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The association between multimorbidity and primary healthcare utilization in South-Eastern Norway Regional Health Authority

A cross-sectional study using register data

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Abstract

Background: Multimorbidity is one of the greatest health-related challenges worldwide. Multimorbidity is associated with several outcomes, such as lower quality of life and higher disability. The main aim of this study was to explore the association between multimorbidity and the use of healthcare services in primary healthcare.

Method: In a register-based, cross-sectional study we extracted data on 6 diseases and on the utilization of primary healthcare. Data were obtained from Norwegian national administrative and health registers and provided to the researchers by the Norwegian Institute of Public Health (NIPH). The study population consisted of people aged ≥ 65 years old, living in the South-Eastern Norway Regional Health Authority in Norway in 2016. We analyzed our data according to the number of morbidities, sex, age, marital status, and county of residents. We defined multimorbidity as the presence of two or more diseases. The association between multimorbidity and primary healthcare utilization was explored using Poisson regression.

Results: The study population included 422 964 individuals. First, this study found that the prevalence of multimorbidity was 13.9 % among patients aged ≥ 65. Second, age was found to be the strongest predictor of multimorbidity. Third, primary healthcare consultations were found to significantly increase among people with multimorbidity (≥ 2 diseases) versus people with zero or one of the predefined conditions. The number of diseases seemed to be approximately linear associated with the number of primary care consultations. The effect of multimorbidity in healthcare utilization occurred independently of age, marital status, gender, and county of residents. Forth, there were significant differences in healthcare utilization across counties in South-Eastern Norway Regional Health Authority. Telemark was the region with the highest utilization rates and Oslo with the lowest.

Conclusion: Multimorbidity was associated with a significant increase in primary healthcare utilization.

Abbreviations

ADL	Activities of Daily Living
ACG	Adjusted Clinical Groups
ANOVA	Analysis of Variance
BMI	Body Mass Index
SSB	Central Population Register
SKDE	Centre for Clinical Documentation and Evaluation
CIRS	Cumulative illness Rating Scale
HRQoL	Health-related Quality of Life
IRR	Incidence Rate Ratio
ICED	Index of Coexistent Disease
ICD-10	International Classification of Diseases
ICPC-2	International Classification of Primary Care
NICE	National Institute for Health and Care Excellence
HELFO	Norwegian Health Economics Administration
HUNT	Norwegian Health Survey
NIPH	Norwegian Institute of Public Health
OR	Odds Ratio
REK	Regional Committees for Medical and Health Research Ethics
KUHR	Register of Norwegian Control and Payment of Health Reimbursement
South-Eastern Norway RHA	South-Eastern Norway Regional Health Authority

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1 Introduction

Multimorbidity is one of the greatest health-related challenges worldwide (1). People with several chronic conditions have higher mortality (2, 3), reduced quality of life (4-6), and increased use of healthcare services (7, 8). Furthermore, living with multimorbidity is associated with a higher likelihood of disability, early retirement, and increased sick leave days (9-11). It is essential to assess the relationship between multimorbidity and healthcare utilization to achieve effective and efficient management of multimorbidity (1). The care models predominating in European countries are characterized by a single-disease focus and are partly inappropriate for responding to the diverse and comprehensive needs of people with multimorbidity (12). There is a need to produce better outcomes for individuals with multimorbidity and strengthen care organizations and health systems in Europe (12). The present study reviews the prevalence of multimorbidity and the association between multimorbidity and healthcare utilization between counties within the South-Eastern Norway Regional Health Authority (RHA).

1.1 Defining and measuring multimorbidity

There is no international consensus regarding the best way to define and measure multimorbidity (13). Hence, carrying out and interpreting research, comparing findings across populations, and developing guidelines and interventions are complex (14). The National Institute for Health and Care Excellence (NICE) commented on this problem of varying measures being used, which recently developed a multimorbidity guideline (15).

A review of prevalence studies of multimorbidity found estimates ranging from less than 5 % to more than 95 %, often due to the differences in the definition of multimorbidity (16). A systematic review of 6 included reviews aimed to pool the findings of systematic reviews examining definitions and measures of multimorbidity (14). They found that multimorbidity was often defined as the presence of multiple diseases, most commonly with a minimum of diseases (cut-off) of two or more (14).

To assess the impact of multimorbidity, we need to measure it (17). Measures of multimorbidity broadly fall into two categories (17). The first category is simple counts of diseases in each individual (based on either patient self-report or clinician assessment). The second category is indices to assess morbidity burden that differentially weight a range of conditions, using weights based on mortality, severity, or likely resource utilization (17). The measures included in the different reviews in the study from Johnston et al. (14) had both disease counts and weighted measures such as the Carlson Index, the Cumulative Illness Rating Scale (CIRS), the Index of Coexistent Disease (ICED), the Adjusted Clinical Groups (ACG) system and the Duke Severity of Illness. A weighted measure validated for the outcome of interest should be chosen if these exist. However, use of disease count is appropriate when evidence is weak or where multiple outcomes are being considered (14). Overall, and most importantly, the researchers are explicit about the definitions and measure(s) and give a rationale for included and excluded conditions (14).

These findings are supported by Huntley et al., who did a systematic review (17). The researchers aimed to identify measures of multimorbidity burden suitable for use in research in primary care. In addition, they investigated the validity of anticipated associations with patient characteristics, process measures, and health outcomes. They found that evidence is strongest for the ACG System, the Charlson index or disease counts in relation to care utilization. About costs, the ACG system was recommended, the Charlson index with regard to mortality, and disease counts or the the Charlson index in relation to quality of life. Simple counts of diseases or medications perform almost well as complex measures in predicting most outcomes. Combining measures can improve validity (17).

The Norwegian Directorate of Health has recently published a report about people living with several chronic conditions (18). They underline the importance of having a common ground in the discussion of multimorbidity. Their work aiming for a valid and useful definition found substantial differences in multimorbidity prevalence, given different definitions of multimorbidity. They recommend a definition of “complex multimorbidity,” which is three or more chronic conditions in other organ systems (18). The reasoning behind this is that the definition maintains the balance of being both sufficiently wide for including many people with chronic conditions and sufficiently narrow to account for those with the largest needs for healthcare services. However, this definition is developed using codes from the National Classification of Diseases (ICD-10) from specialist care, making it less applicable when investigating multimorbidity in the prevalence of primary care.

1.2 Prevalence of multimorbidity

The different definitions and measures of multimorbidity will provide different prevalence rates across studies. Systematic reviews investigating the variation in the estimated prevalence of multimorbidity (16, 19) have found similar results. That is, the number of baseline conditions included in the definition and the mean age of the study population are strong predictors and positively associated with the estimated prevalence of multimorbidity. Another factor influencing multimorbidity prevalence is the choice of cut-off in the definition (16). A cut-off of two or more diseases seems to be the most common, but some studies also operate with three or more (20), or even four or more diseases (21). The higher cut-off, the lower multimorbidity prevalence (16).

Furthermore, data collection methods are suggested to impact multimorbidity prevalence. Self-reported data on the number and the types of conditions may cause a lower prevalence than using administrative databases or registers (22). However, there is not found any statistical significance between the methods for data collection and multimorbidity prevalence (19).

Living with two or more medical conditions at the same time is becoming increasingly common (23). A cross-sectional study investigating multimorbidity trends in the Unites States (US) adults aimed to determine the prevalence of multimorbidity and to examine changes in prevalence during the last 25 years (24). There was found a significant change in the surveys spanning from 1988 to 2014. From 1988-1994, the overall prevalence of adults age < 65 living with two or more morbidities was 45.7 % vs 59.6 % in 2013-2014. For elderly adults over the age of 65, the respective numbers were 83.5 % vs 91.8 % (24). In Europe, an estimated 50 million people live with multimorbidity (12). Surveillance data on chronic diseases in Scotland, United Kingdom (UK), estimate around 25 % of their adult population to be living with multimorbidity (25). By 2035, approximately 17 % of the population in the UK is predicted to have four or more chronic conditions, which is almost double the current prevalence, now being 9.8% (26). Multimorbidity prevalence and patterns in the UK population are comparable to those of Scandinavian countries. A study conducted in Denmark (27) revealed a multimorbidity prevalence at 21.6 % in adults age < 65. For elderly adults aged 65 and above, half of the population had multimorbidity.

