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Pharmacologically treated diabetes and hospitalization among older Norwegians receiving homecare services from 2009 to 2014: a nationwide register study

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ABSTRACT

Introduction The aim was to assess whether annual hospitalization (admissions, length of stay and total days hospitalized) among persons >65 years receiving home care services in Norway were higher for persons with diabetes than those without diabetes. Given the growing prevalence of diabetes, this issue has great importance for policy makers who must plan for meeting these needs.

Research design and methods Data were obtained from national Norwegian registries, and the study population varied from 112 487 to 125 593 per calendar year during 2009–2014. Diabetes was defined as having been registered with at least one prescription for blood glucose lowering medication. Overall and cause-specific hospitalization were compared, as well as temporal trends in hospitalization. Hospitalization outcomes for persons with and without diabetes were compared using log-binomial regression or quantile regression, adjusting for age and gender. Results are reported as incidence rate ratios (IRRs).

Results Higher total hospitalization rates (IRR 1.17; 95% CI 1.12 to 1.22) were found among persons with, versus without, diabetes, and this difference remained stable throughout the study period. Similar reductions over time in hospital length of stay were observed among persons with and without diabetes, but total annual days hospitalized decreased significantly (p=0.001) more among those with diabetes than among those without diabetes.

Conclusions Among older recipients of home care services in Norway, diabetes was associated with a higher overall risk of hospitalization and increased days in the hospital. Given the growing prevalence of diabetes, it is important for policy makers to plan for meeting these needs.

Significance of this study

What is already known about this subject?

- Overall, increased diabetes prevalence, combined with the increased longevity of persons with diabetes, represents a challenge with respect to future healthcare needs.

What are the new findings?

- Persons with diabetes had a 17% higher overall hospitalization rate compared with persons without diabetes.
- Associations between diabetes and hospitalization varied by primary diagnosis as well as by gender.

How might these results change the focus of research or clinical practice?

- Higher quality in home care services has been emphasized as a means to prevent hospital admissions and to facilitate earlier discharge among persons with diabetes.

INTRODUCTION

Diabetes increases risk of hospital admissions and overnight stays.[1 2] Increasing diabetes prevalence[3] makes persons with diabetes a high-risk group with respect to future healthcare needs. Among older Norwegians, persons with diabetes receiving home care services represent a particularly high-risk group. Home care services are part of the national publicly funded primary healthcare system provided to more than 100 000 persons per year who require in-home treatment and nursing care at the lowest effective service level.[4] Previous studies found that in this population, the diabetes prevalence was 24%,[5] which is more than twice that of the general older population.[6] However, the extent to which diabetes adds to hospital utilization among older persons receiving home care services has not been established. Policy makers and others addressing current needs for coordinated healthcare systems require such studies in connection with forecasting and planning for future healthcare needs.

Several factors should be addressed when studying hospitalization among older persons with diabetes. Despite increased diabetes prevalence among the elderly,[7] the burden of the disease for frail, older persons might be reduced by current medical advances and general mortality trends.[8] Although reduced cardio vascular disease (CVD) rates were observed among older Norwegians in the time period 2002–2009,[9] little is known about how general morbidity trends influence recipients of home care services in particular and if the association between diabetes and hospitalization changes over time. One study showed that while the incidence of ischemic stroke and related in-hospital mortality declined among persons without diabetes, the incidence increased among adults of advanced age with diabetes.[10]

As most Western countries are challenged by higher hospitalization rates, increasing attention has been devoted to the importance of high-quality and effective primary care. There is ongoing discussion of whether a proportion of current hospital admissions among persons with diabetes could be prevented by improved treatment and more coordinated follow-up in primary care. A shift in tasks and responsibilities from specialist care to primary care is a recurring element in the initiatives and plans of several countries. Higher quality in home care services has been emphasized as a means to prevent hospital admissions and to facilitate earlier discharge.[11 12] Studies monitoring temporal trends in hospitalization rates among high-risk groups are required to evaluate how hospitalization rates develop in the context of such policy interventions. Deeper insight into the impact of diabetes on hospital utilization among older persons receiving home care services is needed in order to accommodate this group's needs for advanced treatment and primary care. To address this concern, potential gender differences in the burden of diabetes are of particular interest, as there is a gender imbalance among persons receiving home care services.

Merged population-based registries provide an excellent opportunity to investigate hospitalization patterns among older home-dwelling persons with diabetes receiving home care services. The aim of the present population registry study was to investigate whether and how diabetes was associated with hospitalization rates and number of days hospitalized during 2009–2014. To the best of our knowledge, this is the first study using nationwide data to investigate differences in hospital utilization among recipients of home care services with and without pharmacologically treated diabetes. In addition, we assess the impact of diabetes on hospitalization for several different diagnoses for both men and women; this allows us to determine the generalizability of the impact of diabetes on hospitalization and the possible disease mechanisms by which diabetes might affect hospitalization.

