engerdal, a municipality in Hedmark county, is expected to have the fifth-largest decline in both relative FTEN and in population size between 2020-2040. The forecasting results indicate a decline from 14 FTNE in 2020 to 10 FTEN in 2040. This represents a percentage decline of -27.3 %. Population size is expected to decline with -25.3%. By 2040, Engerdal is expected to have 947 inhabitants. This indicates that Engerdal will have 10.7 FTEN per capita in 2040. The share of older adults is expected to increase with 15%. This makes older adults represent the largest age-group in 2040 with 44.2% of the population.

Table 11 FTEN- and demographic forecast for the municipalities with the largest relative decline in FTEN. N=5

	FTEN forecast			Demographic forecast		
Municipality	**FTEN 2020**	**FTEN 2040**	**Growth FTE No. (%)**	**POP 2020**	**POP 2040**	**Growth POP No. (%)**
Loppa	10	6	-4 (-39.0)	922	587	-335 (-36.3)
Røst	3	2	-1 (-37.2)	514	347	-167 (-32.5)
Kvalsund	12	8	-4 (-34.4)	1 009	700	-309 (-30.6)
Vanylven	29	20	-9 (-31.4)	3 057	2 156	-901 (-29.5
Engerdal	14	10	-4 (-27.3)	1 267	947	-320 (-25.3)

Table 12 FTEN per capita for the municipalities the largest relative decline in FTEN. N=5

Municipality	**FTEN per capita 2020**	**FTEN per capita 2040**
Loppa	10.9	10.4
Røst	6.5	6.0
Kvalsund	11.6	11.0
Vanylven	9.6	9.3
Engerdal	11.0	10.7

4.2.2.4 Full-time equivalent nurses per 1000 capita (FTEN per capita)

By 2040, the average national FTEN per capita are expected to be 7.5. This represents an increase from the expected national average of 7.3 FTEN per capita in 2020. As we have seen, there are large differences in FTEN per capita between municipalities. Some of this variety is attributable to age-composition in the municipalities, but a large extent of these differences is also attributed to the unobservable factors, captured by fixed effects. Not only do the results show differences in FTEN per capita between municipalities, but also differences within the same municipalities across time. The interpretation of this finding is a changing demographic within the specific municipality.

Municipalities with highest FTEN per 1000 capita

Modalen, Bykle, Utsira, Sirdal and Kvæfjord is expected to have the highest FTEN per capita in 2040, ranging from 18 to 26.6 FTEN per capita. They are all small municipalities, with expected demand for FTEN between 4 and 50 FTEN in 2040. An overview of main findings is given in table 13 and table 14. Older adults in not expected to represent the largest share of the population in any of the municipalities by 2040. Kvæfjord is expected to have the highest share with 30.6% in 2040.

Modalen in Vestland county is expected to have most FTEN per capita in both 2020 and 2040, with respectively 25.5 and 26.6 FTEN per capita. The population projections indicate a modest population increase with only one inhabitant. By 2040, Modalen is expected to have 384 inhabitants. The forecasting results show a demand for 10 FTEN in both years. By 2040, older adults are expected to account for 30.2% of the inhabitants, compared to 19.6% in 2020.

Bykle in Aust-Agder county is expected to have the second highest FTEN per capita in both 2020 and 2040. The forecasting results suggest 19.8 FTEN per capita in 2020 and 21.6 FTEN per capita in 2040. Our results indicate an increase from 19 FTEN in 2020 to 24 FTEN in 2040. Bykle is expected a simultaneous population increase, reaching 1 096 inhabitants in 2040. Older adults are expected to account for 27.7% of the population in 2040. This is an increase of 12.2% increase from 2020.

Utsira in Rogaland is expected to have 19.6 FTEN per capita in 2020 and 20.3 FTEN per capita in 2040. This indicates that Utsira will have the third highest FTEN per capita in both years. Furthermore, our forecasting results indicate that Utsira will neither have an increasing nor decreasing demand for FTEN. Utsira is expected to demand 4 FTEN in both years. Similar to Modalen, Utsira is expected to have a population rise with one inhabitant between 2020 and 2040, reaching 212 inhabitants in 2040. Contrary to Modalen, Utsira is expected a high rise in the share of children, increasing with 19.2%, while adults are expected to decrease with -26.2%. This makes the share of older adults to increase with 7%. In 2040, children are expected to represent the largest share of the population across all municipalities, with 42.9%.

Sirdal is expected to have the fifth largest FTEN per capita in 2020 and the fourth largest FTEN per capita in 2040. By 2040, Sirdal is expected to have 18.5 FTEN per capita. The forecasting results indicate an increasing demand for FTEN, reaching 36 FTEN in 2040. The population projections by Statistics Norway suggest a simultaneous population increase, reaching 1 938 inhabitants by 2040. The share of older adults is expected to increase with 5.4 %. This suggests that older adults are expected to represent 25.5% of the population in Sirdal.

Our forecasting results indicate that Kvæfjord is expected to have the fourth-highest number of FTEN per capita in 2040, with 18 FTEN per capita. Kvæfjord is expected a decline in both FTEN and population size. FTEN is expected to decline from 51 FTEN in 2020 to 50 FTEN in 2040. Population projections indicate a population fall from 2 903 to 2 776 inhabitants. Older adults are expected to account for 30.6% of the population, an increase of 7.6% from 2020.

Table 13 FTEN- and demographic forecast for the municipalities with the highest FTEN per capita in 2040. N=5

	FTEN forecast			Demographic forecast		
Municipality	**FTEN 2020**	**FTEN 2040**	**Growth FTE No. (%)**	**POP 2020**	**POP 2040**	**Growth POP No. (%)**
Modalen	10	10	0 (0)	383	384	1 (0.3)
Bykle	19	24	4 (22.7)	974	1 096	122 (12.5)
Utsira	4	4	0 (0)	211	212	1 (0.5)
Sirdal	33	36	3 (7.6)	1 854	1 938	84 (4.5)
Kvæfjord	51	50	-1 (-1.3)	2 903	2 776	-127(-4.4)

Table 14 FTEN per capita for the municipalities with the highest FTEN per capita in 2040. N=5

Municipality	**FTEN per capita 2020**	**FTEN per capita 2040**
Modalen	25.5	26.6
Bykle	19.8	21.6
Utsira	19.6	20.3
Sirdal	17.9	18.5
Kvæfjord	17.4	18.0

Municipalities with the lowest FTEN per 1000 capita

The forecasting result indicates that Oslo, Eidsvoll, Asker, Vestby and Nittedal will have the lowest FTEN per capita in both 2020 and 2040. The FTEN per capita ranges from 4.4 to 4.7 FTEN per capita in 2040. An overview of main findings for the municipalities is given in table 14 and table 15. The share of older adults is expected to range from 17.7%-23.9%

As earlier mentioned, Oslo is expected to have the overall lowest FTEN per capita in 2040, with 4.4. This represents an increase from 2020, where the forecast results suggest 4.1 FTEN per capita.

