Received: 29 December 2020 | Accepted: 28 March 2021

DOI: 10.1111/dme.14580

DIABETIC Medicine

RESEARCH: CARE DELIVERY

Factors associated with treatment in primary versus specialist care: A population-based study of people with type 2 and type 1 diabetes

Kristina B. Slåtsve[1,2] | **Tor Claudi**[1] | **Knut T. Lappegård**[1,2] | **Anne K. Jenum**[3] | **Marthe Larsen**[4] | **Kjersti Nøkleby**[5] | **John G. Cooper**[6,7] | **Sverre Sandberg**[7,8,9] | **Tore J. Berg**[10,11]

[1]Department of Medicine, Nordland Hospital, Bodø, Norway

[2]Department of Clinical Medicine, UiT, The Arctic University of Norway, Tromsø, Norway

[3]General Practice Research Unit (AFE), Department of General Practice, Institute of Health and Society, Faculty of Medicine, University of Oslo, Oslo, Norway

[4]Clinical Research Department, University Hospital of North Norway, Tromsø, Norway

[5]Department of General Practice, Institute of Health and Society, University of Oslo, Oslo, Norway

[6]Department of Medicine, Stavanger University Hospital, Stavanger, Norway

[7]Norwegian Quality Improvement of Laboratory Examinations, Haraldsplass Deaconess Hospital, Bergen, Norway

[8]Department of Public Health and Primary Health Care, University of Bergen, Bergen, Norway

[9]Department of Clinical Biochemistry, Haukeland University Hospital, Bergen, Norway

[10]Institute of Clinical Medicine, Faculty of Medicine, University of Oslo, Oslo, Norway

[11]Department of Endocrinology, Morbid Obesity and Preventive Medicine, Oslo University Hospital, Oslo, Norway

Correspondence
Kristina B. Slåtsve, Department of Medicine, Nordland Hospital, Parkveien 95, 8005 Bodø, Norway.
Email: ksl015@uit.no

Funding information
Helse Nord supports the PhD doctoral program of KBS. The data collection of the ROSA 4 study was supported financially with grants from the Norwegian Diabetes Association, a consortium of six pharmaceutical firms (AstraZeneca, Boehringer Ingelheim, Eli Lilly, MSD, Novo Nordisk and Sanofi Aventis), Helse Nord, the Endocrinology Research Foundation, Stavanger, and the University of Oslo.

Abstract

Aims: The objectives of this study are to identify the proportion and characteristics of people with type 1 and 2 diabetes treated in primary, specialist and shared care and to identify the proportion of persons with type 2 diabetes reaching HbA_{1c} treatment targets and the clinical risk factors and general practitioner and practice characteristics associated with treatment in specialist care.

Methods: Population-based cross-sectional study including all adults ≥18 years diagnosed with diabetes in primary and specialist care in Salten, Norway. We used multivariable mixed-effects logistic regression models with level of care as outcome variable and population, general practitioner, and practice characteristics as exposure variables.

Results: Of 2704 people with type 2 diabetes, 13.5% were treated in shared care and 2.1% in specialist care only. Of 305 people with type 1 diabetes, 14.4% received treatment in primary care only. The HbA_{1c} treatment target of 53 mmol/mol (7.0%) was reached by 67.3% of people with type 2 diabetes in primary care versus 30.4% in specialist care. HbA_{1c}, use of insulin, coronary heart disease, retinopathy and urban

practice location were positively associated with treatment in specialist care. General practitioners' use of a structured form and a diabetes nurse were negatively associated with specialist care.

Conclusions: Of people with type 2 diabetes, 16% were treated in specialist care. They had higher HbA_{1c} and more vascular complications, as expected from priority guidelines. The use of a structured diabetes form and diabetes nurses seem to support type 2 diabetes follow-up in primary care.

What's new?

- The increasing prevalence of diabetes calls for an optimal utilization of healthcare resources.
- Individuals with type 2 diabetes treated in specialist care had higher HbA_{1c} and more vascular complications than those treated in primary care only and were thus rightly allocated. General practitioner's (GP's) use of a structured diabetes form and diabetes nurses were negatively associated with treatment in specialist care.
- The use of structured diabetes forms and diabetes nurses in primary care may reduce the workload in specialist care.