Aging populations, socioeconomic deprivation, and undesirable societal lifestyle characteristics are factors reported to influence the prevalence of chronic disease, and in particular, multiple chronic diseases (28). However, even though the increased prevalence is partly driven by the aging of the global population, multimorbidity is not confined to the older population (25). A previous study conducted in Scotland, UK, found that 35 % of people aged 55-64 years, and 55 % of people aged 65-74 years, are living with multimorbidity (25). The same study found that socioeconomic status is a leading determinant of multimorbidity (25). Those with the lowest wealth had a 47 % higher chance of multimorbidity compared with those with the highest wealth (25). One cohort study (29) with participants from seven European countries, including Norway, investigated the association between lifestyle factors and the risk of multimorbidity of cancer and cardiometabolic diseases. The researchers found that pre-diagnostic healthy lifestyle behaviors, measured as body mass index (BMI), smoking status, alcohol intake, physical activity, diet, and their combination as a healthy lifestyle index (HLI) score, were strongly inversely associated with multimorbidity (29). Similar findings were found in a pooled analysis of individual-level data for 120 813 adults from 16 cohort studies from the USA and Europe (30). The association of interest was the risk of incident cardiometabolic multimorbidity in adults who were overweight and obese. The researchers found that, compared with individuals with a healthy weight, the risk of developing cardiometabolic multimorbidity in overweight individuals was twice as high, almost five times higher when individuals were classified as class I obesity, and almost 15 times higher when classified as class II and III obesities combined (30).

1.3 Outcomes related to multimorbidity

A review of longitudinal studies investigated the impact of multimorbidity on work (9). The review included seven studies from different countries; four Scandinavian, two South-European, and one from Egypt. Several of the studies found direct and indirect impacts of multimorbidity on the health of workers. The researchers found that multimorbidity had a negative impact on work, with damages to work productivity. People with multimorbidity had increased chances of temporary or permanent leaves, worsening the absenteeism indices and lowering employability (9). In the United States, the incremental absenteeism-related wage loss associated with multimorbidity was investigated using the Medical Expenditure Panel Survey (MEPS) 2015 data (10). There was found that absenteeism-related wage loss was higher among people living with multimorbidity, compared to those without multimorbidity.

Also, among working adults, multimorbidity was associated with an annually 9 million incremental wage loss, related to absenteeism (10). Similar findings were found in a panel data analysis from China (11). The researchers investigated the association between mental-physical multimorbidity and disability, work productivity, and social participation. The results suggested that an increased number of physical chronic conditions was independently associated with a higher likelihood of disability, early retirement, and increased sick leave days (11).

Poor quality of life is one of the major consequences of multimorbidity (31). In 2019, the first metanalysis exploring the strength of association between multimorbidity and health-related quality of life (HRQoL) was conducted (31). The researchers found that quality of life decreases with an increasing number of diseases. Physical health seemed to be more affected than mental health. Similar findings are found in primary studies investigating the relationship between multimorbidity and quality of life or health-related quality of life (4-6).

1.4 Multimorbidity and healthcare services

Caring for people with multimorbidity is considered more complicated than caring for people with one chronic condition (12). Studies conducted on healthcare systems in both US (32) and UK (25) have found that the appropriate management of long-term disorders is a key challenge for health systems (25). Physical and mental healthcare is particularly divided, which is unfortunate due to the prevalence of physical-mental comorbidity (25). Physical-mental comorbidity is found in studies investigating clusters of diseases in multimorbidity (20). There is found that two of the most prevalent combinations of diseases are psychological problem + vascular disease and back pain + psychological problem (20). For the healthcare system to reflect the population driving the demand, there is a need for a shift from a single disease to a person-centered approach (33). This includes a shift from an approach focusing on health, rather than simply illness (33). Chronic disease management programs have been implemented to provide proactive, evidence-based multidisciplinary care in many European countries (12). However, these programs are developed for specific chronic diseases (34, 35). Because of their disease-specific approach, such programs cannot respond to the healthcare needs of people with multimorbidity, in an adequate way (12). This often results in both gaps and overlaps in the care provided (12). The healthcare system in European countries is almost always organized around medical specialties focusing on specific organ systems. This may risk losing sight of the patient as a whole person. This is especially challenging in hospital care, and patients with multimorbidity might experience fragmentation when using specialized care. In primary care, the situation can be slightly better in countries where people register with a general practitioner (GP). In this case, the primary care physician may serve as the care coordinator (12). On a general basis, the single-disease approaches need to be complemented by strengthening generalization in both primary and specialist care (25).

Another reason for multimorbid patients to experience suboptimal healthcare services is a lack of evidence about the effectiveness and safety of medical interventions for this patient group (36, 37). This lack of evidence can be explained by the limited amount of people with several conditions from clinical trials that test the effectiveness and safety of medical treatments (12).

The problem of multimorbidity is large and affects society as a whole (38). The direct costs of care for patients with multimorbidity are substantial. Additional costs due to adverse treatment effects and reduced quality of life and disability have not been comprehensively explored. Further insight into the various aspects of multimorbidity and knowledge on how to best organize health and long-term care for rising numbers of people living with multimorbidity, is urgently needed (38).

1.5 Multimorbidity and health care use in Norway

By using the definition of complex multimorbidity, the Norwegian Directorate of Health found a multimorbidity prevalence of 3.7 % in the Norwegian population aged 60-79 years old (18). In the population aged 80 years and older the prevalence was 9.5 %. Further, they found that 90 % of individuals with complex multimorbidity, had at least one appointment with their general practitioner in 2019. Moreover, it was found geographical differences both in terms of multimorbidity prevalence and healthcare utilization. The prevalence of complex multimorbidity in the South-Eastern Norway RHA was 3.5 % among people 60-79 years old (18). For comparison, the highest prevalence was 12.4 % in the region of Nord-Trøndelag, and the lowest in the region of Akershus university hospital with 7.1 %. Oslo has a higher multimorbidity prevalence (10.2 %) than the mean of the country (9.5 %). There are also geographical differences in healthcare use across the different regions in both the region of

South-Eastern Norway RHA and in the rest of Norway (18). Oslo has lower utilization rates in general practice among patients with complex multimorbidity above the age of 80 (80 % visited the GP in 2019 in Oslo, vs 87 % in Norway in total). However, similar to all regions is that the oldest age group of >80 has the highest utilization rates (18). Another finding of interest regarding healthcare utilization is the differences between the sexes. Women seem to have higher utilization rates in primary care than men (39).

In Norway, acute hospital stays caused by potentially preventive diseases makes up almost one-third of all acute hospital stays, and the biggest share is for people 50 years of age or older (40). Patients with multimorbidity are admitted to hospitals almost five times the number of patients living without multimorbidity (40). Furthermore, utilization of primary healthcare, including services from general practitioners, is also higher among this patient group (40). The number of consultations with a general practitioner among people living with multimorbidity is 1.5 times the number among patients living with only one chronic condition (40).

A research team in The Nord-Trøndelag Health survey (HUNT-study) investigated how complex multimorbidity affects activities of daily living and mortality among older Norwegians (41). They found a strong association between complex multimorbidity and the need for assistance in activities of daily living (ADL). In addition, having complex multimorbidity was moderately associated with mortality during the follow-up time (41).

Elderly people with multiple chronic conditions may experience poor coordination of clinical services (42). It has been found that insufficient coordination is the main reason that people with chronic diseases lose out in Norway´s healthcare system (43). As a result, the Coordination reform was introduced in Norway in 2009. This reform was implemented 1st of January 2012 and represents the first step in a process to change the way resources are used in the Norwegian healthcare system (43). The greatest difference is the change of responsibility from secondary care to primary care; advanced treatment that earlier was given in hospitals should now be given in the patient`s home, at rehabilitation centers, or at municipal nursing homes (43). The implementation process was challenging, especially due to shorter hospital stays (44). As a result, the municipalities need to treat people in need of heavy care, which requires a lot of resources. The change of responsibility from specialist to primary care has led to increased capacity in the hospitals, and an increased number of hospital admissions (44). However, even though it's too soon to tell whether the reform is efficient or not, it has shown substantial effects in terms of better care in the municipalities for patients discharged from the hospital. Since the implementation of the Cooperation reform in 2009, the municipalities have taken increasing responsibility for the population's health through treatment, rehabilitation, and preventive care (44).

1.6 Areas of topic that are not yet researched or not researched enough

As a result of the increasing prevalence of chronic diseases, considerable attention has been directed toward developing treatment protocols to prevent the progression of specific chronic diseases such as diabetes, asthma, or stoke (42). However, nearly all of these initiatives have focused on one single, rather than multiple conditions (42). There might be several reasons for this, and the complexity of multimorbidity associated with the management of multimorbidity has different sources (1). As already mentioned, one important reason is the inconsistencies across research literature at the very foundation of the conceptualization and definition of multimorbidity. No gold standard definition exists, other than multimorbidity is often defined as the presence of multiple chronic conditions (45). However, there have been some key conclusions from literature examining the definition and measurement of multimorbidity. These key points are important for understanding healthcare costs and resource utilization (17, 45). First, the number of types of diagnosis used to define multimorbidity across studies, differ from each other (17, 45). Second, there are inconsistencies between the conceptualization of comorbidity and multimorbidity (45). Third, the number of conditions attributed to research participants often differ according to the data sources and factors influencing whether a comprehensive list of health conditions has been documented (45). For example, there might be differences in the incentives of a clinician in primary care setting vs a data coder in an insurance-claim setting (1).