Eidsvoll in Akershus county is expected to have the second lowest FTEN per capita in 2040. The forecast results indicate 4.4 FTEN per capita in 2040, an increase from the expected 4.2 FTEN per capita in 2020. The forecast results show an increased demand for FTEN. By 2040, the demand for FTEN is expected to be 138 FTEN. This represent an increase of 29 FTEN from 2020. The population in Eidsvoll is expected to increase with 5 122 inhabitants, reaching 30 980 inhabitants in 2040. Older adults are expected to represent 23.7% of the population, an increase of 7.7% from 2020.

As earlier mentioned, Asker is expected to have the third lowest FTEN per capita. The results suggest 4.6 FTEN per capita in 2040. This represents an increase from the expected 4.4 FTEN per capita in 2020.

With an expected demand of 107 FTEN and a population size of 22 877 inhabitants in 2040, makes Vestby the municipality with the fourth lowest FTEN per capita in 2040. The results suggest 4.7 FTEN per capita. This is an increase from 2020. The forecasting results suggest that Vestby will have 4.5 FTEN per capita in 2020.

The forecasting results indicate that Nittedal in Akershus county is expected to have the fifth lowest FTEN per capita in 2040. The interpretation of our results is an increase from 4.4 FTEN per capita in 2020 to 4.7 FTEN per capita in 2040. Our results indicate that Nittedal is expected to have an increase in demand for FTEN. The results suggest an increase from 106 in 2020 to 133 FTEN in 2040. The population is expected to increase from 24 264 in 2020 to 28 143 by 2040.

Table 14 FTEN- and demographic forecast for the municipalities with the lowest FTEN per capita in 2040. N=3*

	FTEN forecast			Demographic forecast		
Municipality	**FTEN 2020**	**FTEN 2040**	**Growth FTEN No. (%)**	**POP 2020**	**POP 2040**	**Growth POP No. (%)**
Eidsvoll	108	138	29 (27)	25 858	30 980	5 122 (19.8)
Vestby	82	107	26 (31.2)	18 099	22 877	4 778 (26.4)
Nittedal	106	133	26 (24.9)	24 264	28 134	3 870 (15.9)

* FTEN forecast and demographic forecast of Oslo and Asker can be found in table 5.

Table 15 FTEN per capita for the municipalities with the lowest FTEN per capita in 2040. N=3*

Municipality	**FTEN per capita 2020**	**FTEN per capita 2040**
Eidsvoll	4.2	4.4
Vestby	4.5	4.7
Nittedal	4.4	4.7

* FTEN per capita forecast of Oslo and Asker can be found in table 6.

6.0 Limitation

Since neither of the datasets was updated with the new municipality structure, the forecasting of future demand for nurses are based on old municipality structure. Due to municipality merges within the period of historical data, 54 municipalities had to be dropped, as it raised concern about the robustness of estimation results. Demand for FTEN for all municipalities, in addition to national demand, can easily be produced in the near future, as soon as Statistics Norway provide updated demographic forecasts that reflect the new municipality structure in Norway.

Mean Squared Error (MSE) was used to compare the residuals from two competing models: A model based on logarithmic transformation and maximum likelihood estimation, and a model where FTEN per capita was estimated by means of Weighted Least Squares. MSE is a popular measurement of accuracy due to its theoretical relevance in statistical modelling. MSE is useful when comparing different methods applied to the same dataset. However, MSE is sensitive to outliers. Additional methods, such as Mean Absolute Percentage Error could alternatively be applied for model assessment to see if we would reach the same conclusion on model choice (Hyndman & Koegler, 2006).

7.0 Discussion

In this thesis, we have estimated a functional form that relates FTEN to population size and composition while controlling for fixed unobserved factors at the municipality level and used our model estimate to predict future demand for FTEN under alternative demographic projections. Such predictions are always uncertain, and prediction results must be interpreted with caution. There are several factors that are likely to affect the demand for nurses, which are captured by our time-dependent effect. The future evolution of these factors is, of course, uncertain. Examples of uncertainties include how the future health care demands will be affected by increasing life expectancy, the future supply of informal care by families, and the evolution of service standards. Also, technological advance can, in general shift both demand and supply, and future equilibria are uncertain (Hjemås et al., 2019).

It is expected that both life expectancy and remaining life expectancy will continue to rise. The relation between increased life expectancy and the state of health gives rise to two alternative hypotheses. The hypothesis often referred to as*failures of success* (Gruenberg,1977) states that increased life expectancy will give more years with reduced ability to function and adverse health (Godager et al., 2018). The increase in life expectancy is interpreted as a result of medical advances that prolong the life of the chronically ill, but without significantly improving their state of health (Hjemås et al., 2019). This implies that medical advances allow people with chronic diseases to get an extension of life, while they are simultaneously getting an extension of life with disease and disabilities (Gruenberg, 1977). One case of this development is that the age-specific health condition is not affected by the elderly living longer. A simplified description of this case is that a given increase in life expectancy results in an equal increase in the number of sick years (Hjemås et al., 2019). People acquire diseases at the same time as before, even though life expectancy is increasing. Despite the goal of medical research is to diminish diseases, the *failures of success* hypothesis imply that the share of people with multimorbidities will rise. These increasingly prevalent chronic conditions represent the *failure of success* (Gruenberg, 1977). If we are facing a period with increasing rates of one or several chronic diseases due to higher life expectancy, it will require a considerable increase in the need for health services (Godager et al., 2018).

The alternative hypothesis often referred to as *compression of morbidity*, is a hypothesis of healthy ageing. This hypothesis states that higher life expectancy will give more healthy years, and the period with disabilities and poor health will impose a relatively short part of life (Godager et al., 2018). *Compression of morbidity* implies that the state of health is improving at every age. Not only will people live longer, but the number of years with bad health during their life remains the same, or declines (Hjemås et al., 2019). Functional impairments occur only in the last years of life, regardless of age (Godager et al., 2018). The hypothesis holds if chronic diseases can be postponed at a greater extent than the age of death. This allows the lifetime illness burden to be compressed into a shorter period of time and closer to the age of death (Fries et al., 2011). A rising life expectancy will, according to the *compression of morbidity* hypothesis, contribute to lowering the demand for HC-services.