1 | INTRODUCTION

The prevalence of diabetes is increasing worldwide and so is the proportion of people living with diabetes and vascular complications and the overall healthcare related costs of the disease.[1] The goal of diabetes care is to reduce vascular complications and prolong high quality of life.[2] Several studies have shown the importance of glucose-lowering therapy, blood pressure and lipid control in reducing the risk of cardiovascular outcomes.[3] Preventing or postponing vascular complications will reduce both the individual and the societal burden of the disease.

Accordingly, this calls for an efficient, evidence-based and cost-effective organization of diabetes healthcare. The World Health Organization supports the trend of chronic care shifting from the secondary to the primary healthcare sector because a strong primary care service is essential to meet the observed worldwide challenges related to diabetes.[4] Finding the right balance between levels of care and identifying individuals who may benefit from treatment in specialist care is essential. This will also facilitate optimal utilization of available healthcare resources.

The pathophysiology, aetiology and treatment of type 2 diabetes (T2D) and type 1 diabetes (T1D) differ. Optimal care should integrate individual, medication and provider factors.[5] As there are no international guidelines on allocation to primary or specialist care of persons with T2D, both guidelines and organization differ between countries.[6,7] The Norwegian diabetes guidelines state that individuals with T1D should be treated in specialist care. Individuals with complicated T2D should be referred to specialist care. Studies on people with T2D have shown that socio-economic status (SES) influences follow-up in many ways, including individual capabilities, health-related behaviours, access to care, processes of care and risk of complications.[8,9]

Given the two levels of care (primary and specialist care) in people with T2D, it is important to evaluate the current patterns of management of the population of people with diabetes, as well as the characteristics of general practitioners (GPs) and GP practices associated with treatment levels.

We hypothesized that people with T2D treated in specialist care have more complex diseases with less achievement of treatment targets and more vascular complications than those treated in primary care only. Thus, we aimed to identify the proportion and characteristics of people with T2D and T1D treated in primary, shared and specialist care as well as the proportion of people with T2D reaching HbA_{1c} treatment targets. Furthermore, our aim was to identify clinical risk factors, GP and practice characteristics associated with T2D treatment in specialist care.

2 | RESEARCH DESIGN AND METHODS

2.1 | Study design and setting

We used data from the Norwegian cross-sectional study ROSA 4 including all adults (≥18 years) with T1D and T2D living in the Salten region as at 31 December 2014.[10,11] The ROSA 4 study was approved by the Regional Ethical Committee West (REK 2014/1374, REK Vest), with

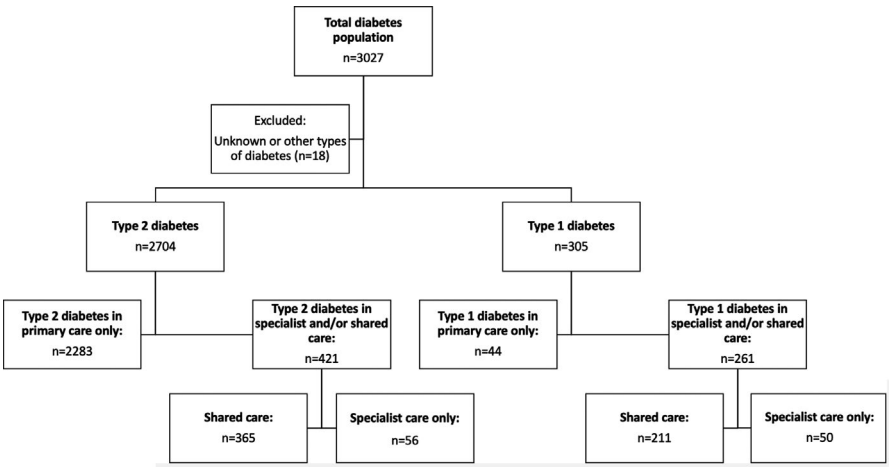

FIGURE 1 Study population according to level of care; primary, specialist or shared care

permission to collect data without written consent from all individuals with diabetes visiting primary care. Data on individuals visiting specialist care were collected in those consenting to send their data to the Norwegian Adult Diabetes Registry.

All residents in Norway have equal access to primary and specialist healthcare services free of charge once their own contribution to medical services has exceeded the annual limit (approximately 233 EUR in 2014). All residents are assigned to one GP, who cares for a maximum of 2500 individuals. The GP acts as a gatekeeper to specialist healthcare as specialists cannot see patients without referral.