RESEARCH DESIGN AND METHODS

Study design

The present study used merged data from nationwide population registries. The Norwegian Information System for the Nursing and Care Sector (IPLOS) contains data from everyone who has applied for or received primary healthcare services.[13] The Norwegian Prescription Database (NorPD) contains data about dispensed drugs from all outpatient pharmacies.[14] The Norwegian Patient Registry (NPR) covers all hospitalizations.[15]

Data obtained from IPLOS were used to identify older persons receiving home care services during January 2009 through December 2014. Data from IPLOS were linked with the NorPD, the NPR and information on gender and year of birth from Statistics Norway. Data from the registries were merged by Statistics Norway using the 11-digit personal identification number unique for every Norwegian resident.

Study population

The study population consists of all persons aged ≥65 years receiving home care services provided by registered nurses or licensed nurses' aides in Norwegian municipalities during 2009–2014. Persons identified as needing home care services at least 14 hours in a respective calendar year were included in the study population. Overall individual functional level (levels 1–3) is the decision criterion for providing a person with home care services. Level 1 refers to high functional level (=low need for in-home nursing care), level 2 refers to medium functional level (=medium need for in-home nursing care), level 3 refers to low functional level (=high need for in-home nursing care). The number of persons included in the study population varied from 112 487 to 125 593 per calendar year.

Hospitalizations

Information from NPR included dates of hospitalization and discharge, and primary discharge diagnoses are coded according to version 10 of the International Classification of Diseases. The primary diagnosis reflects the main reason for the hospitalization. Data on prehospitalization diagnoses, secondary diagnoses and readmission diagnoses were not available.

The most common primary discharge diagnoses for hospitalizations (online supplemental table 1) were: CVD, with separate analyses for coronary artery disease (CAD), acute myocardial infarction (AMI), heart failure and stroke; infections (with separate analyses for sepsis and pneumonia); kidney diseases (with separate analyses for kidney failure); lung diseases; cancer; and fractures (with separate analyses for hip and vertebral fractures) (online supplemental table 1). For each person, we assessed four outcomes per calendar year: at least one hospitalization (yes/no), number of hospitalizations, length of stay (calculated as days from date of admission to date of discharge) and total days hospitalized during a calendar year (calculated by summing up the length

of stay for each hospitalization within a given calendar year). Analyses were performed for overall hospitalizations (all hospitalizations) regardless of discharge diagnosis and within primary discharge diagnosis subgroups.

Pharmacologically treated diabetes

Persons with at least one prescription for insulin (A10A) or other blood glucose lowering medication (A10B) in NorPD during the current or previous calendar year were defined as having pharmacologically treated diabetes. Persons without a registered prescription for blood glucose lowering drugs in NorPD were defined as not having pharmacologically treated diabetes. In the following, persons with pharmacologically treated diabetes are classified as persons with diabetes, and all other persons are classified as persons without diabetes.

Ethical considerations

The Norwegian Social Science Data Services provided a license to use, and merge data were provided by the Norwegian Social Science Data Services, the Norwegian Directorate of Health and the Norwegian Institute of Public Health. The data file was anonymized by Statistics Norway so that individual participants, hospitals or municipalities could not be identified. The study complies with the Declaration of Helsinki.

Statistics

Differences in rates of hospital admissions for home care recipients with and without diabetes were analyzed using log-binomial regression adjusted for age, gender and calendar year and reported as incidence risk ratios (IRRs) with 95% CIs. Additional analyses also adjusted for the number of hours of home care received during a calendar year, transfer to permanent residence in nursing home (yes/no) and the Charlson comorbidity index.[16] The comorbidity index for each person was updated 1 January each calendar year based on primary and secondary diagnoses reported during hospitalizations the previous year. We compared the total number of hospitalizations (regardless of primary diagnosis) and rates of hospitalization for different categories of primary diagnoses. In supplementary analyses, we divided those with diabetes into three diabetes medication groups: (1) insulin (A10A) only (which includes type 1 and type 2 diabetes), (2) non-insulin glucose-lowering medication (A10B) only and (3) non-insulin glucose-lowering medication (A10B) in combination with insulin (A10A); groups 2 and 3 do not typically include those with type 1 diabetes. Log-binomial regression was used to compare rates of hospital admission for the three diabetes groups versus the group without diabetes with adjustment for age, gender and calendar year. Gender differences in associations were tested by analyzing interaction effects between gender and diabetes. Temporal trends in the frequency of hospitalizations were analyzed using log-binomial regression with calendar year included as a continuous covariate in the model in addition to age and gender. The results are reported as IRR with 95% CI and can be interpreted as average percentage change in hospitalization rate per calendar year.