A register-based study conducted in Denmark (7) investigated the relationship between multimorbidity and utilization of services in specialist healthcare. The study population comprised 1 397 173 individuals, and the prevalence of multimorbidity was 22 %. The researchers found an approximately linear trend between the number of chronic conditions and utilization of hospitalizations and bed days. However, in people living with five or more chronic conditions, a steep increase in the utilization of bed days was observed. Van Oostrom et al. (8) investigated the association between multimorbidity and healthcare utilization in primary care. In general practice, there was found a significant difference in the number of contacts (including face-to-face consultations, phone contacts, and home visits) between patients diagnosed with multiple chronic diseases vs patients with one chronic disease, respectively 18.3 contacts vs 11.7 contacts. They also found that a higher number of chronic diseases was associated with more contacts, more prescriptions and more referrals to specialized care (8).

A systematic review identified 35 studies investigating relationships between multimorbidity and healthcare costs (medication costs, out-of-pocket costs, total health care costs) and healthcare utilization (i.e., physician use, hospital use, medication use) for elderly general populations (38). The included studies were from the United States, Europe, Australia, Asia, and Canada. All studies revealed a positive correlation between multimorbidity and at least one aspect of healthcare utilization. Several studies found a near exponential relationship between multimorbidity and costs. In almost all studies, healthcare utilization and healthcare costs significantly increased with each additional chronic condition. However, the researchers found it complicated to synthesize the studies included in the review. This is because of methodological heterogeneity between studies, different definitions of multimorbidity itself, and a multitude of outcomes investigated (38). Pooling results included in a review investigating the relationship between multimorbidity and healthcare utilization – and costs remain a challenge (17). In addition to the factors explained in the mentioned study - differences in environment, such as healthcare systems, period of observation, and perspectives make a synthesis of studies complicated (17). However, reviews are consistent in their results that multimorbidity increases health care utilization and costs of both primary and secondary care (1, 17, 46).

1.7 Relevance and importance of the research done

It´s predicted that in the next 40 years the proportion of the Norwegian population ≥ 67 years of age will almost double (47). Therefore, it’s important to investigate the health services that are used by the elderly population, and how this population uses the services that are offered by the society when health and function are impaired. Rising prevalence, substantial costs, and the fear that current care arrangements may be inappropriate for many patients with multiple conditions are reasons why this topic needs further investigation (38). Current evidence-based healthcare and scientific research methods are, in most European countries developed for specific chronic diseases (34, 35). This makes such programs inappropriate for people living with multimorbidity and may contribute to the risk of multimorbid patients deteriorating their health over time (12). The societal and economic burden associated with the current guidelines could therefore be tremendous (38). Hence, a better understanding of the epidemiology of multimorbidity is necessary to develop interventions to prevent it, reduce its burden, and align healthcare services more closely with patients' needs (25). More specifically, to ensure that the patients get the best treatment, how the use of health care distributes between primary and secondary healthcare should be investigated. Multimorbidity is a common challenge in both primary and secondary care, and interventions to address costs associated with multimorbid patients should therefore focus on services offered in both primary and specialist healthcare (48). Multimorbidity is a consequence of the success of clinicians and the health system over the past decades (33). We must now urgently aim to effectively tackle this new challenge, to ensure future generations to live healthy and equitable lives (33).

1.8 Main aim and objectives

The aim of this study is to investigate the relationship between multimorbidity and health care utilization, specified in the following objectives:

- Investigate the prevalence of multimorbidity among people ≥ 65, living in South-Eastern Norway Regional Health Authority in the year 2016
- Investigate the association between sociodemographic factors and multimorbidity
- Investigate the association between multimorbidity and primary care utilization
- Examine and compare the healthcare utilization between counties within South-Eastern Norway Regional Health Authority

Research questions: What is the prevalence of multimorbidity within the region of South-Eastern Norway Regional Health Authority, and what is the association between multimorbidity and primary healthcare utilization?

2 Methodology

2.1 Data sources

This is a register-based, cross-sectional study, using data provided by the Norwegian Institute of Public Health (NIPH). Data on chronic conditions and the use of primary healthcare services were obtained from the register of Norwegian Control and Payment of Health Reimbursement (KUHR) (49). These data are based on the reimbursement claims which are sent to the Norwegian Health Economics Administration (HELFO) by the general practitioners. KUHR includes codes from the International Classification for Primary Care (ICPC-2). These ICPC-2 provides all codes on medical conditions in primary care (50) and were used to identify diagnosis and multimorbid patients.

Data on demographics including gender, date of birth, marital status, and municipality were obtained from The Central Population Register (SSB) (51). Data from KUHR and SSB was merged into a new dataset, from now Dataset A (figure 1). Merging of the two at the individual level was performed using the registrants' unique project ID. The two variables from KUHR included in Dataset A were diagnosis and type of care. Variables from SSB included in Dataset A were sex, marital status, municipality, and date of birth. The extracting and merging of data were done using Python software.

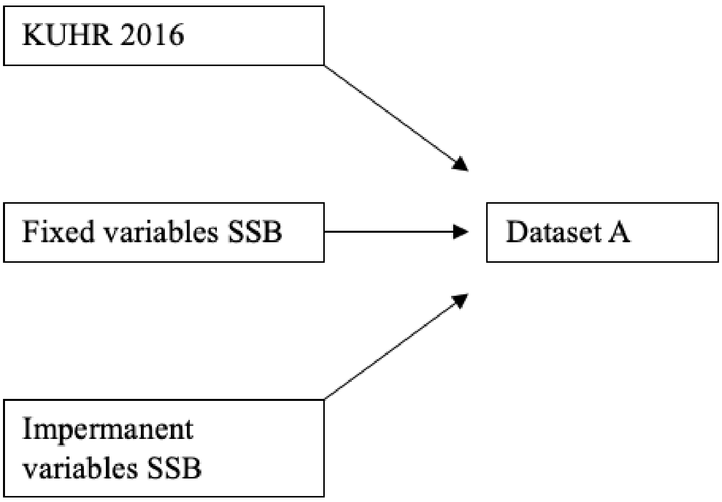

Figure 1. Merging of data

2.2 Study population

Data from KUHR and SSB included all individuals aged 65 years and older who lived in the region of South-Eastern Norway RHA and were in contact with primary healthcare, in the time period January 1st 2016 to December 31th 2016. This included 460 353 participants. Reports from the Norwegian Institute of Public Health were used to identify 6 groups of diseases of interest for the Norwegian, elderly population (52). Dementia, diabetes, chronic lung diseases, cardiovascular diseases, cancers, and musculoskeletal diseases, are all conditions highlighted in the public health report on the elderly in Norway (52). A significant proportion of years lived with disability, and in some cases, loss of life years, amongst the elderly population, are associated with these conditions (52). Descriptive statistics were used to find the 15 most prevalent ICPC-2 codes (diseases) in the dataset KUHR 2016. These 15 diseases were grouped into their 6 belonging groups (Table 1).

Table 1. Diseases (n=6) and their respectively ICPC-2 codes (n=15), included in the definition of multimorbidity

Disease	**ICPC-2 codes**
Dementia	P70
Cancer	D75, Y77
Chronic lung disease	R95, R96
Musculoskeletal conditions	L15, L03, L99
Diabetes type 2	T90
Cardiovascular disease	K86, K77, K99, K78, K76, K83

2.3 Study variables

2.3.1 Multimorbidity

Multimorbidity was defined as having two or more of 6 baseline conditions, occurring simultaneously, that is within the year 2016, in the same person.

When merging the datasets from KUHR and SSB, into Dataset A, the variable representing multimorbidity was made into three different variables. One nominal variable representing the number of diseases in each individual (0-5 conditions of the 6 diseases listed in Table 1). This variable was used in One-Way analysis of variance (ANOVA) for further investigation of the association between multimorbidity and primary care consultations. Another nominal variable, which grouped the number of conditions in 0, 1 and ≥ 2, was used both in the descriptive statistics and in Poisson regression analysis. In logistic regression analysis, the variable multimorbidity was made into a binary variable: Multimorbidity yes: ≥ 2 diseases, multimorbidity no: 0 or 1 diseases.

In the three mentioned variables, 0 diseases are included. That is people who have used primary health care due to other reasons than the 6 predefined conditions.

2.3.2 Primary care consultations

We identified the number of primary care consultations through KUHR, with data collected from 1.1.2016-31.12.2016. KUHR is based on the reimbursement claims that are sent to HELFO by the general practitioners (53). In our data, two main types of healthcare are included in the variable “primary care consultations”: General practice and emergency visits. General practice accounts for approximately 95 % of the data. This is representative of the Norwegian population as they have in total 2 million visits to their general practitioner every year, and 160 000 visits to the emergency care (53).