Norwegian diabetes guidelines state that individuals with T1D ought to be treated in specialist care with individualized follow-up and at least one annual consultation.[12] In most people with T2D, cost-effective diabetes care can be provided in a primary care setting,[13-15] with at least one visit per year. GPs can use a software tool (Noklus diabetes application) that lists recommended tasks in the annual review and allows the performance of these tasks to be reported to the Norwegian Adult Diabetes Registry. Additional support from specialist care is recommended in individuals with poor glycaemic control, severe diabetes complications or complicating co-morbidities.[12] The Priority Guideline for Diabetes in the Specialist Health Service covers rights and deadlines for assessment of referrals to the specialist health service and ensures equality in clinical practice.[16] People with T2D without severe vascular complications or co-morbidities and reaching treatment targets are generally returned to primary care.[16] Diabetes nurses in Norway have additional education, some at master level, enabling them to independently provide lifestyle advice, educate on the use of insulin and contribute to better diabetes management.

Salten is a geographical area in Norway, both urban and rural, with a population of 80 338, 83 GPs and one diabetes outpatient clinic (i.e., diabetes specialist care) but no private diabetologists as of 31 December 2014. The total prevalence of diagnosed diabetes in Salten was 3.8% in 2014, 3.4% for T2D and 0.45% for T1D.[10] As a result of a regional diabetes action plan, there has been a close cooperation between diabetes specialist care and GPs in this region during the last 20 years.

2.2 | Population

The study population covered all individuals registered with T2D and T1D visiting primary care and all consenting individuals with T2D and T1D visiting the diabetes outpatient clinic ($n = 682$ out of 690 [98.8%]) between 1 January 2012 and 31 December 2014. After excluding individuals with gestational and other types of diabetes (maturity-onset diabetes of the young [MODY] or pancreatitis, $n = 18$) from the total diabetes sample ($n = 3027$), the final study sample included 3009 individuals: 2704 with T2D and 305 with T1D (Figure 1). Individuals registered with primary care follow-up had visited their GP for diabetes and were not treated in specialist care during the study period. Individuals registered with specialist care had one or more visits at the diabetes outpatient clinic. This group included individuals with specialist care only and individuals with consultations in both primary and specialist care, defined as shared care. All GPs and GP practices in the area were invited, and all GPs agreed to participate in the study.

2.3 | Data sources

In primary care, all individuals ≥18 years with diabetes (T89 and T90 in the International Classification of Primary Care) registered in electronic medical records from 1 January 2012 to 31 December 2014 were included. Predefined data were extracted according to a protocol.[11] Data quality was ensured by an experienced research nurse visiting all GPs to verify data and search for missing data in the electronic medical records, including reports from specialists. The search had been

tested in a pilot ensuring the accuracy of key search words used. Data from the only outpatient clinic were obtained from the Norwegian Adult Diabetes Registry and included all consenting individuals treated at the clinic. Information about education level and country of birth was obtained from 'Statistics Norway' and linked to the electronic health records. Information about the GPs and GP practices was collected by a questionnaire, with 96.3% response rate.

2.4 | Variables

A detailed description of variables used in the present study has been published.[11] In short, the following population variables were registered: sex, age, diabetes duration, body mass index (BMI), medication, HbA_{1c}, blood pressure (BP), total cholesterol, low-density lipoprotein (LDL) cholesterol, creatinine and vascular complications (retinopathy, nephropathy, neuropathy, foot ulcer, lower limb amputation, coronary heart disease [CHD], stroke, percutaneous transluminal angioplasty/arterial surgery). Serum creatinine was measured in μmol/L, and estimated glomerular filtration rate (eGFR) was calculated using the CKD-EPI equation. We used the last registered value within 3 years for HbA_{1c}, BP, lipids and eGFR. BP values in primary care were registered within 15 months (Table S1). We used the most adverse outcome or complication in the analyses if registrations in primary and specialist care differed in individuals with shared care. Medications were extracted from the GP's electronic prescription records from 1 October 2013 to 31 December 2014, and from GP and specialist database registrations. The classification of diabetes type was based on the doctor's clinical diagnoses, supplemented by measurements of beta cell antibodies and C-peptide when indicated.[10]

Variables regarding GPs included sex, age, medical education in Norway (yes/no), specialist status, workload defined as number of people on the list, number of individuals with T2D listed and the use of a national structured electronic diabetes form with an annual review template supplying data to the Norwegian Adult Diabetes Registry. Practice variables included location (urban/rural) and diabetes nurse employed. Urban/rural status was defined as living in the only city (Bodø) versus small towns or rural areas.