The difference in the median of total days spent in hospital among persons with diabetes relative to persons without diabetes was analyzed using quantile regression adjusted for age, gender and calendar year. The regression coefficient can be interpreted as the difference in medians. Length of stay and median number of hospitalizations per person were analyzed for the whole population as well as those with at least one hospitalization, with separate estimates for persons with and without diabetes. Trends in the median of total number of days in hospital per year were also evaluated using quantile regression with year as a continuous covariate and adjusted for age and gender. The regression coefficients obtained for the calendar year can be interpreted as the average change in the median of total days spent in hospital per calendar year. In addition to analyses of total days spent in hospital per year, we also analyzed the average length of stay per hospitalization. Differences in the median of this measure between home care recipients with and without diabetes and trends over time were evaluated using quantile regression, adjusted for age and gender. All regression models used clustered robust standard errors with person identifier as a cluster variable to account for repeated observations within persons. Alpha level was set at $p<0.05$ in all analyses. All statistical analyses were conducted using Stata V.14.

RESULTS

The number of older recipients of home care services in Norway increased during the 6-year study period; the most pronounced increase occurred in the youngest and the oldest age groups (table 1). The mean age in the study population was 81.9 (SD 7.2) years. One-third of the study population was men and two-thirds lived alone. In 2009, the median home care services provided was 52 (IQR 14–161) hours per year, with only small changes during the years of observation. The proportion of persons defined with pharmacologically treated diabetes increased from 14.2% (n=16 007) in 2009 to 15.7% (n=19 752) in 2014.

Associations of diabetes with risk of hospital admissions and days hospitalized

There were 1 195 625 hospitalizations among older persons receiving home care services during 2009–2014 (table 2). As shown in figure 1A, more than half of the study population was hospitalized at least once during a calendar year. When restricting analyses to persons with at least one hospitalization, median number of hospitalizations per person per year was 2 in persons with diabetes as well as without diabetes (figure 1B). Log-binomial regression analysis results (table 2) showed significantly higher hospitalization rates among those with diabetes after adjustment for age, gender and calendar year (IRR

Table 1 Descriptive characteristics of the study population: a nationwide cohort of persons receiving home care services, with and without pharmacologically treated diabetes (2009–2014) (n=721 300)

	2009 n=112 487	2010 n=117 673	2011 n=119 307	2012 n=122 566	2013 n=123 674	2014 n=125 593
Age (years), n (%)						
65–69	8159 (7.3)	9083 (7.7)	9963 (8.4)	10 883 (8.9)	11 669 (9.4)	11 910 (9.5)
70–74	10 476 (9.3)	11 057 (9.4)	11 238 (9.4)	11 871 (9.7)	12 339 (10.0)	13 197 (10.5)
75–79	17 226 (15.3)	17 251 (14.7)	17 201 (14.4)	17 242 (14.1)	17 469 (14.1)	17 706 (14.1)
80–84	26 618 (23.7)	27 247 (23.2)	27 074 (22.7)	27 500 (22.4)	26 533 (21.5)	26 393 (21.0)
85–89	30 681 (27.3)	31 121 (26.5)	30 768 (25.8)	30 539 (24.9)	30 252 (24.6)	30 254 (24.1)
90+	19 327 (17.2)	21 914 (18.6)	23 063 (19.3)	24 531 (20.0)	25 412 (20.6)	26 133 (20.8)
Female, n (%)	74 391 (66.1)	77 387 (65.8)	78 258 (65.6)	79 809 (65.1)	79 902 (64.6)	80 676 (64.2)
Living alone n (%)*	62 765 (62.7)	67 448 (63.8)	69 615 (63.7)	70 542 (63.1)	72 413 (62.9)	73 289 (62.7)
Home care service hours per year median (IQR)	52 (14–161)	52 (15–162)	52 (17–168)	52 (16–167)	53 (16–167)	52 (15–165)
Overall functional level (1–3)†						
Persons with level 1, n (%)	48 335 (49.5)	49 033 (47.4)	48 090 (45.8)	48 077 (44.7)	48 256 (44.4)	48 298 (43.9)
Persons with level 2, n (%)	38 302 (39.3)	42 424 (41.0)	44 358 (42.3)	46 284 (43.0)	46 729 (43.0)	47 851 (43.5)
Persons with level 3, n (%)	10 921 (11.2)	11 963 (11.6)	12 515 (11.9)	13 315 (12.4)	13 667 (12.6)	13 922 (12.7)
Pharmacologically treated diabetes, n (%)	16 007 (14.2)	17 985 (15.3)	18 393 (15.4)	18 839 (15.4)	19 291 (15.6)	19 752 (15.7)

*Due to 8.6% missing data, civil status was registered in 91.4% (n=659 089).
†Due to 12.3% missing data, overall functional level was registered in 87.7% (n=632 340).