There were made two variables regarding the number of primary care consultations. The first included all consultations independent of the reason for visit, called “all primary care consultations”. The second included consultation only due to the 6 baseline conditions, called “selected primary care consultations”. To investigate differences in the two variables, they were both included in the descriptive statistics. The variable “all primary care consultations” was used in the regression analysis. If not otherwise stated in the text, the variable “all primary care consultations” are used.

2.3.3 Sociodemographic factors

Date of birth, sex, marital status, and municipality was obtained from SSB and included in Dataset A.

Age was computed from the variable date of birth, and grouped into 5 different categories; 65-70, 71-75, 76-80, 81-85, and >80. This categorical variable was used in the descriptive statistics, to give an overview of the included sample. The continuous variable of age was used in the regression analysis.

Marital status was regrouped from nine groups into a dichotomous variable with married or cohabitant and single. The reason for this grouping is that these two main groups are found to be associated with health outcomes (54).

Municipality was grouped in 10 different counties representing South-Eastern Norway RHA in 2016: Oslo, Østfold, Akershus, Oppland, Aust-Agder, Vest-Agder, Hedmark, Buskerud, Telemark and Vestfold.

2.4 Statistical analysis

To investigate the prevalence of multimorbidity among people ≥ 65, living in South-Eastern Norway RHA in the year 2016, frequencies (percentages) for population characteristics, including sex, age, marital status, and counties. This was done both as baseline characteristics and according to the number of diseases. Means for healthcare utilization according to the number of conditions, were calculated and displayed in a scatter plot.

To investigate the association between sociodemographic factors and multimorbidity, logistic regression was used to find the association between the sociodemographic factors age, sex, marital status, and county (independent variables) and multimorbidity (dependent variable) (55). Results were reported as odds ratios (ORs) and confidence intervals (CIs).

To investigate the association between multimorbidity and primary care utilization, Poisson regression was used. This due to count data serving as the dependent variable for the outcome “all primary care consultations” (56). Results were reported as incidence rate ratios (IRRs) and confidence intervals. IRRs were calculated in both a univariate model and a multivariate model adjusting for sex, age, marital status, and geographics. The significance level was $p<0.05$. To further explore and improve our understanding of the relationship between multimorbidity and healthcare utilization, One-Way ANOVA was used to investigate a potential linear trend between multimorbidity (1-5 conditions) and healthcare utilization. Previous studies have suggested an approximately linear relationship between the given variables (7, 48). One-Way ANOVA was chosen as it measures the significance of the linear trend between the variables, and may give an impression regarding linearity (57).

To examine and compare the healthcare utilization between municipalities within South-Eastern Norway RHA, the distribution of primary care consultations across the different counties in the region of South-Eastern Norway RHA was investigated and displayed in a histogram. Poisson regression was used to investigate healthcare utilization across the different regions.

All analyses were performed in SPSS 28.0

2.5 Ethical approval

The variables in the provided dataset are depersonalized and cannot be tracked to individuals. A project ID replaces the social security number of each individual. The data has been stored in the University of Oslo´s (UiO) research server and has not contained identifiable information. The data has been protected by a password, and access is only given to those named in the application to the Regional Committees for Medical and Health Research Ethics (REK). All analyses were performed in the mentioned UiO secure research server.

3 Results

3.1 Final study population

Missing data were handled in different ways, according to the expected reason for missing. Missing data on the outcome variable "number of primary care consultations" (n=37 388) were excluded from the analysis. The reason behind this was when merging the files from SSB and KUHR, all of the participants from SSB were included in Dataset A, even though they were not in contact with the primary healthcare in 2016. Since we only wanted patients from 2016 included in our analysis, these participants were excluded. Due to a large number of missing values, county (n=1331, 0.3%) were included in the frequency table (table 3) with baseline characteristics to check whether or not we can assume it is random. As it most likely is and because of a small percentage of missing values, these values were included in the analysis. Missing values in gender (n=3, <0.01 %), marital status = (n=742, 0.2 %) and age (n=3, <0.01 %) were included in the analysis as the percentage is low and are not expected to affect the results due to the large sample size. Extreme values considered as true outliers were identified through a box plot and removed from the dataset (n=1). This value was in the variable "all primary care consultations" and had a value of 945, which seems unlikely. When excluding this value, the range in the given variable is 1-317. This brought to a final study sample of 422 964 participants (figure 2).

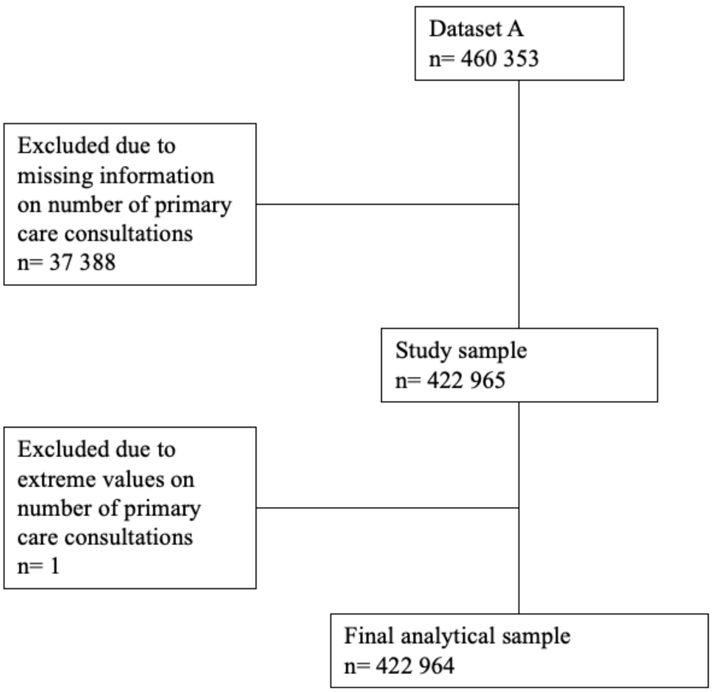

Figure 2. Flow diagram for the final study population

These 422 964 participants represented approximately 8 % of the entire Norwegian population (58), and close to half (48.5 %) of the Norwegian population over the age of 67 (59).

South-Eastern Norway RHA is the largest of four regional health trusts in Norway (60). The region of South-Eastern Norway RHA contains 70.000 employees and 2.6 million people (61). Before the merging of counties in Norway, in 2020, South-Eastern Norway RHA consisted of 10 different counties: Østfold, Akershus, Oslo, Hedmark, Oppland, Buskerud, Østfold, Telemark, Øst-Agder og Vest-Agder (61). The included sample of 422 964 indicates that about 88 % of the population above the age of 65 in South-Eastern Norway RHA, had at least one primary care visit during 2016.

3.2 Baseline characteristics of the study population

The study sample of 422 964 men and women had a mean age of 75 years (range 66-107). There were 44.9 % (n=189 898) men and 55.1 % (n=233 066) women in the study population. Furthermore, table 2 displays that Akershus has the largest proportion of study participants with n=80 264 (19.0%). Aust-Agder has the smallest proportion with n=17 877 (4.2%). The proportion of people married or cohabitant vs single was almost shared, with 57.5 % married/cohabitant and 42.5 % single.

Table 2. Baseline characteristics (n=422 964) of the study population in Dataset A

	Number	**Percentage**
Age		
Mean age	75.4	3.8
65-70	137 661	32.5
71-75	109 441	25.9
76-80	74 976	17.7
81-85	51 617	12.2
85 <	89 269	11.6
Sex		
Men	18 9898	44.9
Women	23 3066	55.1
Marital status		
Married/cohabitant	240 663	57.5
Single	178 238	42.5
County		
Østfold	47 411	11.2
Akershus	80 264	19.0
Oslo	66 947	15.9
Hedmark	36 156	8.6
Oppland	34 220	8.1
Buskerud	43 628	10.3

Vestfold	39 778	9.4
Telemark	29 780	7.1
Aust-Agder	17 877	4.2
Vest-Agder	25 960	6.2

3.3 Prevalence of multimorbidity

Among 422 964 included in the study population, 13.9 % (n=58 816) had multimorbidity (Table 3). There were 12.3 % with two diseases, 1.5 % with 3 diseases, 0.1 % with 4 diseases and < 0.1 % with 5 diseases. Due to a small number of participants with 3, 4, and 5 diseases, these groups were merged into one group of ≥ 2 diseases for the following analysis.

The prevalence of both 1 and ≥ 2 conditions was higher for men than for women, respectively 45.8 % and 15.9 % for men vs 42.3 % and 12.3 % for women. The age group 81-85 had the highest prevalence of multimorbidity (17.8 %), followed by those who were 76-80 years old (16 %). The youngest age group (65-70 years old) had the lowest prevalence. Individuals living in Hedmark had the largest proportion of people living with multimorbidity representing 16.3 %, and Telemark the smallest with 11.2 %.