Treatment targets were based on the key recommendations in the Norwegian diabetes guidelines from 2009 [12] : HbA_{1c} ≤53 mmol/mol (7.0%), intervention threshold for BP >140/85 mmHg with treatment target ≤135/80 mmHg, LDL cholesterol ≤3.5 mmol/L without lipid lowering therapy and ≤1.8 mmol/L with and ≤2.5 mmol/L without known CHD.

Education was categorized as: (1) pre-primary and primary education (completion of compulsory school) or less (≤10 years), (2) secondary education (high school 11–13 years) and (3) tertiary education (university >13 years).

3 | STATISTICAL ANALYSES

Descriptive statistics are presented as frequencies and percentages (categorical variables), means with standard deviations or medians with interquartile range (IQR) (continuous variables). Nephropathy was categorized for descriptive purposes according to standard categorization (eGFR ≥60, 30–59 and <30 ml/min/1.73 m^2).

We used multivariable mixed-effects logistic regression to analyse the odds of being treated in specialist care and population, GP and practice characteristics as exposure variables. We ran separate models for each exposure variable. We adjusted for age, sex, diabetes duration and education as fixed effects in the models due to possible confounding between outcome and the different exposure variables. GP practice was included as a random effect in the models. BMI was not included in the models due to a high level of missing values. In the regression analyses, we excluded 56 (2.1%) individuals with T2D treated in specialist care only due to lack of information on GP and practice characteristics and individuals not registered with a GP. Odds ratios (ORs) and 95% confidence intervals (CIs) were presented for univariable and multivariable results.

All statistical analyses were performed using STATA/SE 14 (StataCorp, LP).

4 | RESULTS

4.1 | Population characteristics in primary, specialist and shared care

In individuals with T2D, 84.4% (n = 2283) were treated in primary care only, 2.1% (n = 56) in specialist care only and 13.5% (n = 365) in shared care (Table 1). Individuals treated in primary care only had mean age 66.4 (SD =12.6) years, compared with 64.1 (SD =13.0) and 60.7 (SD =12.9) years in specialist and shared care, respectively. The proportion of men was 54.9%, 69.9% and 63.0% in primary, specialist and shared care, respectively. In primary care, 16.7% of individuals with T2D had university education, compared with 28.6% and 20.8% in specialist and shared care, respectively. The prevalence of CHD was 23.1% in primary care, 40.0% in specialist care and 28.8% in shared care. For retinopathy, the prevalence was 7.6%, 44.8% and 29.4%, respectively.

In individuals with T1D, the majority were treated in specialist and shared care, but 14.4% (n = 44) were treated in primary care only (Table 2). Among those treated in primary care only, mean age was 51.4 (SD =18.3) years, compared with 43.7 (SD =14.2) years in specialist care and 47.0 (SD =15.7) years in shared care. Median diabetes duration was 16 (IQR: 7–33), 25 (IQR: 14–36) and 19 (IQR: 11–28) years, respectively.

TABLE 1 Type 2 diabetes persons characteristics, cardiovascular risk factors, prescribed medication and vascular complications