1.17; 95% CI 1.12 to 1.22). The difference was significant after further adjustment for number of hours of home care received, transfer into nursing home and Charlson comorbidity index (IRR 1.11; 95% CI 1.06 to 1.14). Analyzes of hospitalization rates in the diabetes medication treatment subgroups showed lower overall hospitalization rates among those treated with only non-insulin blood glucose lowering medication compared with persons without diabetes (IRR 0.86; 95% CI 0.83 to 0.90). Persons receiving insulin only (IRR 2.13; 95% CI 1.94 to 2.53) as well as recipients receiving insulin and non-insulin blood glucose lowering medication (IRR 1.11; 95% CI 1.06 to 1.16) had increased risk (online supplemental table 2).

In analyses of subgroups with different primary diagnoses, the strength of the association between diabetes and hospital admissions varied between different groups of diagnoses (table 2). Diabetes was associated with a 44% increased risk of hospitalization for CVD (IRR 1.44; 95% CI 1.41 to 1.48) and also for all the subgroups within CVD (CAD, AMI, heart failure and stroke). Diabetes was associated with an increased risk of hospitalization for infections (IRR 1.26; 95% CI 1.21 to 1.30) and also for sepsis and pneumonia. Furthermore, diabetes was associated with an increased risk of hospitalization for kidney diseases (IRR 1.54; 95% CI 1.44 to 1.64) and also for kidney failure. By contrast, diabetes was associated with a reduced risk of hospitalization for cancer (IRR 0.79; 95% CI 0.77 to 0.82) and fractures (RR 0.79; 95% CI 0.79 to 0.82) and also for the subgroups of fractures. Diabetes was not significantly associated with the risk of hospitalization with lung diseases as the primary diagnosis.

As shown in online supplemental table 2, the strength of the associations between diabetes and hospitalization rates varied across the different groups of pharmacologically treatment. With regard to kidney failure, infections and lung diseases, higher IRR were seen among those receiving insulin only compared with the two other groups. For lung diseases, significant associations were seen only in the stratified analysis (online supplemental table 2) and not in the overall sample of pharmacologically treatment (table 2).

Comparisons of the median of total days spent in hospital per calendar year and the median of days spent in hospital per hospitalization between persons with and without diabetes are displayed in figure 1. Although there was no significant association between diabetes and the median of days hospitalized per admission (length of stay), the median of total annual days hospitalized was significantly higher among persons with diabetes (B 0.42; 95% CI 0.29 to 0.54) after adjustment for age, gender and calendar year using quantile regression.

Gender differences in the effect of diabetes on hospitalization rates

As shown in table 2, the increased risk of hospitalization for persons with diabetes was greater among women than men for AMI (p=0.021 for interaction between gender and diabetes), kidney diseases (p=0.013), infections (p=0.012) and sepsis (p<0.001). The reduced risk of hospitalization for persons with diabetes was greater

Table 2 Frequencies in hospitalization for persons with and without pharmacologically treated diabetes in home care services, stratified by gender and primary diagnosis