Table 3. Distribution of baseline characteristics (n=422 964) by the number of diseases, N (%)

Number of chronic conditions					
0	1	2	3	4	5
178503 (42.2)	185645 (43.9)	52099 (12.3)	6332 (1.5)	377 (0.1)	9 (< 0.1)

	Number of chronic conditions		
	0	1	≥ 2
	n = 178 503 (42.2)	n = 185 645 (43.9)	n = 58 816 (13.9)
Sex			
Male	72 697 (38.3)	86 960 (45.8)	30 241 (15.9)
Female	105 806 (45.4)	98 685 (42.3)	28 576 (12.3)
Age			
65-70	68 526 (49.8)	54 604 (39.7)	14 532 (10.6)
71-75	46 446 (42.4)	47 742 (43.6)	15 253 (13.9)
76-80	28 584 (38.1)	34 376 (45.8)	12 016 (16.0)

81-85	17 535 (34.0)	24 902 (48.2)	9 180 (17.8)
>85	17 412 (35.3)	24 021 (48.8)	7 836 (15.9)
Marital status			
Married/cohabitant	102 786 (42.7)	105 258 (43.7)	32 619 (13.6)
Single	73 871 (41.4)	78 711 (44.2)	25 656 (14.4)
County			
Østfold	18 025 (38.0)	21 807 (46.0)	7 579 (16.0)
Akershus	34 513 (43.0)	35 105 (43.7)	10 646 (13.3)
Oslo	30 625 (45.7)	28 178 (42.1)	8 144 (12.2)
Hedmark	13 908 (38.5)	16 359 (45.2)	5 889 (16.3)
Oppland	14 101 (41.2)	15 150 (44.3)	4 969 (14.5)
Buskerud	17 445 (40.0)	19 750 (45.3)	6 433 (14.7)
Vestfold	16 188 (40.7)	17 665 (44.4)	5 925 (14.9)
Telemark	14 084 (47.3)	12 357 (41.5)	3 339 (11.2)
Aust-Agder	7 990 (44.7)	7 644 (42.8)	2 243 (12.5)
Vest-Agder	11 132 (42.9)	11 275 (43.4)	3 553 (13.7)
Missing county	492 (<0.01)	355 (<0.01)	96 (<0.01)

The binary logistic regression model used to examine the relationship between sociodemographic factors and multimorbidity (Table 4) demonstrated that age was the strongest predictor for multimorbidity (using Wald statistics). The odds of having multimorbidity increase significantly with increasing age (OR=1.026, 95 % CI: 1.024-1.027). Men have 1.432 higher odds of having multimorbidity and being married and cohabitant increases the risk of multimorbidity by a factor of 1.072. The categorical variable of geographics is significant (p<0.01) at all levels. The odds of having multimorbidity are lowest in Aust-Agder (OR=0.934), Telemark (OR=0.818), and Oslo (0.903), and highest in Hedmark (1.261) followed by Østfold (OR=1.247).

Table 4. Association between multimorbidity and age, gender, marital status and geography

Multimorbidity						
	Univariate (unadjusted)			Multivariate (adjusted)		
	OR	95 % CI	p-value	OR	95 % CI	p-value
Age (cont.)	1.024	1.023-1.025	<0.01	1.026	1.024-1.027	<0.01
Sex, male	1.355	1.332-1.379	<0.01	1.432	1.406-1.459	<0.01
Marital status, married/cohabitant	1.072	1.054-1.092	<0.01	1.072	1.052-1.093	<0.01
County						
Akershus[a]						
Aust-Agder	0.938	0.894-0.985	0.010	0.934	0.889-0.981	0.006
Vest-Agder	1.037	0.995-1.080	0.082	1.033	0.991-1.076	0.125

Østfold	1.244	1.205-1.285	<0.01	1.247	1.208-1.288	<0.01
Vestfold	1.145	1.106-1.184	<0.01	1.136	1.097-1.176	<0.01
Telemark	0.826	0.792-0.861	<0.01	0.818	0.785-0.853	<0.01
Buskerud	1.131	1.094-1.169	<0.01	1.129	1.092-1.168	<0.01
Oppland	1.11	1.071-1.152	<0.01	1.102	1.063-1.143	<0.01
Hedmark	1.272	1.229-1.317	<0.01	1.261	1.218-1.306	<0.01
Oslo	0.906	0.878-0.934	<0.01	0.903	0.875-0.931	<0.01

[a]Akershus reference

3.4 Primary care consultations

Mean number of primary care consultations among people with multimorbidity were much higher than for people living with zero or one condition (table 5). People with none of the 6 conditions, used primary health care 8.5 times in 2016 due to other reasons. People with 5 of the selected conditions had a mean rate of 46.8 primary care consultations within the year of 2016. The mean number of utilization of primary care services increased approximately linearly with the number of conditions (figure 3). This was tested by One-Way ANOVA which revealed a significant linear trend ($p<0.01$). The mean number of "all primary care consultations" had a range of 8.5-46.8. The mean number of "selected primary care consultations" was overall lower ranging from 0.00-31.11.

Table 5. Mean for primary care consultations among individuals with 0-5 conditions

Number of chronic conditions						
	0	1	2	3	4	5
Mean number "all primary care consultations" (sd)	8.50 (8.74)	12.24 (10.78)	17.06 (13.50)	23.74 (17.25)	32.31 (26.90)	46.78 (25.56)
Mean number "selected primary care consultations" (sd)	0.00 (0.00)	4.68 (5.2)	9.48 (8.01)	14.87 (10.90)	21.11 (13.49)	31.11 (15.07)
Mean difference	8.50	7.56	7.58	8.87	11.20	15.67

The mean difference between "all primary care consultations" and "selected primary care consultations" is increasing by the number of chronic conditions (range 8.5-15.7). This suggests that patients with the 6 predefined conditions, have primary care consultations also due to other diseases.

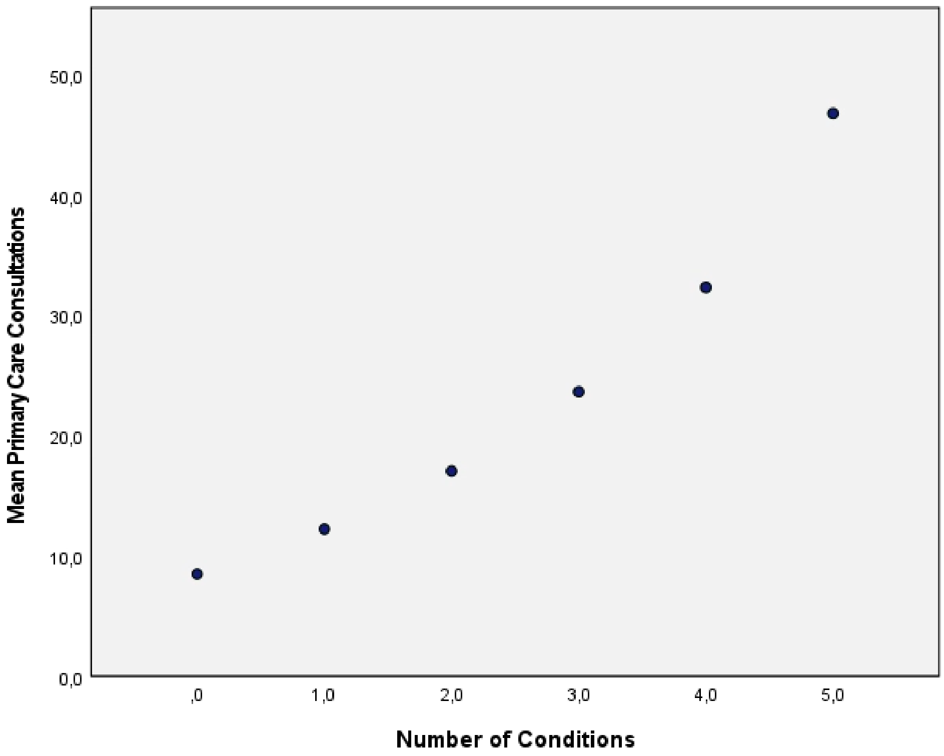

Figure 3. Mean for "all primary care consultations" among individuals with 1-5 conditions.

Mean numbers of all primary care consultations across the South-Eastern Norway RHA, follow the same pattern as the study population as a whole (figure 4). That is, people with multimorbidity have the highest primary healthcare utilization. Among people with multimorbidity, Telemark has the highest number of mean primary care consultations and Oslo the lowest, respectively 21.9 and 16.0. Oslo has the lowest numbers of primary care visits also among people with zero and one condition. However, figure 4 displays small differences across the counties regarding primary care consultation. All of the counties follow the same pattern. That is, increased health care utilization according to the number of diseases.