How increasing life expectancy affects the relationship between health and illness in older ages has been widely discussed. Leknes et al. (2018) mentioned a relatively recent study by Chatterji et al. (2015) which has summarized international research on this area. They find that neither of the studies provides any clear support for any of the alternatives. Various health indicators seem to provide support for different options. More specifically, they find that if morbidity is measured as a functional limitation in everyday life, the hypothesis of *compression of morbidity* is supported. If morbidity is defined as living with a chronic illness, they find support for the theory of *failure of success*.

Holmøy et al. (2014) argue that it is far from obvious that improved health among the elderly will reduce the future need for health personnel. The health improvements themselves may partly depend on the use of health services. For example, a major contribution to the reduction in mortality during the last decades is a result of the development of better treatment methods for cardiovascular disease, and increased use of such treatments. The resulting health improvements and reduced mortality will lead to an increasing number of people reaching an age where the use of HC-services will be relatively high anyway. Further, lower mortality among 70- and 80-year-olds can lead to more people developing dementia in their last years of life. Treating patients with dementia is relatively resource demanding.

The future role of families in providing informal care is uncertain. Provision of family care can be divided between assistance within their own household and outside their own household. Cohabitants assist each other when they age. Assistance outside the household is highest for family care providers between 50-69 years, as this age-group have parents with assistance needs (Hjemås et al., 2019). Family care can replace much of the public care, especially within practical assistance. Residents in nursing homes require frequent help, care and supervision, whereas these services themselves are not complicated. This implies that family members can easily perform these services, either fully or partially (Holmøy et al., 2014).

The family pattern has changed considerably since the 1950s and 60s. One of the main features of the historical development is that public care has replaced much of the family care for children, the elderly and the sick. This is a result of increased labour participation among women. The Norwegian families are different from how they were a generation ago, and future family patterns can change in several different directions. On the one hand, the proportion of older people with partners is increasing. Living with someone can have a positive health impact alone, but also combined with the possibility of family care within the household. Opposite effects can appear from the expected increase in the number of childless men. Here, the main impact is the decrease in opportunities for family care, which will hence increase the demand for public provision of care services. Another leading factor is the increased migration and centralisation, which makes children live far from their parents and reduce the ability to provide family care (Hjemås et al.,2019).

Holmøy et al. (2014) describe several factors pointing in the direction of modest changes in the provision of family care. Fewer housewives, more one-person households as result divorces and breakups, lower fertility rates and higher alternative costs associated with transferring hours from formal to the informal sector. This suggests that family care is not expected to increase substantially from the current level. This indicates that the future increased demand for HC-services will mainly be provided by the public sector.

Whether there will be an improvement in service standards, defined as full-time equivalent per user, is uncertain. People’s expectations to the health sector increases in line with income growth and standard of living (Helse- og omsorgsdepartementet, 2016). This suggests that service standards could continue to increase in the future. The future demand for healthcare personnel will be affected by both increasing service standards and by the expected demographic shift, causing the demand to increase substantially. It has been discussed that the resource challenges caused by demographic development can be addressed by controlling the service standard (Theie et al., 2017). On the one hand, it seems realistic to assume that the standard of HC services will continue to improve as per capita real growth in consumption continues to rise (Holmøy et al., 2014). In addition, it would represent a violation of historical development if there were no improvements in service standards. On the other hand, the great impact of the demographic development, together with increased pressure on public finances, indicates that the opportunities for further standard improvements are clearly smaller than what took place from around 1970 until the early 2000s (Hjemås et al., 2019).

The health sector is characterized by technological advance, and new technology is one of the pillars of future HC-services. Not only does technology contribute to better quality and patient autonomy, but current tasks can be solved with far less human resources (Helse- og omsorgsdepartementet, 2015). The use of telemedicine and eHealth solutions is increasing. While providing easier access to healthcare services for patients, it also improves efficiency due to time-saving for healthcare personnel. This suggests that more patients can be treated, with less human resources. On the other hand, new technology and treatment methods can generate new needs and hence allow more patients to be treated (Helse- og omsorgsdepartementet, 2011). This will, in turn, reinforce the dependence and demand for nurses. In either way, a prerequisite for utilising the technology in the best possible way requires formal preparation, training and new skills, both among nurses and patients (Lie, 2019).

The impact, but also the uncertainty of these factors on future demand for nurses concern the entire population. It is, however, a great deal of uncertainty that is related to the specific municipality. The uncertainty is related to the factors captured by the municipality specific intercept in our model. By implementing fixed effects, we assume that the unobserved factors in each municipality are constant over time. The main assumption of predictions is the continuation of past patterns in the future. This is a strong assumption. There are several factors within each municipality that can change towards 2040, and one may argue that the degree of uncertainty become larger the further into the future we look (Leknes et al., 2019).

The municipality specific intercept captures several unobserved factors. A municipality can, for instance, have generous funding, a large share of inhabitants living in nursing homes and municipality council who prioritise elderly health. This would lead to high projected demand for nurses, due to the assumption of the continuation of past patterns. Such factors explain why some municipalities have a high predicted FTEN per capita, while other municipalities with similar demography have a low FTEN per capita. Bykle municipality has the second-highest projected FTEN per capita in both 2020 and 2040. This is related to the municipality dummy, which is the second highest (after Modalen) among the 369 municipalities. Bykle has a large hydropower reservoir which is a source of income that most municipalities do not have. The generous funding situation can explain the high projected FTEN per capita. Taxation rules for hydropower plants can be revised by policymakers. This implies that Bykle’s source of income is uncertain. This is an example that the unobservable factors that affect demand may change over time. Another example is the change of Municipality Councils. Members of the Municipality Council are elected every fourth year. Their decisions likely reflect their values and prioritisation. Since the Municipality Council changes regularly, the prioritisations and delegation of resources to healthcare may change with time.

Additionally, the forecasting model assumes that the age-specific utilisation rates are constant across time. These might, however, change. Health technology may assist younger patients and reducing the demand for nurses for this group. If younger patients become relatively easier to provide care for, adults and older adults will consequently become more resource demanding, assuming that the age groups sum to unity. The functional form with a constant return to scale may also change with time. This means that it may not be a proportional relationship between increasing population size and demand for nurses in the future.