	Hospitalizations among persons with diabetes	Hospitalizations among persons without diabetes	Association between diabetes and hospitalization rates IRR (95% CI)*			P value of interaction†
	n (%)	n (%)	Total study population	Men	Women	P value
Total count of hospitalizations	230 432 (100)	965 193 (100)	1.17 (1.12 to 1.22)	1.14 (1.07 to 1.21)	1.19 (1.13 to 1.26)	0.060
CVD	36 888 (16.0)	137 825 (14.3)	1.44 (1.41 to 1.48)	1.46 (1.41 to 1.51)	1.43 (1.38 to 1.48)	0.055
CAD	11 318 (4.9)	38 189 (4.0)	1.57 (1.51 to 1.64)	1.52 (1.43 to 1.62)	1.62 (1.53 to 1.70)	0.334
AMI	6057 (2.6)	19 694 (2.1)	1.72 (1.64 to 1.80)	1.60 (1.50 to 1.72)	1.82 (1.71 to 1.94)	0.021
Heart failure	7275 (3.2)	22 194 (2.3)	1.92 (1.82 to 2.04)	1.87 (1.74 to 2.01)	1.96 (1.79 to 2.14)	0.622
Stroke	4841 (2.1)	21 438 (2.2)	1.23 (1.16 to 1.31)	1.22 (1.10 to 1.35)	1.24 (1.14 to 1.35)	0.806
Lung diseases	17 674 (7.7)	91 760 (9.5)	0.97 (0.94 to 1.00)	0.95 (0.91 to 1.00)	0.98 (0.94 to 1.03)	0.025
Pneumonia	9101 (3.9)	45 772 (4.7)	1.03 (1.00 to 1.07)	1.05 (1.00 to 1.10)	1.02 (0.97 to 1.07)	0.920
Fractures	7058 (3.1)	52 252 (5.4)	0.79 (0.77 to 0.82)	0.76 (0.72 to 0.80)	0.81 (0.78 to 0.84)	0.020
Hip fracture	3828 (1.7)	28 846 (3.0)	0.80 (0.77 to 0.83)	0.74 (0.69 to 0.79)	0.84 (0.80 to 0.88)	0.001
Vertebral fracture	1297 (0.6)	9458 (1.0)	0.82 (0.76 to 0.87)	0.87 (0.77 to 0.98)	0.78 (0.72 to 0.85)	0.074
Cancer	16 563 (7.2)	98 404 (10.2)	0.79 (0.77 to 0.82)	0.78 (0.74 to 0.82)	0.82 (0.77 to 0.86)	0.019
Kidney diseases	13 691 (5.9)	45 885 (4.8)	1.54 (1.44 to 1.64)	1.41 (1.26 to 1.58)	1.65 (1.53 to 1.78)	0.013
Kidney failure	6887 (3.0)	16 456 (1.7)	2.07 (1.82 to 2.36)	1.82 (1.48 to 2.25)	2.28 (1.94 to 2.68)	0.062
Infections	5940 (2.6)	24 291 (2.5)	1.26 (1.21 to 1.30)	1.21 (1.15 to 1.27)	1.31 (1.24 to 1.38)	0.012
Sepsis	2698 (1.2)	10 704 (1.1)	1.28 (1.21 to 1.34)	1.16 (1.09 to 1.24)	1.43 (1.33 to 1.54)	0.001
Diabetes	5012 (2.2)					
Diabetes complications	3169 (1.4)					

*Incidence rate ratio estimated using log-binomial regression models with count of hospitalizations within each disease group as outcome and diabetes as a binary independent variable with 'no diabetes' as reference. All models are adjusted for age and calendar year. Additional adjustment for gender in model for the total study population.
†P value for interaction term between gender and diabetes as a test for difference in strength of association between diabetes and risk of hospitalization.
AMI, acute myocardial infarction; CAD, coronary artery disease; CVD, cardio vascular disease.

among men than women for lung diseases (p=0.025), fractures (p=0.020), hip fracture (p=0.001), cancer (p=0.019) and kidney diseases (p=0.013).

Trends in hospitalization rate and days hospitalized

No significant changes in the overall annual hospitalization rate across the survey years were identified among persons with or without diabetes (table 3). With the exception of hospitalizations for pneumonia, which increased more among persons with than without diabetes (p=0.009), there were no significant interactions between diabetes status and calendar year in any of the regression models, indicating that hospital admission trends for all diagnoses developed in a similar manner among those with and without diabetes.

During the years of observation, the median number of total days spent in hospital during a calendar year decreased by 0.5 days per year (p<0.001) among persons with diabetes and 0.6 days per year (p<0.001) among persons without diabetes; the test for interaction between diabetes status and calendar year showed a significantly larger decrease among persons with diabetes (p=0.001). The median number of days per hospitalization decreased by 0.05 days per calendar year in both groups (p=0.001); there was no significant interaction.

DISCUSSION

The results of this study indicate that diabetes adds to hospital utilization among older persons receiving home care services. Persons with diabetes had a 17 percent higher hospitalization rate compared with persons without diabetes. However, the association between diabetes and hospitalization varied in relation to primary diagnosis. Overall, there were similar temporal trends in hospitalization rates among persons with and without diabetes. Length of stay decreased similarly over time among those with and without diabetes, but total annual days hospitalized decreased more over time among persons without diabetes than among persons with diabetes.

Diabetes was associated with frequency of hospitalization

Diabetes was associated with an increased frequency of hospital admissions for CVD and kidney diseases, similar to