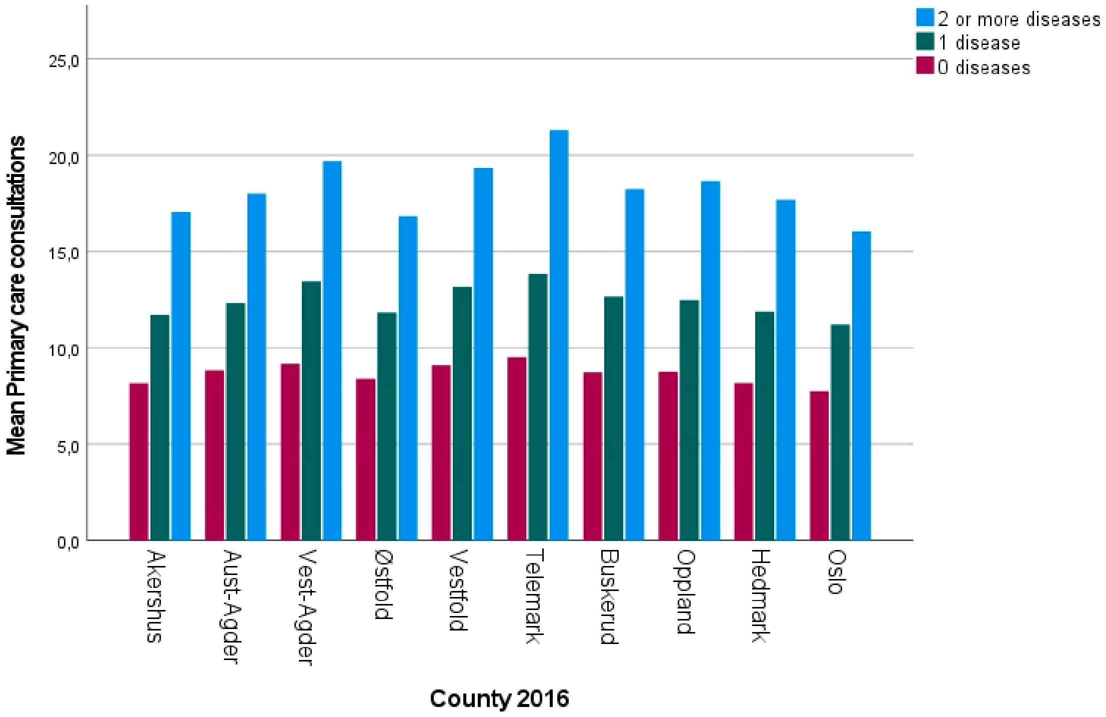

Figure 4. Mean numbers of primary care consultations across South-Eastern Norway RHA, according to the number of diseases

3.5 Association between multimorbidity and primary care consultations

3.5.1 Sociodemographic factors

All eligible sociodemographic factors were identified through Dataset A: age, sex, marital status, and county. Further, they were checked regarding their possibly confounding impact on the outcome (table 6). This was done through univariate Poisson regression analysis, which displayed a significant association between all the mentioned factors and the outcome: all primary care consultations (p<0.01). As all of the eligible sociodemographic factors were significant in the unadjusted model, they were all included in the multivariate, adjusted model. With marital status as a dichotomized variable, people being married or cohabitant had significantly more primary care consultations compared to single people with an incidence rate ratio of 1.098. More women than men use primary care services (IRR = 0.891, 95 % CI 0.889-0.893). Age was significantly and positively associated with the outcome. For every additional year, the incidence of primary care consultations increased by 1.023.

All p-values for the 10 included counties were significant at the 1 % level. Akershus, being the largest county, served as the reference category. All counties, except Oslo (IRR=0.936), were associated with an increase in health care utilization compared to Akershus (IRR > 1).

Table 6. Association between age, gender, marital status, geography and morbidity factors, and the number of primary care consultations

Number of primary care consultations						
Univariate (unadjusted model)				Multivariate (adjusted model)		
	IRR	95 % CI	p-value	IRR	95 % CI	p-value
Age, cont.	1.029	1.029-1.029	<0.01	1.023	1.023-1.023	<0.01
Sex, male	0.874	0.872-0.875	<0.01	0.891	0.889-0.893	<0.01
Marital status, married/cohabitant	1.240	1.238-1.243	<0.01	1.098	1.095-1.100	<0.01
County						
Akershus[a]						

Øst-Agder	1.053	1.047-1.058	<0.01	1.064	1.059-1.070	<0.01
Vest-Agder	1.145	1.140-1.150	<0.01	1.131	1.127-1.136	<0.01
Østfold	1.039	1.035-1.042	<0.01	1.008	1.005-1.012	<0.01
Vestfold	1.142	1.138-1.146	<0.01	1.115	1.111-1.119	0.20
Telemark	1.158	1.154-1.162	<0.01	1.172	1.168-1.177	<0.01
Buskerud	1.094	1.090-1.098	<0.01	1.069	1.066-1.073	<0.01
Oppland	1.086	1.082-1.090	<0.01	1.061	1.057-1.065	<0.01
Hedmark	1.046	1.042-1.050	<0.01	1.004	1.001-1.008	0.020
Oslo	0.940	0.937-0.943	<0.01	0.936	0.933-0.939	<0.01
Multimorbidity						
0 diagnosis[b]						
1 diagnosis	1.439	1.436-1.442	<0.01	1.397	1.394-1.400	<0.01
≥ 2 diagnoses	2.101	2.095-2.106	<0.01	2.023	2.018-2.028	<0.01

[a]Akershus reference
[b]0 diagnosis reference

3.5.2 Multimorbidity

When comparing people with multimorbidity and those with zero of the predefined conditions, IRRs of primary care consultations were much higher for people with multimorbidity. Multimorbidity is a strong predictor of the outcome “number of primary care consultations”, and adjusted IRR for primary care consultations were significantly bigger than 1 ($p<0.01$). Unadjusted IRRs for people with multimorbidity vs. people with no conditions were 2.101 (table 6). Adjusted IRRs for the same group were 2.018. Hence, according to both adjusted and unadjusted analysis, having two or more diseases approximately doubles the rate of primary care consultations. All confidence intervals are highly narrow.

When comparing people with one disease with people with zero of the selected conditions, IRRs of primary care consultations were higher for those with one condition. IRRs for people with one condition compared to people with zero conditions were significantly bigger than 1 ($p<0.001$), both in the unadjusted and adjusted analysis (respectively 1.439 vs 1.397). Hence, having one disease instead of zero, increases the number of primary care consultations by a rate of about 1.4.

4 Discussion

4.1 Summary of main findings

The aim of this study was to investigate the relationship between multimorbidity and healthcare utilization. First, this study found that the prevalence of multimorbidity was 13.9 % among patients aged ≥ 65 with two or more of 6 predefined conditions. Second, age was found to be the strongest predictor of multimorbidity. Third, primary healthcare consultations were found to significantly increase among people with multimorbidity (≥ 2 diseases) versus people with zero or one of the predefined conditions. The number of diseases seemed to be approximately linear associated with the number of primary care consultations. The effect of multimorbidity in healthcare utilization occurred independently of age, marital status, sex, and county of residents. Forth, there are significant differences in healthcare utilization across regions South-Eastern Norway RHA. Telemark is the region with the highest utilization rates and Oslo with the lowest.

4.2 Interpretation of results

4.2.1 Prevalence of multimorbidity

The prevalence rate of multimorbidity varies greatly in the literature ranging from 3.5 % to almost 100 % (62). This wide variation most likely reflects differences in the definition and measures of multimorbidity, and differences in the population studied (63). There are many factors that influence the prevalence of multimorbidity. First, sociodemographic factors in the study population, in particular the mean age (19). A systematic review investigated the variation in the estimated prevalence of multimorbidity through adjusted meta-regression models (19). The researchers found that together with the number of baseline conditions, mean age accounted for 47.8 % of heterogeneity in effect sizes. One possible explanation for this is the aspect of heterogeneity of healthy aging (64). In the older age groups, the variation is large in many aspects, such as physical, cognitive, psychological, and social function (65). However, chronological age is not necessarily a relevant marker for understanding and measuring healthy aging (64). It appears that different factors over the life span are leading to dramatic differences in health outcomes. Such factors may be both behavioral and psychosocial and include exercise, social engagement and support, stress levels, career experiences, and geographical location (64).

Another component of the definition of multimorbidity is the cut-off of diseases used to classify a patient as multimorbid (16). The choice of cut-off is also shown to contribute to variations in the prevalence of multimorbidity (16). In our study, we follow the widely adopted definition with a cut-off of two or more diseases (14). Even though this is described as the most commonly used cut-off (14), other studies also use cut-offs such as 3 or more (20) or even 4 or more (21). Higher cut-off results in a lower prevalence of multimorbidity (16).

The measures of multimorbidity, that is, whether a counting or weighting method is used, is also shown to influence the prevalence of multimorbidity (14, 66). In our study, we used a simple count of conditions which remains the most commonly used method for the measurement of multimorbidity (17). Weighted measures are often used when the outcome is clear, for example, healthcare utilization, disability, mortality, or quality of life, and when the purpose of measurement is to predict future outcomes. However, simple counts of diseases or medications perform almost well as complex measures in predicting most outcomes (17). Further, counting is found to be optimal for estimating multimorbidity prevalence (17, 66).