Not only do our predictions depend on model assumptions and assumptions about the unobservable, but also on assumed future values of the regressors. The forecasts are based on the population predictions provided by Statistics Norway. Similar to our predictions, the future population and age distribution are uncertain. There may be surprises in the near or distant future that are difficult or impossible to predict today. This includes sudden changes in immigration, noteworthy changes in the desire for children or sudden pandemics, such as Covid-19. The various consequences of the Covid-19 pandemic and the subsequent economic uncertainty are likely to influence future demography. The 2020 national population projections have assumed particular low immigration in 2020 and 2021 due to the travel restrictions and other circumstances related to the Covid-19 pandemic. There is also uncertainty related to future fertility rates. Research on the Spanish flu pandemic from 1918 has shown that health crises tend to reduce fertility, at least in the short term. Fertility in Norway is currently at a historically low level. Financial uncertainty can also help to reduce, or at least delay, fertility. Emigration from Norway is also likely to be affected. Norway has a government pension fund (Statens pensjonsfond utland) that reduce many of the unfortunate financial consequences of the pandemic. It is likely that less people will emigrate from Norway, either because the country of destination is more affected by the pandemic, or because it is safer to remain in Norway during uncertain times (Gleditsch et al., 2020).

The same implications of the Covid-19 pandemic are likely to influence future municipality demographics. This may lead to a diversion between the forecasted population projections used in this thesis and future municipal demographics. This will, in turn, affect our forecasting results, as population demographics are used as the main driver in demand for nurses. As mentioned by Gleditsch et al. (2020), the implications of this pandemic are mainly associated with the coming years. It is, therefore, reasonable to believe that the impacts of the Covid-19 pandemic on population demographics will not be as prevalent in 2040 as in the coming years. The implications of the Covid-19 pandemic, does, however, illustrate both the general uncertainty of forecasting and the uncertainty related to the use of assumed future values of the regressors to predict future values of FTEN.

Suggestions for further research

Recruitment of nurses is driven by the need for replacing nurses that retire or resign and by the increasing demand caused by population demographics and other factors affecting demand. The predicted development of FTEN in this text reflects net changes. This net changes in FTEN reflect the change in FTEN demand in each municipality, ignoring nurse turnover caused by retirement, nurses relocating or nurses resigning. The annual turnover is likely to vary over municipalities, according to for instance the age composition of nurses employed by the municipality. Information about turnover would be necessary to translate the net changes reported in this text into information about the actual need for hiring additional nurses each year.

Comparing the forecasting results with previous similar work would provide an indication of the accuracy of the model. I have been in contact with Geir Hjemås, who is frequently mentioned in this thesis. Hjemås is working on a project forecasting nurses at a regional level. Due to the complications with Covid-19, there has been a delay in their work. When his report is published, it is possible to compare the results, by summing municipalities to regions. Short term comparison is available when the 2020 KOSTRA number is released by Statistics Norway. This will allow us to compare our forecasting results to actual full-time equivalent numbers in 2020.

8.0 Conclusion

The objective of the thesis is to forecast future demand for full-time equivalent nurses (FTEN) in 369 Norwegian municipalities. The forecasts use future population size and composition as the main driver for future demand for FTEN. The municipality population projections show a great diversity in population growth and demographic composition. In particular, the proportion of older adults is expected to vary between municipalities. Since the use of Municipality Health Services (MHS) increases with age, give reasons to believe that the demand for MHS to differ between municipalities. FTEN are an important part of the municipalities nursing and care services. The larger the nursing and care services, the larger the volume of FTEN becomes.

Our main findings show a rising national demand for FTEN within the MHS. Given the assumption that the reference alternative (M) is most similar to a population prognosis, and fixed time-dependent effect provides a more plausible long-run forecast, our forecast suggests that the 369 municipalities will require 40 005 FTEN in 2040. This represents a percentage increase of 16.3% from the expected number of FTEN in 2020.

Our forecasting results show large municipality differences in future demand for FTEN. Between 2020-2040, our forecast results suggest that the absolute growth in FTEN is expected to range from -9 FTEN to 748 FTEN. The relative change in demand is expected to range from -39% to 64.5%. Most municipalities are expected to experience increasing demand in FTEN. However, the results indicate that as much as 33% of the municipalities are expected to experience a decline in demand for FTEN between 2020-2040. Typically, medium to large municipalities is expected to have a rising demand for FTEN, while small municipalities in the districts are expected to have declining demand. The demand for nurses is expected to follow the population forecast. The municipalities with the largest absolute and relative population growth are roughly the same municipalities who are expected to have the highest absolute and relative growth in demand for FTEN. The same concerns municipalities with the largest decline in absolute and relative population size. The forecast results follow the assumption that there is a proportional relationship between population size and demand for FTEN.

There are large differences between municipalities in terms of full-time equivalent nurse per 1000 capita (FTEN per capita). Our results show that smaller municipalities are expected to have the highest projected FTEN per capita, while larger municipalities are expected to have the lowest FTEN per capita. The differences in FTEN per capita can be a result of differences in age-composition, where a higher share of older adults is expected to drive the demand for nurses upwards. However, a large amount of these differences lies within the unobserved heterogeneity, captured by fixed effects. Furthermore, not only is it differences between municipalities, but also differences within the same municipality over time. Most municipalities are expected to have a higher FTEN per capita in 2040. The interpretation of this finding is a changing population composition with a larger share of older adults.

These forecast results can be applied by each municipality to prepare for their future demand for FTEN. Ås municipality, who have the highest expected relative increase in FTEN can consider implementing measures to meet the expected demand. Given the relatively low share of older adults, these measures do not necessarily relate to services demanded by the older generation, but services demanded by the general public. This imply that not only are the extension of the future demand important, but also the expected type of nursing services demanded, given the population composition. The rising national demand also requires action from the central government, in terms of extending educational capacity and other measures that tries to seek to meet the increasing demand.

Whether the assumptions made for the forecasting holds in the future, is uncertain. The assumption of constant unobserved heterogeneity across time periods is a strong assumption. Several factors within each municipality can change over time. Moreover, the forecasting has assumed that Statistics Norway's population projections are correct. A good example of sudden changes that may change future demographics is the potential after-effects of Covid-19 pandemic.

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Appendix

Table of contents

Tables and figures

A. Excluded municipalities

The government implemented the Municipality Reform in 2014. From 2014 to 2020, 428 municipalities were reduced to 356 municipalities, and 19 counties were reduced to 11 counties. During the period 2014 and 2020, several of these municipalities and county merges took place. The data used in the thesis have applied municipality structure 2018-2019. At the time, six municipality merges had already taken place, and Nord-Trøndelag and Sør-Trøndelag county were merged to Trøndelag county. Because these municipalities only contained data for certain years, and not for all 12 years (2008-2019), led to the exclusion of 54 municipalities.