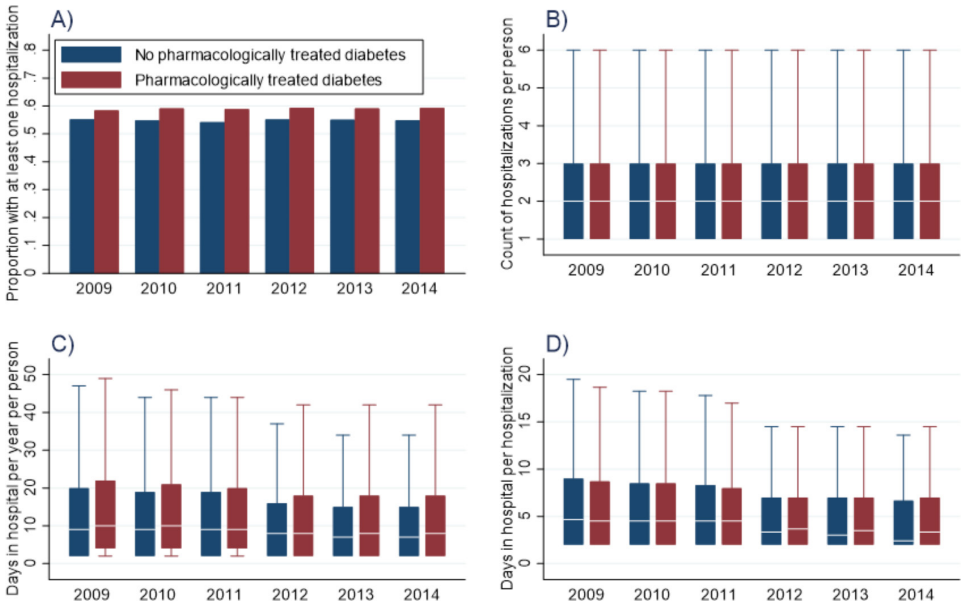

Figure 1 Panel A shows proportions with at least one hospitalization among persons with and without pharmacologically treated diabetes. Panel B shows a box plot with median and 25–75 percentiles of number hospitalizations per person, among persons with at least one hospitalization and separately for persons with and without pharmacologically treated diabetes. Panel C shows a box plot with median and 25–75 percentiles of total days in hospital per person, separately for persons with and without pharmacologically treated diabetes. Panel D shows median days in hospital per hospitalization, 25–75 percentiles separately for persons with and without pharmacologically treated diabetes.

the results of previous studies on microvascular and macrovascular diabetes complications.[2 17–20] The findings underscore that cardiorenal diseases are important complications and call for improved preventive strategies. Also in line with previous studies,[21] diabetes was associated with an increased risk of hospitalizations due to infections, another potential

Table 3 Annual trends in hospitalization rates in persons with and without pharmacologically treated diabetes, stratified by primary diagnosis (n=1 195 625)

	Persons with diabetes	Persons without diabetes	P value of interaction*
	IRR per year (95% CI)	IRR per year (95% CI)	P value
Overall hospitalizations	1.01 (1.00 to 1.03)	1.00 (0.99 to 1.01)	0.158
CVD	0.97 (0.96 to 0.99)	0.98 (0.97 to 0.98)	0.591
CAD	0.93 (0.92 to 0.95)	0.94 (0.93 to 0.95)	0.494
AMI	0.93 (0.92 to 0.94)	0.93 (0.91 to 0.95)	0.853
Heart failure	0.99 (0.97 to 1.02)	0.99 (0.98 to 1.00)	0.773
Stroke	0.95 (0.92 to 0.99)	0.95 (0.94 to 0.97)	0.905
Lung diseases	1.01 (1.00 to 1.03)	1.00 (0.99 to 1.01)	0.175
Pneumonia	1.02 (1.01 to 1.04)	1.00 (0.99 to 1.00)	0.009
Fractures	1.00 (0.98 to 1.01)	0.99 (1.01 to 1.01)	0.298
Hip fracture	0.99 (0.97 to 1.01)	0.99 (0.98 to 0.99)	0.789
Vertebral fracture	0.98 (0.94 to 1.01)	0.98 (0.97 to 0.99)	0.904
Cancer	1.02 (1.00 to 1.04)	1.00 (0.99 to 1.01)	0.090
Kidney diseases	1.03 (1.00 to 1.06)	1.03 (1.02 to 1.05)	0.863
Kidney failure	1.00 (0.96 to 1.05)	1.00 (0.97 to 1.03)	0.861
Infections	0.98 (0.96 to 0.99)	0.96 (0.96 to 0.97)	0.223
Sepsis	0.91 (0.89 to 0.93)	0.88 (0.87 to 0.89)	0.057

IRR was estimated using negative binomial regression with calendar year as a continuous variable and adjustment for age and gender.
*Significance test for interaction term between calendar year as a continuous variable and diabetes as a binary variable as indication of for difference in trends between persons with and without pharmacologically treated diabetes.
AMI, acute myocardial infarction; CAD, coronary artery disease; CVD, cardio vascular disease; IRR, incidence risk ratio.

complication of diabetes. Our findings underline the vulnerability of older persons with diabetes receiving home care services, suggesting that multimorbidity constitutes an even higher risk of hospitalization. The present findings are of interest with regard to the government aim of reducing preventable hospital admissions by improving the coordination of healthcare between hospitals and primary care.[11] Improving patient discharge and reducing hospital readmissions can be guided by frameworks for providers and policy makers.[22] For example, advanced nursing competence in primary care together with adequate ambulatory care may lead to earlier detection of infection symptoms, adequate in-home treatment at an early stage and potentially fewer hospitalizations for less severe infections. This underlines the importance of policy actions addressing quality as well as quantity in primary care's health workforce.