	Type 2 diabetes, *n* = 2704					
	Primary care only, *n* = 2283		Shared care, *n* = 365		Specialist care only, *n* = 56	
	Valid numbers, *n* (%)		Valid numbers, *n* (%)		Valid numbers, *n* (%)	
Patient characteristics						
Age (years), mean (SD)	2283 (100)	66.4 (12.6)	365 (100)	60.7 (12.9)	56 (100)	64.1 (13.0)
Men, *n* (%)	2283 (100)	1254 (54.9)	365 (100)	230 (63.0)	56 (100)	39 (69.9)
Diabetes duration (years), median (IQR)	2093 (91.7)	6 (3–11)	365 (100)	12 (7–17)	56 (100)	11 (7–19)
Age at diagnosis (years), median (IQR)	2093 (91.7)	59 (51–67)	365 (100)	48.0 (41–56)	56 (100)	52.0 (42–61)
BMI (kg/m^2), mean (SD)	1142 (50.0)	30.1(5.9)	361 (98.9)	31.7 (6.1)	54 (96.4)	29.9 (5.8)
Education	2261 (99.0)	—	361 (98.9)	—	56 (100)	—
Primary school, *n* (%)	—	829 (36.7)	—	116 (32.1)	—	11 (19.6)
High school/craftmanship, *n* (%)	—	1054 (46.6)	—	170 (47.1)	—	29 (51.8)
University, *n* (%)	—	378 (16.7)	—	75 (20.8)	—	16 (28.6)
Born outside Europe, *n* (%)	2283 (100)	71 (3.1)	365 (100)	7 (1.9)	56 (100)	3 (5.4)
Cardiovascular risk factors						
HbA_{1c}, %, mean (SD)	2212 (96.9)	6.9 (1.1)	365 (100)	7.9 (1.4)	56 (100)	7.4 (1.3)
HbA_{1c}, mmol/mol, mean (SD)	2212 (96.9)	51.4 (11.9)	365 (100)	62.4 (15.3)	56 (100)	57.6 (14.6)
Systolic blood pressure, mmHg, mean (SD)	1855 (81.3)	138 (16)	365 (100)	135 (15)	55 (98.2)	133 (15)
Diastolic blood pressure, mmHg, mean (SD)	1855 (81.3)	78 (10)	365 (100)	77 (10)	55 (98.2)	73 (11)
LDL cholesterol, mmol/L, mean (SD)	1987 (87.0)	2.8 (0.9)	365 (100)	2.7 (1.0)	54 (96.4)	2.6 (0.9)
With CHD, mmol/L, mean (SD)	469 (89.3[a])	2.5 (0.9)	105 (100[a])	2.4 (1.0)	14 (100[a])	2.3 (0.8)
No CHD, mmol/L, mean (SD)	1511 (86.3[a])	2.9 (0.9)	260 (100[a])	2.8 (0.9)	21 (100[a])	2.6 (1.0)
Prescribed lipid lowering agents, mmol/L	1204 (93.8[a])	2.6 (0.9)	277 (100[a])	2.5 (0.9)	31 (100[a])	2.4 (0.8)
No lipid lowering agents, mmol/L, mean (SD)	783 (78.4[a])	3.2 (0.9)	88 (100[a])	3.1 (0.9)	23 (92.0[a])	2.9 (0.9)
Prescribed medication						
Antihypertensive agents, *n* (%)	2283 (100)	1645 (72.1)	365 (100)	277 (75.9)	56 (100)	37 (66.1)
Insulin, *n* (%)	2283 (100)	320 (14.0)	365 (100)	245 (67.1)	56 (100)	38 (67.9)
Lipid lowering medication, *n* (%)	2283 (100)	1284 (56.2)	365 (100)	277 (75.9)	56 (100)	31 (55.4)
Lipid lowering medication with CHD, *n* (%)	525 (100)	428 (81.5)	105 (100[a])	100 (95.2)	14 (100[a])	12 (85.7)
Lipid lowering medication with no CHD, *n* (%)	1750 (100)	850 (48.6)	260 (100[a])	177 (68.1)	21 (100[a])	11 (52.4)
Acetylsalicylic acid, *n* (%)	2283 (100)	844 (37.0)	365 (100)	162 (44.4)	56 (100)	18 (32.1)
Complications						
Coronary heart disease, *n* (%)	2275 (99.6)	525 (23.1)	365 (100)	105 (28.8)	35 (62.5)	14 (40.0)
Stroke, *n* (%)	2281 (99.9)	186 (8.2)	365 (100)	19 (5.2)	35 (62.5)	3 (8.6)
PTA/arterial surgery, *n* (%)	2274 (99.6)	45 (2.0)	364 (99.7)	22 (6.0)	34 (60.7)	2 (5.9)
History of foot ulcer, *n* (%)	2278 (99.8)	27 (1.2)	365 (100)	30 (8.2)	34 (60.7)	6 (17.7)
Lower limb amputations, *n* (%)	2282 (100)	17 (0.7)	365 (100)	10 (2.7)	34 (60.7)	0 (0)

(Continues)

TABLE 1 (Continued)