Trøndelag county (-2018)

- In 2018, Sør-Trøndelag county and Nord-Trøndelag country were merged to one county, Trøndelag county. The new Trøndelag county consisted of all municipalities previously in Sør and Nord-Trøndelag county, representing 48 municipalities. There is no information about Trøndelag county before 2018 and hence ten years with data are missing. This excludes all 48 municipalities from the dataset.

Rindal Municipality (-2019)

- In 2019, Rindal municipality became part of Trøndelag county. This makes Rindal municipality miss data for 2019.

Sandefjord municipality (2017-2019)

- In 2017, Andebu 0719, Stokke 0720 and Sandefjord 0706 were merged to one municipality, Sandefjord 0710. This means that data is available for Sandefjord 0710 between 2017-2019 and information is lacking between 2008-2016.

Færder municipality (2018-2019)

- Nøtterøy 0722 and Tjøme 0723 were merged to one municipality, Færder 0729, in 2018. Information about Færder 0729 is only available between 2018-2019, leading to missing information between 2008-2017.

Holmestrand municipality (2018-2019)

- Hof 0714 and Holmestrnad 0702 was merged to Holmestrand 0715 in 2018. Information about Holmestrand 0715 is only available for 2018- 2019 while missing for 2008-2017.

Larvik municipality (2018-2019)

- Larvik 0709 and Lardal 0728 was merged into Larvik 0712 in 2018. Information about Larvik 0712 is only available between 2018-2019 while missing for 2008-2017.

B. Age interval groups

The initial dataset had 21 age groups, composed of five-years age-interval. These age-intervals were later merged into three age groups.

Table 16 Explanatory variables

Age-group	Year	Age-interval	Share of pop. size (%)
Children	0-19	1-5	19
Adults	20-64	5-13	43
Older adults	65-100+	14-21	38

Table 17 Five-year age-interval

Age group	1	2	3	4	5	6	7	8	9	10
Age-interval	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49

Age group	11	12	13	14	15	16	17	18	19	20	21
Age interval	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-99	>100

C. Weighted Least Square with specification testing

Specification tests were also applied to a model FTEN per capita was estimated by means of Weighted Least Squares (WLS). This was done in order to find the model that provided the best fit. We started with the same set of variables: Children (0-19), adults (20-64) and older adults (65-100+) per gender, giving a total of six independent variables.

The variables are weighted by the square root of the numbers of observations that are used in the estimation of the averages. Since the variables are municipality averages, all the variables are multiplied with the squared root of the number of the inhabitants in the specific municipality.

Weighting can easily be computed in Stata with analytical weights and specifying with the number of people in a municipality in a specific year. Analytical weights work as if each variable and the constant are multiplied by the square root of the observations and then preformed an ordinary least square regression. Analytical weights are often applied for correction for heteroscedasticity when both the dependent and the independent variables are means or proportions (Woolridge, 2016)

Fixed or random effect

The result of the Hausman test was significant (p-value 0,00), implying that we reject the null hypothesis in favour of a fixed-effect method. This was similar for the model with logarithmic transformation.

Year dummies or linear trend

The likelihood ratio test (lrtest) guided our decision whether to use year-dummies or linear trend. The results indicate that year-dummies had significant better explanatory power (p-value 0,0087) than a linear trend with squared term. This was contrary to the model with logarithmic transformation.

Clustered municipalities

The municipalities were grouped into clusters to account for the unexplained variation in the outcome that may be correlated across time. By clustering, we get robust standard errors.

Gender effects

Under the assumption of gender-specific effects, the number of independent variables becomes six in total, with three age groups per gender. After clustering and adding a linear trend with squared year, the regression results revealed that the confidence intervals for men and women overlapped for each age-group. This implies that the difference between each age-group is not statistically significant, which gives reasons to test the assumption of equal gender effects.

Due to clustered municipalities, the log-likelihood test can no longer be used. Instead, the Wald test were used. I ran a simultaneous test on the assumption of equal gender effects across all three age groups (H_0) over the alternative of unequal gender effects (H_1). The p-values (Children: 0.2782. Adults: 0.1531. Older adults: 0.5944) are consistently so high that we cannot reject the null hypothesis of equal gender effects for the three age groups. The conclusion of the Wald test is that we may assume equal gender effects for all three age groups, thereby reducing the number of independent variables from six to three. The specification tests with Weighted Least Squares resulted in a regression model with municipality level fixed effects, year-dummies, clustered municipalities and equal gender effects.

Comparing the errors of Weighted Least Squares and logarithmic transformation

To find the model that provided the best fit, specification tests were applied to two competing sets of models: Models based on the logarithmic transformation and maximum likelihood estimation, and Models where FTEN per capita was estimated by means of with Weighted Least Squares (WLS). The MSE tells us the average squared difference between the predicted FTEN and the observed FTEN on a national level. The goal is to have a model where the mean is as low as possible, indicating a low deviation between the predicted and the observed value. A regression model that is well-fitted gives predicted values that are close to the observed data values. The model based on MLE and log-transformed data provided a lower MSE. I, therefore, proceed with the MLE and log transformation.

Table 18 Mean Square Error

Model	Mean square error
Weighted Least Square	89.89
Maximum Likelihood Estimation	70.09

D. Regression estimates and observed values for 2008-2019

The regression estimates allow us to compare results to the observed values. This gives an indication of the models' ability to forecast its own values. In the table below, the estimation results are summed up to the national number of FTEN. As seen, the predicted FTEN are close to the observed FTEN in the period 2008-2019.

Even though this is not an ex-ante prediction with a validation period, it still allows assessing the fit of the model. Ex-ante prediction leaves out historical data for one year and projects the data for that year. This allows to see the ability of the model to project future years. Nevertheless, a good ex-ante prediction is not a guarantee for a good ex-post forecast.