A reduced risk of hospitalization for cancer and fractures was found among persons with, versus without, diabetes. Previous studies found an increased risk of hospitalization due to cancer[23] and falls[24] among persons with diabetes, compared with persons without diabetes. In our study, the reference group was not composed of healthy individuals but rather of persons receiving home care services because of frailty or healthcare needs due to diagnoses other than diabetes. Unfortunately, we did not have information on the reasons for receiving home care services in the current study. However, cancer is a highly prevalent diagnosis among persons receiving home care services in Norway[25] and might be a frequent reason for receiving home care services among those without diabetes. Furthermore, older persons with cancer have a greater risk of falls and fractures,[26 27] probably because of symptoms of the illness or side effects of treatment such as fatigue, neurotoxicity and deconditioning. This may explain our findings of a higher hospitalization risk for cancer and fractures among persons without diabetes. Another possible explanation is that preventive initiatives may have been implemented more systematically among persons with diabetes than in the reference group, in order to reduce the risk of falls due to hypoglycemia. Also, the findings of diabetes as a 'protective factor' for fractures might be a result of confounding in which higher BMI (associated with diabetes) is protective for fractures. This, however, is contrary to evidence from other studies that diabetes is a risk factor for fractures.[28] Diabetes was listed as the primary diagnosis in only 2% of the hospitalizations among persons with pharmacologically treated diabetes. The low number might reflect that in the current study population, type 2 diabetes is most likely the most prevalent diabetes diagnosis, which seldom requires hospitalization. Most persons with type 2 are treated in outpatient clinics or in primary care.

Gender differences in the association between diabetes and hospitalization

We found that the increased relative risk of hospitalization among persons with diabetes was significantly higher for women than men for AMI, kidney diseases and infections. This is in line with a recent review that concluded that diabetes is a stronger risk factor for vascular diseases among women than men.[29] Another study reported that while diabetes doubles the risk of CVD among men, it triples it among women.[30] In contrast, persons with diabetes had a reduced risk of hospitalization for lung diseases, fractures and cancer, and this apparent protective effect was stronger among men than women. Gender differences might be related to genetic and hormonal factors as well as more frequent prevalence of drug side effects among women and increased resistance to the action of drugs used in prevention or therapy.[31] Although more research is needed to provide a deeper understanding of the mechanisms underpinning gender differences in the impact of diabetes on hospitalization, our results indicate the need for more attention to the gendered burden of diabetes.

Trends over time in hospitalizations

There were no significant changes across the study period in annual all-cause hospitalization rates or most discharge diagnoses, among persons with diabetes compared with those without diabetes. However, there was an increase in hospitalization for pneumonia among those with diabetes compared with those without diabetes. This might reflect greater severity of pneumonia for people with diabetes or greater emphasis by healthcare providers on protecting a vulnerable population.

Diabetes was associated with more days spent in hospital in a given calendar year, primarily due to higher hospitalization rates among persons with diabetes rather than longer stays for each hospitalization. A reduced length of stay during the study period was found among persons both with and without diabetes, in line with the general decline in length of stay in the Scandinavian countries.[32] Reduced length of stay is consistent with the government aim of reducing hospital costs through enhanced primary care treatment. However, pressure to achieve rapid hospital throughput and reduced length of stay may threaten patient safety. Attention should be devoted to studies examining potential negative associations between length of stay and readmission probability among older persons.[33 34] Norwegian physicians have recently concluded that, compared with previous years, patients are being discharged with more complex medical conditions, and discharge is sometimes perceived as premature.[35] This is consistent with our data showing that the number of days persons with diabetes are hospitalized has recently been reduced, which may result in the primary healthcare system sometimes being unable to provide care for these patients' needs.[35] At a minimum, this underlines the need for improved information sharing between hospital clinicians and home care burses during transitions from hospital to home care services.[36] This may facilitate patient re-integration into community living environments, and thus potentially prevent unplanned hospital readmissions.

Strengths and limitations

Nationwide data from Norwegian registries represent an excellent data source for studies of healthcare utilization. However, the reported total hospitalization rate and length of stay might be overestimated because persons who were transferred from one hospital to another for the same disease event were identified as two hospital admissions; data restrictions did not allow us to identify hospitalizations occurring on the same date in two different hospitals. Additional factors that could affect hospitalization include between-group differences in mortality rates, transfer to permanent residence in nursing homes and the amount of home care services received. However, preliminary analysis indicated significant differences after adjustment for these factors, and therefore, we do not think these factors have biased our results.