	Type 2 diabetes, $n = 2704$					
	Primary care only, $n = 2283$		Shared care, $n = 365$		Specialist care only, $n = 56$	
	Valid numbers, n (%)		Valid numbers, n (%)		Valid numbers, n (%)	
Retinopathy, all, n (%)	1717 (75.2)	131 (7.6)	348 (95.3)	101 (29.4)	29 (51.8)	13 (44.8)
Untreated	—	114 (6.6)	—	73 (21.3)	—	9 (31.0)
Treated	—	17 (1.0)	—	28 (8.2)	—	4 (13.8)
Nephropathy, (eGFR, ml/min/1.73 m^2), n (%)	2167 (94.9)	—	365 (100)	—	56 (100)	—
≥60	—	1932 (89.2)	—	332 (91.0)	—	44 (78.6)
30–59	—	209 (9.6)	—	29 (8.0)	—	9 (16.1)
<30	—	26 (1.2)	—	4 (1.1)	—	3 (5.4)

Abbreviations: BMI, body mass index; eGFR, estimated glomerular filtration rate; PTA, percutaneous transluminal angioplasty.

Data are presented as means with standard deviation (SD), median with interquartile range (IQR) or percent. Specialist care = Hospital diabetes outpatient clinic.

[a]Percentage of subpopulation with/without coronary heart disease (CHD) and prescribed/not prescribed lipid lowering medication.

4.2 | General practitioner and practice characteristics

For the 82 GPs included in the study, mean age was 44.7 (SD =11.2) years, 58.1% were men and median years working as GP was 9 (IQR: 3–24) (Table 3). A diabetes nurse was employed in 53.9% ($n = 14$) of the 27 practices.

4.3 | Attained treatment targets in primary and specialist care in people with T2D

In individuals with T2D, the HbA_{1c} treatment target of 53 mmol/mol (7.0%) was reached by 67.3% (95% CI [65.3, 69.2]) in primary care versus 30.4% (95% CI [26.2, 35.0]) in specialist/shared care (Figure 2). In primary care, 6.7% ($n = 148$) had HbA_{1c} values >69 mmol/mol (8.5%), of whom 45.9% ($n = 68$) were younger than 60 years. There were no differences between levels of care in the proportion of individuals with T2D reaching treatment targets for BP and LDL cholesterol.

4.4 | Clinical and GP characteristics associated with treatment in specialist care setting

In adjusted analyses, HbA_{1c} was positively associated with treatment in specialist care (OR =1.54, 95% CI [1.39, 1.71]), as the odds for specialist care treatment increased by 54% per one-unit increase in HbA_{1c} (%) (Table 4). Diabetes-related complications such as CHD (OR =1.99, 95% CI [1.47, 2.68]), retinopathy (OR =2.78, 95% CI [1.97, 3.93]) and foot ulcer (OR =5.55, 95% CI [2.94, 10.48]) were also positively associated with treatment in specialist care. The use of a structured diabetes form and a diabetes nurse employed at the GP's office were both associated with reduced odds for treatment in specialist care (OR =0.53, 95% CI [0.40, 0.69] and OR =0.64, 95% CI [0.50, 0.82], respectively). GP's age and urban location were positively associated with treatment in specialist care (OR =1.01, 95% CI [1.00, 1.02] and OR =1.53, 95% CI [1.18, 1.98], respectively). In unadjusted analyses, education was not associated with treatment in specialist care.

5 | DISCUSSION

The present study shows that 15.6% of people with T2D in Salten, Norway, were treated in specialist care (shared care or specialist care only). They were younger, more likely to be men and had higher HbA_{1c} levels, less achievement of HbA_{1c} treatment target and a higher prevalence of CHD, foot ulcer and retinopathy compared with individuals treated in primary care only. The GP's age and urban practice location were positively associated with treatment in specialist care, and the GP's use of a structured diabetes form and a diabetes nurse employed at the GP practice were associated with reduced odds for treatment in specialist care. In people with T1D, 14.4% were treated in primary care only.

In accordance with our hypothesis, people with T2D treated in specialist care had more vascular complications and less achievement of treatment targets than those treated in primary care, despite their younger age, indicating a more complex disease.