We´ll now look at the influencing factors of multimorbidity prevalence in relation to our study. We had a study population ≥ 65 years of age and a cut-off of two or more diseases. As explained in the paragraphs above, these are all factors considered to increase the prevalence estimates of multimorbidity. Our study found a multimorbidity prevalence of 13.9 %.

A recently published systematic review and meta-analysis aimed to identify what factors influence the variation in prevalence estimates across studies (19). They found the number of baseline conditions to be the strongest predictor of multimorbidity prevalence. One study from Sweden found a multimorbidity prevalence of 55 % among the Swedish population aged ≥ 65 years of age (67). The given study included 30 diagnoses in their definition of multimorbidity. The prevalence of multimorbidity in our study was 13.9 %. This is consistent with studies that have chosen a similar amount (n≤8) of baseline conditions (68, 69). In light of the issues discussed above, this rather low prevalence rate can be partly explained by our choice of including 6 predefined groups of diseases in our definition of multimorbidity. However, even though the 6 selected groups do not show the whole spectrum of diseases, they include highly prevalent conditions, considered they were selected from a list of the top 50 most prevalent diseases in our dataset. In addition, these predefined conditions were identified on The Norwegian Directorate of Health`s list of top diseases of interest particular to the elderly population in Norway (52).

Another factor that contributes to the explanation of our prevalence finding, is that our data is from one year.

4.2.2 The association between multimorbidity and healthcare utilization

The present study shows that patients with multiple diseases had significantly more primary care consultations than patients with one or zero of the baseline conditions. The number of consultations increased linearly with the number of conditions. The unadjusted utilization rate among individuals with multimorbidity was 2.101 (95 % CI, 2.095-2.106) compared to those living with none of the predefined conditions. When adjusted for sex, age, county of residents, and marital status, utilization differences decreased but were still 2.018 (95 % CI, 2.018-2.024) times as high as the rate among individuals with zero conditions. This is consistent with previous research, as the positive relationship between the number of chronic conditions and healthcare utilization is well documented in the literature (1, 8, 70). Our study indicates that there is an approximately linear trend between the number of diseases and primary healthcare utilization, which is also found in research (48).

Our findings suggest that people with multimorbidity have primary care visits also due to other conditions than the 6 baseline conditions. This may be related to the aspect of disease clustering. Previous research has been investigating combinations of morbidities (20). One study found that two of the most prevalent combination of diseases was psychological problem + vascular disease and back pain + psychological problem (20). This highlights the issue of co-occurrence of mental and physical chronic conditions, called mental-physical multimorbidity (11). Further investigations regarding this topic are beyond the scope of this thesis. However, the issue proposes that it may be beneficial to include mental conditions as baseline conditions, as it could paint a more holistic picture of multimorbidity.

4.2.3 Sociodemographic factors influencing healthcare utilization

Concerning the association between age and multimorbidity, our study is consistent with research. That is, age is a strong predictor of multimorbidity prevalence (25). In our study, the prevalence increases from the lowest age group of 65-70 to the second highest age group of 80-85. The prevalence value declines among the oldest in our study population, >85 years of age. This can be seen in relation to age and healthcare utilization. There is consistency in the literature regarding age as a significant predictor of health care utilization (48, 70). As with multimorbidity prevalence, our data found an equivalent decrease in healthcare utilization among the oldest age group > 85 years of age. This is consistent with previous research saying that individuals above the age of 80, often use other healthcare services such as nursing homes or hospital services (47). GP consultations in nursing homes are not registered in the KUHR database (53), hence they are not included in our analysis. In addition, elderly people have both higher rates of hospital utilization and longer hospital stays than younger age groups (47). An additional explanation to this is discussed in the previous section (4.2.1) regarding age heterogeneity.

Our study findings are consistent with previous research that women have higher utilization of primary health care services than men (71-73). This is also found in the general Norwegian population (39). The same study found that the higher number of primary care consultations is linked to women's higher rate of morbidity. This is inconsistent with our study as more men than women were multimorbid. Our findings that men have a higher prevalence of multimorbidity, while women have higher healthcare utilization, deserve further consideration. This is partly inconsistent with the literature as high rates of female morbidity may be linked to increased use of health services (74). However, our findings can partly be explained by the variables included in the different analyses. When investigating the association between multimorbidity and sex, only the 6 predefined conditions are included in the variable multimorbidity. Some of the included conditions are specific or overrepresented in men (75). For example, the Norwegian Institute of Public Health reports that men are more vulnerable to cardiovascular diseases and metabolic diseases (75), while the prevalence of psychological disorders such as anxiety and depression is found to be approximately twice as high among women than men (76). In our study, heart diseases were included as a large group of diseases, overrepresented by men (appendix 1, frequency of conditions by sex). In addition, in the group of cancer diseases, prostate cancer is included which also makes this group overrepresented by men. On the contrary, no psychological conditions were included as predefined conditions. However, when investigating the association between healthcare utilization and sex, the variable “all primary care consultations” were used in the analysis. This variable is independent of baseline conditions and includes visits both due to the 6 baseline conditions and all other diseases.

Concerning the association between the region of residence and healthcare utilization, our overall findings are that utilization rates across the different regions in South-Eastern Norway RHA have small variations. This is consistent with the Norwegian Directorate of Health`s report (18). Healthcare utilization will among other things, depend on the population`s needs and the availability of the services. There are great differences in the Norwegian counties and municipalities regarding population numbers and characteristics, in addition to distance to the healthcare service (77). These factors make it challenging to compare healthcare utilization across counties and municipalities (77). However, our study found Oslo to be the region in South-Eastern Norway RHA with the lowest number of primary care consultations. This is consistent with both the Norwegian Directorate of Health`s report (18) and a report published by the Centre for Clinical Documentation and Evaluation (SKDE) (53). In addition, Oslo has the lowest utilization rate in Norway, except for the region of “Helgeland” in North of Norway (53). The data from SKDE were representing general practice, and since only 5 % of our data is regarding emergency care visits, this leaves the remaining 95 % to general practice. This allows for comparison between the different data. The geographical finding of Oslo having the lowest utilization rates can be explained by population characteristics (77). As people tend to move out of the city and into the districts when getting older, the population in the districts is older than those in Oslo (78). In addition, our study population is limited to those 65 years of age and older. Since age is positively associated with healthcare utilization, this may provide a possible explanation for Oslo having lower utilization rates than the nine other counties. We did not stratify the ten different regions by age in our study, which would have strengthened our argument in terms of displaying the age distribution in Oslo versus the districts. However, since the multivariate analysis is adjusted for sociodemographic factors such as age, this argument is valid only in the unadjusted analysis.

Regarding the geographical differences in healthcare utilization, another finding of our study deserves our attention. Telemark is the region with the lowest prevalence of multimorbidity and at the same time the region with the highest utilization rate. Since there were used different regression models in the two analyses, the effect estimates are not directly comparable. However, it indicates that healthcare utilization is influenced by other factors than the number of diseases. One of these factors may be physical distance. People living in the districts may experience longer distance to their general practitioner which leads to lower utilization rates (79). For this argument to make sense, Telemark needs a shorter distance to a primary care office than some of the other districts in South-Eastern Norway RHA. However, that topic is beyond the scope of this thesis.

4.3 Strengths and limitations of the research

4.3.1 Strengths

The major strength of our study is that it is a register-based study that provides a large study sample. This makes the results more applicable for generalizing from the study sample to the general elderly population (80). Our data included comprehensive information about diseases and primary healthcare utilization of the complete population of South-Eastern Norway RHA in Norway, aged 65 years and above. The study population was representative of the national population ≥ 65 years of age in terms of age (59). There were approximately 5 % more women than men in our data, which does not match the general population, as men have been overrepresented in the Norwegian general population the recent years (59). However, since we are using data from a primary care setting, this can be explained by the fact that more women than men are using the primary healthcare services (73).

As a general population-based register study, our findings reflect a real-world setting, in addition to being free of recall bias and loss of follow-up (attrition bias) (7). Further, since the data are collected independent of research questions, non-differential classification is avoided (81).

4.3.2 Limitations

Several limitations of our study deserve consideration. First, this study is designed as a cross-sectional, observational study, which makes it difficult to infer causal relationships (7). Also, cross-sectional studies are only measured from one point in time (82). Hence, if we had data from another year than 2016, the results might be different.