Table 19 Observed and predicted national numbers of FTEN in 2008-2019

Year	Observed FTEN	Predicted FTEN	Deviation
2008	22 871	22 787	84
2009	23 955	23 817	137
2010	24 849	24 897	-48
2011	25 924	26 003	-79
2012	27 306	27 154	152
2013	28 150	28 284	-134
2014	29 021	29 366	-345
2015	30 168	30 422	-254
2016	31 424	31 414	10
2017	32 782	32 377	405
2018	33 824	33 266	558
2019	34 761	34 084	677

E. Statistics Norway demographic forecast

Population composition in 2020 and 2040 for municipalities mentioned in the result section

Table 20 Forecasted age-composition for the ten most populated municipalities in 2040. N=10

	2020			2040		
Municipality	**Children No. (%)**	**Adults No. (%)**	**Older adults No. (%)**	**Children No. (%)**	**Adults No. (%)**	**Older adults No. (%)**
Oslo	145 963(21.2)	453 602(66)	87 761 (12.8)	161 488(19.8)	509 887(62.5)	144 139(17.7)
Bergen	63 070 (22.4)	173 785(61.7)	44 595 (15.8)	66 298 (21.3)	176 329 (56.8)	68 021 (21.9)
Bærum	32 646 (25.8)	73 094 (57.7)	21 029 (16.6)	33 119 (23.1)	77 501 (53.9)	33 053 (23)
Stavanger	32 013 (24.2)	80 641 (61)	19 481 (14.7)	30 720 (22.2)	76 988 (55.6)	30 702 (22.2)
Kristiansand	23 039 (24.3)	57 161 (60.3)	14 607 (15.4)	25 900 (23.6)	60 357 (55)	23 540 (21.4)
Fredrikstad	18 708 (22.6)	48 326 (58.5)	15 578 (18.9)	20 990 (21.5)	52 517 (53.5)	24 567 (25)
Sandnes	20 958 (27)	46 669 (60)	10 103 (13)	23 391 (24.3)	54 335 (56.4)	18 657 (19.4)
Tromsø	17 600 (22.9)	48 488 (63.1)	10 792 (14)	17 366 (21.2)	46 866 (57.1)	17 854 (21.8)
Drammen	16 052 (22.9)	41 610 (59.4)	12 373 (17.7)	17 577 (21.4)	45 957 (56)	18 512 (22.6)
Asker	16 068 (26.1)	35 271 (57.4)	10 155 (16.5)	16 460 (24.1)	35 579 (52)	16 325 (23.9)

Table 21 Forecasted age-composition for the municipalities with the largest absolute decline in FTEN. N=5

	2020			2040		
Municipality	**Children No. (%)**	**Adults No. (%)**	**Older adults No. (%)**	**Children No. (%)**	**Adults No. (%)**	**Older adults No. (%)**
Vanylven	597 (19.5)	1 553 (50.8)	907 (29.7)	361 (16.7)	819 (38)	976 (45.3)
Kvinnherad	3 150 (24.2)	6 988 (53.6)	2 905 (22.3)	2 497 (20.6)	5 717 (47.3)	3 881 (32.1)
Årdal	1 039 (21.1)	2 915 (56.4)	1 217 (23.5)	6 88 (16.2)	1 914 (45)	1 650 (38.8)
Saltdal	1 023 (22)	2 479 (53.3)	1 149 (24.7)	747 (18.5)	1 923 (47.5)	1 378 (34)
Meløy	1 441 (23)	3 451 (55)	1 381 (22)	1 039 (19.4)	2 519 (46.9)	1 810 (33.7)

Table 22 Forecasted age-composition for the municipalities with the greatest relative growth in FTEN. N=5

	2020			2040		
Municipality	**Children No. (%)**	**Adults No. (%)**	**Older adults No. (%)**	**Children No. (%)**	**Adults No. (%)**	**Older adults No. (%)**
Ås	4 986 (23.5)	13 285 (62.7)	2 920 (13.8)	8 964 (26.3)	20 057 (58.9)	5 008 (14.7)
Våler	1 516 (26.3)	3 414 (59.2)	839 (14.4)	2 004 (22.7)	5 179 (58.7)	1 640 (18.6)
Hobøl	1 330 (22.9)	3 589 (61.8)	893 (15.4)	1 756 (21.1)	4 895 (58.7)	1 682 (20.2)
Hemsedal	585 (23.2)	1 534 (60.9)	399 (15.8)	764 (20.8)	2 194 (59.8)	711 (19.4)
Ullensaker	10 023 (25.8)	23 587 (60.7)	5 233 (13.5)	12 262 (23.1)	30 285 (57.1)	10 493 (19.8)

Table 23 Forecasted age-composition for the municipalities with the largest relative decline in FTEN. N=5

	2020			**2040**		
Municipality	**Children No. (%)**	**Adults No. (%)**	**Older adults No. (%)**	**Children No. (%)**	**Adults No. (%)**	**Older adults No. (%)**
Loppa	135 (14.6)	509 (55.2)	278 (30.2)	65 (11.1)	254 (43.3)	268 (45.7)
Røst	91 (17.7)	293 (57)	130 (25.3)	40 (11.5)	125 (36)	182 (52.5)
Kvalsund	177 (17.5)	520 (51.5)	312 (30.9)	81 (11.6)	315 (45)	304 (43.4)
Vanylven	597(19.5)	1553 (50.8)	907 (29.7)	361 (16.7)	819 (38)	976 (45.3)
Engerdal	243 (19.2)	653 (51.5)	371 (29.3)	147 (15.5)	381 (40.2)	419 (44.2)

Table 24 Forecasted age-composition for the municipalities with the highest FTEN per capita. N=5

	2020			**2040**		
Municipality	**Children No. (%)**	**Adults No. (%)**	**Older adults No. (%)**	**Children No. (%)**	**Adults No. (%)**	**Older adults No. (%)**
Modalen	101 (26.4)	207 (54)	75 (19.6)	86 (22.4)	182 (47.4)	116 (30.2)
Bykle	205 (21)	618 (63.4)	151 (15.5)	211 (19.3)	581 (53)	304 (27.7)
Utsira	50 (23.7)	1 17 (55.5)	44 (20.9)	91 (42.9)	62 (29.2)	59 (27.8)
Sirdal	468 (25.2)	1 014 (54.7)	372 (20.1)	463 (23.9)	981 (50.6)	494 (25.5)
Kvæfjord	640 (22)	1 595 (54.9)	668 (23)	653 (23.5)	1 274 (45.9)	849 (30.6)

Table 25 Forecasted age-composition for the municipalities with the lowest FTEN per capita. N=3*

	2020			**2040**		
Municipality	**Children No.(%)**	**Adults No.(%)**	**Older adults No.(%)**	**Children No.(%)**	**Adults No.(%)**	**Older adults No.(%)**
Eidsvoll	6303 (24.4)	15415 (59.6)	4140 (16)	6749 (21.8)	16878 (54.5)	7353 (23.7)
Vestby	4741 (26.2)	10302 (56.9)	3056 (16.9)	5453 (23.8)	12448 (54.4)	4976 (21.8)
Nittedal	6481 (26.7)	14201 (58.5)	3582 (15.8)	6498 (21.1)	14907 (53)	6729 (23.9)

* Demographic forecast of Oslo and Asker can be found in table 3.