Our findings are in line with previous studies on T2D reporting that specialists often see younger individuals that are more likely to be men with more vascular complications and higher HbA_{1c} levels living in urban centres.[17-19] Individuals

TABLE 2 Type 1 diabetes persons characteristics, cardiovascular risk factors, prescribed medication and vascular complications

	Type 1 diabetes, *n* = 305					
	Primary care only, *n* = 44		Shared care, *n* = 211		Specialist care only, *n* = 50	
	Valid numbers, *n* (%)		Valid numbers, *n* (%)		Valid numbers, *n* (%)	
Patient characteristics						
Age (years), mean (SD)	44 (100)	51.4(18.3)	211 (100)	47.0 (15.7)	50 (100)	43.7 (14.2)
Men, *n* (%)	44 (100)	30 (68.2)	211 (100)	114 (54.0)	50 (100)	34 (68.0)
Diabetes duration (years), median (IQR)	40 (90.9)	16 (7–33)	211 (100)	19 (11–28)	50 (100)	25 (14–36)
Age at diagnosis (years), median (IQR)	40 (90.9)	35 (16–50)	211 (100)	23 (12–38)	50 (100)	17 (11–26)
BMI (kg/m^2), mean (SD)	27 (61.4)	27.1 (5.0)	210 (99.5)	26.4 (4.6)	50 (100)	26.4 (4.2)
Education	43 (97.7)	—	210 (99.5)	—	50 (100)	—
Primary school, *n* (%)	—	13 (30.2)	—	55 (26.2)	—	11 (22.0)
High school/craftmanship, *n* (%)	—	20 (46.5)	—	91 (43.3)	—	23 (46.0)
University, *n* (%)	—	10 (23.3)	—	64 (30.5)	—	16 (32.0)
Born outside Europe, *n* (%)	44 (100)	1 (2.3)	211 (100)	3 (1.4)	50 (100)	0 (0)
Cardiovascular risk factors						
HbA_{1c}, %, mean (SD)	34 (77.3)	7.8 (1.7)	211 (100)	8.3 (1.4)	50 (100)	7.9 (1.4)
HbA_{1c}, mmol/mol, mean (SD)	34 (77.3)	61.8 (18.1)	211 (100)	67.2 (15.2)	50 (100)	63.4 (15.6)
Systolic blood pressure, mmHg, mean (SD)	30 (68.2)	134 (15)	211 (100)	126 (14)	50 (100)	128 (17)
Diastolic blood pressure, mmHg, mean (SD)	30 (68.2)	74 (11)	211 (100)	74 (9)	50 (100)	73 (10)
LDL cholesterol, mmol/L, mean (SD)	31 (70.5)	2.9 (1.1)	210 (99.5)	2.7 (0.8)	49 (98.0)	2.6 (0.6)
With CHD, mmol/L, mean (SD)	6 (100[a])	2.3 (0.7)	22 (100[a])	2.0 (0.7)	4 (100[a])	2.6 (1.0)
No CHD, mmol/L, mean (SD)	25 (65.8[a])	3.1 (1.1)	188 (99.5[a])	2.7 (0.8)	24 (100[a])	2.7 (0.5)
Prescribed lipid lowering agents, mmol/L	16 (94.1[a])	2.8 (1.1)	82 (100[a])	2.5 (1.0)	11 (100[a])	2.6 (0.6)
No lipid lowering agents, mmol/L, mean (SD)	15 (55.6[a])	3.1 (1.1)	128 (99.2[a])	2.8 (0.7)	38 (97.4[a])	2.7 (0.6)
Prescribed medication						
Antihypertensive agents, *n* (%)	44 (100)	17 (38.6)	211 (100)	86 (40.8)	50 (100)	15 (30.0)
Lipid lowering medication, *n* (%)	44 (100)	17 (38.6)	211 (100)	82 (38.9)	50 (100)	11 (22.0)
Lipid lowering medication with CHD, *n* (%)	6 (100)	6 (100)	22 (100)	20 (90.9)	4 (100)	4 (100)
Lipid lowering medication with no CHD, *n* (%)	38 (100)	11 (29.0)	189 (100)	62 (32.8)	24 (100)	5 (20.8)
Acetylsalicylic acid, *n* (%)	44 (100)	11 (25.0)	211 (100)	41 (19.4)	50 (100)	6 (12.0)
Complications						
Coronary heart disease, *n* (%)	44 (100)	6 (13.6)	211 (100)	22 (10.4)	28 (56.0)	4 (14.3)
Stroke, *n* (%)	44 (100)	4 (9.1)	211 (100)	8 (3.8)	28 (56.0)	0 (0)
PTA/arterial surgery, *n* (%)	44 (100)	3 (6.8)	211 (100)	5 (2.4)	28 (56.0)	1 (3.6)
History of foot ulcer, *n* (%)	44 (100)	0 (0)	211 (100)	17 (8.1)	28 (56.0)	2 (7.1)
Lower limb amputations, *n* (%)	44 (100)	0 (0)	211 (100)	6 (2.8)	28 (56.0)	0 (0)
Retinopathy, all, *n* (%)	34 (77.3)	14 (41.2)	203 (96.2)	103 (50.7)	30 (60.0)	34 (80.0)