Diabetes was defined as being registered with at least one prescription for insulin (A10A) or other blood glucose lowering medication (A10B) in NorPD during the current or previous calendar year. Consequently, information on non-pharmacologically treated diabetes was unavailable. Laboratory values also were unavailable for evaluation in the current study. Classifying persons with diabetes into categories of HbA1c or detecting undiagnosed diabetes was therefore not possible. Including undiagnosed diabetes as well as non-pharmacologically treated diabetes as separate comparison groups could have been of interest but such information was not available in the current study. Furthermore, we used filled prescriptions to define pharmacologically treated diabetes, which is not always equivalent to use of the medication.

In summary, the results of the present study highlight the healthcare burden of diabetes among older persons receiving home care services. The findings are important for health authorities and others aiming to provide effective health services and sustainable solutions to meet future healthcare challenges. Future research should evaluate healthcare coordination from a multilevel perspective, including patients as key stakeholders.

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Supplementary Table 1

Disease groups for hospitalizations

Disease groups based on primary diagnosis at discharge

Group	**ICD10 codes**
Total	All
Infections	A00-A99, B00-B99
Sepsis	A40-A41
Cancer	C00-C99
Diabetes	E10-E14
Diabetes with complications	E100-E108 E110-E118 E130-E138 E140-E148
Cardiovascular disease	I00-I99
Coronary heart disease	I20-I25
Acute myocardial infarction	I21, I22
Stroke (bleeding or infarction)	I60-I64
Other cardiovascular disease	I00-I99 excluding I20-25 and I60-I69
Lung disease	J00-J99
Pneumonia	J13-J18
Kidney disease	N00-N39
Kidney failure	N17, N18
Fractures	S02, S07, S12, S17, S22, S28, S32, S38, S42, S47, S52, S57, S62, S67, S72, S77, S82, S87, S92, S97
Hip fracture	S72
Vertebral fracture (lower back/vertebral /ribs)	S22, S32, T08

Supplementary Table 2: Frequencies in hospitalization for persons without pharmacologically treated diabetes and different subgroups of pharmacologically treated diabetes in homecare services, stratified by gender and primary diagnosis

	IRR(95% CI)*			
	No diabetes	Insulin only	Non-insulin med. only	Insulin + non-insulin med.
Overall hospitalizations	1 (ref)	2.13 (1.94-2.33)	0.86 (0.83-0.90)	1.11 (1.06-1.16)
CVD	1 (ref)	1.77 (1.68-1.85)	1.23 (1.19-1.26)	1.75 (1.68-1.82)
CAD	1 (ref)	1.89 (1.76-2.03)	1.32 (1.26-1.38)	2.00 (1.86-2.16)
AMI	1 (ref)	2.19 (2.01-2.38)	1.38 (1.30-1.46)	2.26 (2.07-2.46)
Heart failure	1 (ref)	2.88 (2.49-3.33)	1.39 (2.49-3.33)	2.58 (2.38-2.79)
Stroke	1 (ref)	1.10 (0.97-1.24)	1.25 (1.15-1.36)	1.31 (1.16-1.48)
Lung diseases	1 (ref)	1.14 (1.07-1.21)	0.82 (0.79-0.86)	1.19 (1.13-1.27)
Pneumonia	1 (ref)	1.29 (1.22-1.37)	0.86 (0.83-0.90)	1.24 (1.16-1.31)
Fractures	1 (ref)	0.90 (0.85-0.96)	0.79 (0.77-0.82)	0.69 (0.65-0.74)
Hip fracture	1 (ref)	0.89 (0.82-0.97)	0.82 (0.78-0.86)	0.68 (0.63-0.74)
Vertebral fracture	1 (ref)	0.88 (0.77-1.01)	0.78 (0.72-0.85)	0.84 (0.73-0.97)
Cancer	1 (ref)	0.92 (0.86-0.99)	0.71 (0.68-0.75)	0.88 (0.83-0.95)
Kidney diseases	1 (ref)	2.83 (2.46-3.25)	1.08 (1.01-1.16)	1.60 (1.49-1.71)
Kidney failure	1 (ref)	5.04 (4.08-6.23)	1.14 (0.97-1.35)	1.90 (1.67-2.16)
Infections	1 (ref)	1.71 (1.60-1.83)	1.01 (0.96-1.06)	1.50 (1.40-1.60)
Sepsis	1 (ref)	1.71 (1.57-1.86)	1.04 (0.97-1.11)	1.52 (1.39-1.67)
Diabetes		5.26 (4.69-5.91)	1 (ref)	5.72 (5.13-6.36)
Diabetes complications		7.23 (6.24-8.39)	1 (ref)	6.69 (5.76-7.77)

*Adjusted for age, sex and calendar year