F. Alternative forecasting results

F.1 Forecasting results for low and high population growth with fixed time-dependent effect (TDE)

Table 26 FTEN forecasting results with low pop. growth and fixed time-dependent effect (TDE). N=369

	2020		2040	
	Median	**[Min-Max]**	**Median**	**[Min-Max]**
FTEN	42	[3,2822]	44	[2,3374]
FTEN/1000	9.6	[4.1, 25.5]	9.7	[4.4,26.5]

	Median	[Min-Max]
Growth FTEN NO.	0.7	[-17,552]
Growth FTEN %	2.2	[-42, 55.8]

Table 27 FTEN forecasting results with high pop. growth and fixed time-dependent effect (TDE). N=369

	2020		2040	
	Median	**[Min-Max]**	**Median**	**[Min-Max]**
FTEN	43	[3, 2852]	51	[2, 3870]
FTEN/1000	9.7	[4.1, 25.3]	9.8	[4.4, 26.7]

	Median	[Min-Max]
Growth FTEN NO.	6	[-8, 1018]
Growth FTEN %	15.7	[-33.6, 75.6]

F.2 Forecasting results for low, medium high population growth with increasing time-dependent effect (TDE)

Table 28 FTEN forecasting results with low pop. growth and increasing time-dependent effect (TDE). N=369

	2020		2040	
	Median	**[Min-Max]**	**Median**	**[Min-Max]**
FTEN	43	[3,2866]	44	[2,3387,]
FTEN/1000	9.6	[4.1, 25.5]	9.7	[4.4, 26.5]

	Median	[Min-Max]
Growth FTEN NO.	0.3	[-19,520]
Growth FTEN %	1	[-42.7, 54]

Table 29 FTEN forecasting results for medium pop. growth and increasing time-dependent effect (TDE). N=369

	2020		2040	
	Median	**[Min-Max]**	**Median**	**[Min-Max]**
FTEN	43	[3, 2884]	47	[2, 3600]
FTEN/1000	9.8	[4.2, 25.9]	9.8	[4.4, 26.7]

	Median	[Min-Max]
Growth FTEN NO.	2	[-11, 717]
Growth FTEN %	6.7	[-39.7, 62.6]

Table 30 FTEN forecasting results with high pop. growth and increasing time-dependent effect (TDE). N=369

	2020		2040	
	Median	**[Min-Max]**	**Median**	**[Min-Max]**
FTEN	43	[3,2897]	51	[2,3884]
FTEN/1000	9.8	[4.2, 25.9]	9.9	[4.4, 26.8]

	Median	[Min-Max]
Growth FTEN NO.	6	[-8, 987]
Growth FTEN %	14.3	[-34.3, 73.5]

G. Growth in FTEN for municipalities mentioned in the results section

Reference alternative with fixed time-dependent effect. All municipalities start at 1 FTEN to illustrate the diversity in growth.

Figure 4 FTEN growth (2020-2040) for the ten most populated municipalities in 2040. N=10

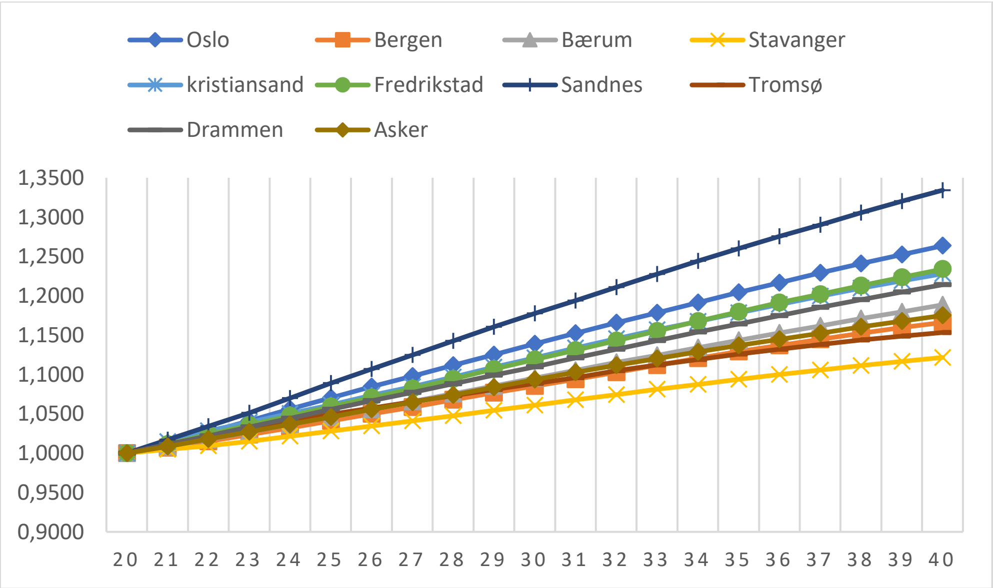

Figure 5 FTEN growth (2020-2040) for the municipalities with the highest and lowest absolute change in FTEN. N=10