Second, for register studies in general, data selection is defined by the register, and not the researcher (81). This may cause a lack of important information, in this case, a lack of confounder. For example, studies show that socioeconomic status is inversely associated with both the prevalence of multimorbidity and healthcare utilization (7). This issue may cause selection bias, as it's not random who`s in the group of multimorbidity or not. Depending on the socioeconomic status of our study population, this may cause an over – or underestimation of the true association between multimorbidity and healthcare utilization. Another potential confounder not included in the analysis is lifestyle factors such as BMI, smoking status, alcohol intake, physical activity, and diet. Research has found an association between the mentioned factors and multimorbidity (28, 29). There is, in particular, found an association between cardiometabolic multimorbidity and BMI (30). Since our data included a great share of heart diseases, the confounder of BMI would be of interest. This may lead to the same issue explained above; selection bias may occur as it's not random who is in the exposed group of multimorbidity, and the unexposed group of zero or one disease. Depending on the lifestyle status of our population, this may cause an under – or overestimation of the true association between multimorbidity and healthcare utilization (83).

Third, 6 diseases, specific to the elderly population were included in the definition of multimorbidity. People included in the groups of zero and one condition do only have zero or one of the 6 selected conditions. Hence, people classified as "free of multimorbidity", may in reality have several diseases other than the 6 included in the analysis. This choice of baseline conditions may cause non-differential misclassification of exposure (84). In our case that means that the people exposed to multimorbidity, will be misclassified to the unexposed group. This again may lead to underestimation of the multimorbidity prevalence. Further, there is found that considering 4 to 7 diagnoses may lead to an underestimation of the prevalence and that a list of at least 12 diseases should be included in the definition of multimorbidity (16). It may also affect the statistical analysis as if there are more people in the group of ≥ 2 diseases, the association between multimorbidity and healthcare utilization in our study would be underestimated compared to the true association.

The fourth limitation of our study is missing data, which may provide systematic errors. As the researchers themselves have not been collecting the data, the reason for missing is unclear. This makes it challenging to decide what strategies are best for handling the missing data.

However, the group missing in each group had a range of <0.01% (gender) to 0.3 % (county) and contained few participants. In addition, the variable with the highest percentage of missing (county) was included in the frequency table to check whether the distribution of missing values was similar to the not missing values. As it was, we considered the missingness to be random. Based on this, in addition to the low percentages of missing, we estimated the effect of missing data to be minimal and possible changes in the effect estimates to be very small.

Fifth, population studies investigating healthcare utilization need reliable data. Even though procedure codes are considered one of the most reliable sources of data, one cannot exclude bias (53). General practitioners may, on a busy schedule, make the wrong procedure codes. These biases are considered as random as they may be equally distributed across the different general practices (53). This may give rise to imprecise results. However, due to the large sample size, these potential random errors are considered to have minimal effect on the outcome.

Sixth, our regression model investigating the association between multimorbidity and primary healthcare utilization, did not include any interaction terms. Several relevant interactions could have been considered. By provide more detailed predictions, this could have expanded our understanding of the relationships between multimorbidity, sociodemographic factors and healthcare utilization and (85). However, because of the large number of individuals, even microscopic effects will display a statistical significance which may be misleading (7). This is in general a challenging aspect in large-scale register-based studies. Due to the large sample size, unimportant differences may become statistically significant, even though the clinical relevance may be limited (81).

Finally, the choice of statistical method may be an important source of limitations. Regarding our second objective to investigate the association between sociodemographic factors and multimorbidity, logistic regression was performed. The choice of a logistic regression model was due to a dichotomous outcome variable (multimorbidity yes/no) (55). There are some assumptions regarding logistic regression that needs to be met to obtain valid results. First, the relationship between the independent variable and its logit needs to be linear (55). Second, observations need to be independent of each other. In this study, the first assumption was not tested and may have affected the results. Regarding the second, repeated measurements within the subjects in our study were not observed.

Our main aim of investigating the association between multimorbidity and healthcare utilization was done through Poisson regression. Poisson regression is commonly used when dealing with count outcomes that take on discrete values (56). However, alternative variants of Poisson regression can be used when a key assumption of standard regression is violated. There are variants such as overdispersed Poisson regression and negative binomial regression. These alternatives may be more optimal when dealing with overdispersion. That is when the data have too much variability to be represented by standard Poisson regression (56). However, the assumption regarding overdispersion was not tested, and may, if violated, give rise to imprecise results. Also, when there are big differences in the study samples, data do not fit the Poisson distribution well (86). In the present study, the group of individuals having multimorbidity (13.9%) was small compared to the group not having multimorbidity (86.1%). This may indicate that an alternative model to the Poisson regression, could have been more appropriate for our data.

The association between multimorbidity and healthcare utilization was further investigated by testing the significance of the linear trend in One-Way ANOVA (57). However, to claim a linear trend it's not only the significance of the test that needs to be checked (87). Since One-Way ANOVA is a parametric test, assumptions such as normality, independence, and equal variance of the samples must be fulfilled (87). These assumptions were not tested and may provide imprecise results.

4.4 Implications for further research

The present study contributes by supporting the large number of studies indicating the positive association between multimorbidity and healthcare utilization. In addition, it adds up to research suggesting age is a predictor of multimorbidity. With a rapidly aging population, a better understanding of the epidemiology of multimorbidity is crucial to developing interventions to both prevent it and reduce its burden (25).

In order to increase the quality of care to patients living with multiple conditions, we need to know how to best organize the healthcare to address the needs of people with multimorbidity (25). Improvement in the coordination of care for people with multimorbidity is a key challenge for healthcare systems worldwide, and each person needs a dedicated clinician to ensure good coordination (88). Who this clinician is, will depend on individual circumstances (88). A specialist could be the best choice for those with one dominating disease or comorbidities that are closely related. However, a strong primary care system based around a skilled multi-professional team might be the best way to deliver this holistic and longitudinal care for most people living with multimorbidity (89).

Existing guidelines are usually based on evidence from clinical trials carried out in a narrow subset of the population, where elderly people living with multiple diseases often get excluded (90). Driven by this nature of evidence, in addition to the current healthcare organization, guidelines are usually focused on one single condition (91). These guidelines are partly inappropriate and not applicable to people with multimorbidity (25). This may rapidly cumulate to drive polypharmacy (91), as the patients get prescribed several drugs, each of which is recommended by a disease-specific guideline (25). To make clinical guidelines more applicable to patients with multimorbidity, future clinical guidelines should provide a practical example of how patient-centered care can be achieved for a disease process. Attempts should be made to integrate policies for similar disease processes (91).

As some conditions may share similar pathophysiology and treatment, the concept of disease clusters plays an important role in disease management among people with multimorbidity (38, 92). Ideally, the etiology of and pathophysiology of disease clusters would be sufficiently understood to impede disease development through primary interventions (38). In addition, identifying which long-term conditions co-occur together, would help clinicians to develop multi-disease clinical strategies and avoid conflicting treatment regimens (93). Further research could be directed towards quantifying which combinations of diseases drives the health care utilization (7). Cluster-wise healthcare utilization in relation to people with high utilization of health care services may improve our knowledge of how complex disease portfolios impact healthcare utilization (7, 22).

The lack of consensus regarding defining and measuring multimorbidity makes the definition of multimorbidity in relation to measurement and outcomes complex (94). This leads to widely varying prevalence rates across studies (48). There is consistency in the literature that the number of baseline conditions included in the multimorbidity measure, in addition to the mean age of the study population, are strongly associated with varying prevalence of multimorbidity (16, 19). Therefore, it's reasonable to suggest that in order to improve comparability and quality of reporting, future studies should use common core conditions set for the measurement of multimorbidity.

It will take great effort to gain further insight into the various aspects of multimorbidity and how to best organize the health care, and long-term care for people living with multiple diseases (38). The problem is large and affects both patients, healthcare workers, and society as a whole (38). Direct costs of care for patients with multimorbidity are substantial, and additional costs associated with a range of outcomes such as quality of life, disability, quality of care, and mortality have yet to be comprehensively explored (25, 38). Further multimorbidity research needs to be prioritized using high-quality real-world data and future interventional studies to gain a better insight into the complexities of multimorbidity (95).

5 Conclusion

Multimorbidity was associated with a significant increase in the utilization of primary care services in the region of South-Eastern Norway Regional Health Authority in Norway. The relevance of this study lies in the production of scientific evidence regarding multimorbidity and healthcare use in Norway. This evidence may contribute to the discussion about the possible need for the Norwegian healthcare system to adapt to multimorbid patients. The impact of multimorbidity on healthcare is partly captured by primary care and therefore this topic needs further investigation. Further research could focus on combinations of diseases that overdrive healthcare utilization. This could help in developing multi-disease prevention strategies, and change the focus from single diseases to patient-centered care.

6 References

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7 Appendices

Appendix 1: Frequency of the included conditions by sex

Disease	**Men, N (%)**	**Women, N (%)**
Dementia	4158 (2.2)	7060 (3.0)
Cancer	12793 (6.7)	2548 (1.1)
Chronic lung disease	15307 (8.1)	19453 (8.3)
Musculoskeletal conditions	14873 (7.8)	24618 (10.6)
Diabetes type 2	23878 (12.6)	20220 (8.7)
Cardiovascular conditions	80347 (42.3)	85135 (36.5)