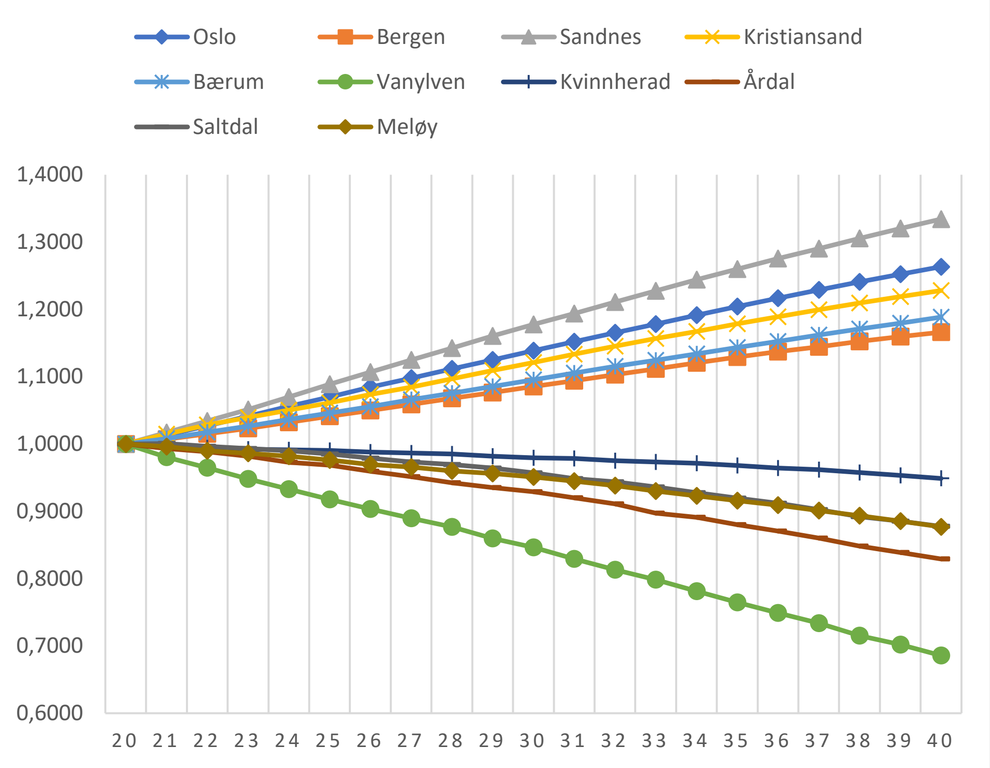

Figure 6 FTEN growth (2020-2040) for the municipalities with the highest and lowest relative change in FTEN. N=10

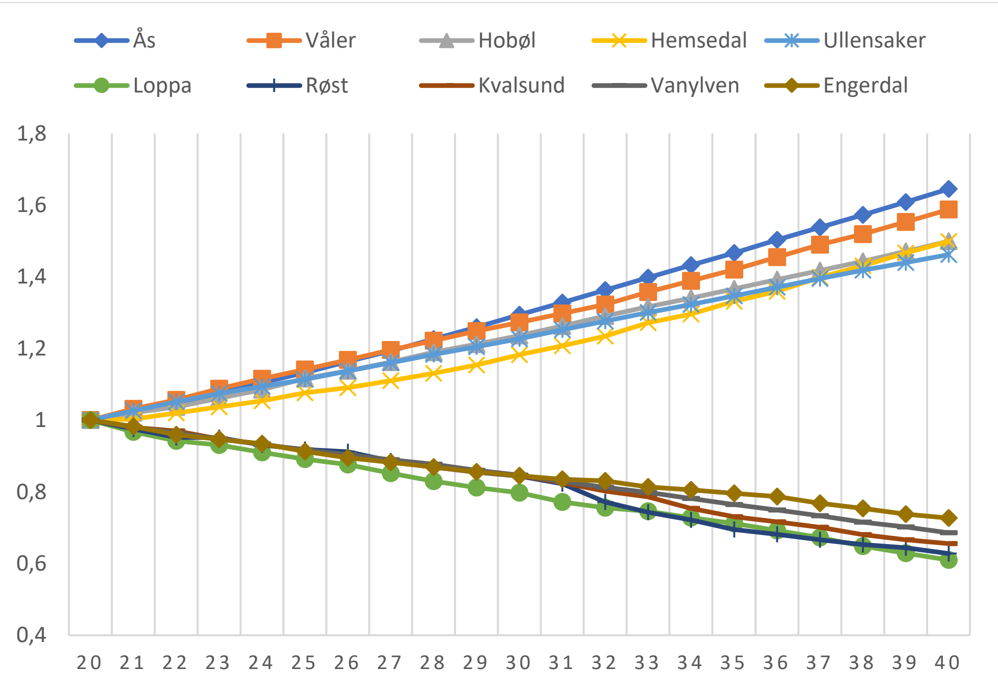

Figure 7 FTEN growth (2020-2040) for the municipalities with the highest and lowest FTEN per capita in 2040. N=10

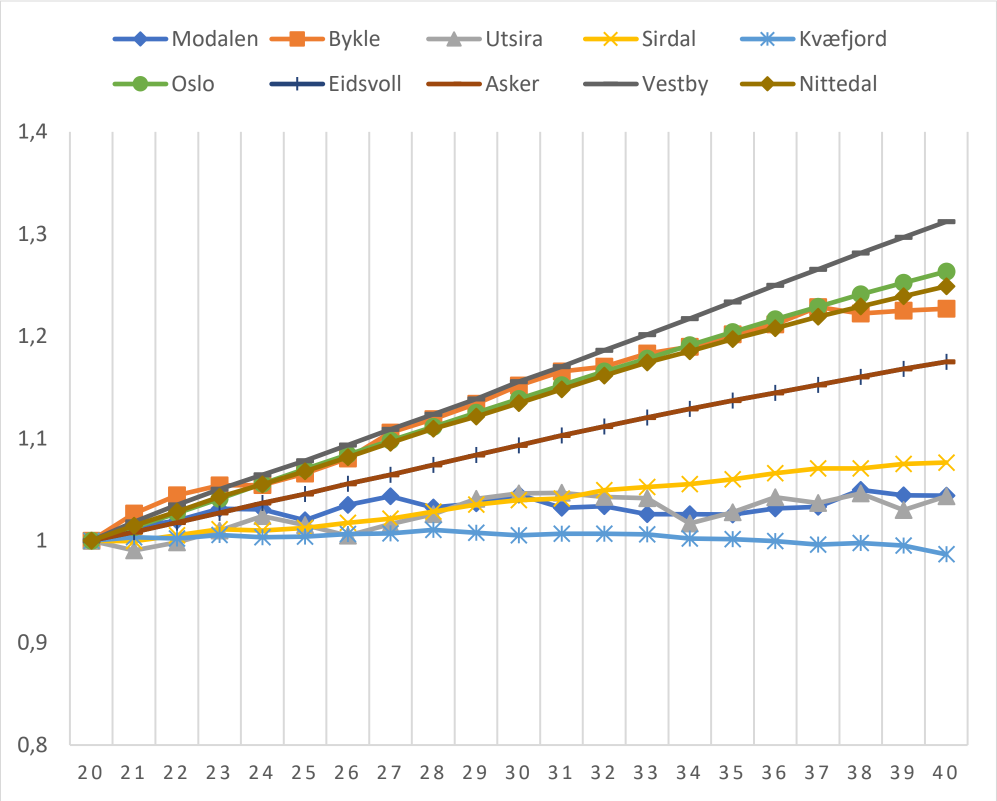

Figure 8 FTEN relative growth for all municipalities, weighted by population size. N=369