(Continues)

TABLE 2 (Continued)

	Type 1 diabetes, $n = 305$					
	Primary care only, $n = 44$		Shared care, $n = 211$		Specialist care only, $n = 50$	
	Valid numbers, n (%)		Valid numbers, n (%)		Valid numbers, n (%)	
Untreated	—	7 (20.6)	—	71 (35.0)	—	15 (50.0)
Treated	—	7 (20.6)	—	32 (15.8)	—	9 (30.0)
Nephropathy, (eGFR, ml/min/1.73 m^2), n (%)	35 (79.5)	—	210 (99.5)	—	50 (100)	—
≥60	—	33 (94.3)	—	205 (97.6)	—	50 (100)
30–59	—	2 (5.7)	—	4 (1.9)	—	0 (0)
<30	—	0 (0)	—	1 (0.5)	—	0 (0)

Abbreviations: BMI, body mass index; eGFR, estimated glomerular filtration rate; PTA, percutaneous transluminal angioplasty.

Data are presented as means with standard deviation (SD), median with interquartile range (IQR) or percent. Specialist care = Hospital diabetes outpatient clinic.

[a]Percentage of subpopulation with/without coronary heart disease (CHD) and prescribed/not prescribed lipid lowering medication.

TABLE 3 Characteristics of general practitioners ($n = 82$) and practices ($n = 27$)

	Valid numbers	
General practitioners characteristics ($n = 82$)		
Age (years), mean (SD)	76	44.7 (11.2)
Men, n (%)	74	43 (58.1)
Medical education in Norway, n (%)	75	54 (72.0)
Specialist in general practice, n (%)	75	37 (49.3)
Years working as GP, median (IQR)	72	9 (3–24)
Workload (patients on list), median (IQR)	78	989 (826–1224)
No. of people with T2D per GP, median (IQR)	82	31 (20–46)
No. of people with shared care, median (IQR)	82	4 (2–6)
General practitioner office characteristics ($n = 27$)		
Diabetes nurse employed, n (%)	26	14 (53.9)
Urban location, n (%)	26	14 (53.9)

Abbreviations: GP, general practitioner; IQR, interquartile range; T2D, type 2 diabetes.

treated in specialist care are more likely to be monitored according to guidelines, with achievement of adequate HbA_{1c} levels [19-22]; the last stands in contrast to our findings of higher HbA_{1c} levels in specialist care. Whether follow-up in specialist care positively affects HbA_{1c}, hypertension, vascular complications or improves survival is unclear, as results are conflicting.[17,23-26]

In a recent Norwegian study on people with T2D, the GP's use of a structured diabetes form was associated with 23% higher odds of achieving the HbA_{1c} treatment target and 17% higher odds of achieving LDL cholesterol target.[27] In our study, the GP's use of a structured diabetes form and a diabetes nurse employed at the office were both associated with reduced odds for treatment in specialist care. This may indicate a more structured diabetes review and increased knowledge and competence in diabetes treatment, all leading to less need for referrals to specialist care. Whereas GP characteristics such as sex, specialist status and workload were not associated with treatment in specialist care, urban location was. This indicates geographical proximity to the specialist care to be of importance. The reason for this is unknown but could possibly be caused by short transport distance to specialist care or patients' preferences.

Previous studies in people with T2D have reported that SES influences follow-up at multiple levels, including access of care.[8] In the present study, education was not associated with treatment in specialist care, indicating no differences in access to healthcare according to SES. However, only 91 patients treated in specialist care had university education.

According to Norwegian diabetes guidelines,[12] all individuals with T1D have the right to specialist care. Yet, our study surprisingly showed that 14.4% were treated in primary care only. A longitudinal cohort study from the UK including 113 young people with T1D reported that 3% did not attend any clinic and 22% were cared for exclusively by their GPs at follow-up.[28] In a Finnish study, individuals with T1D received follow-up in primary care without compromising good quality and patient satisfaction.[29] Others report associations between specialist care and lower HbA_{1c} levels; however, individuals in specialist care also reported higher education and income levels.[30] A higher proportion of diabetes duration spent in specialist care delayed the development of certain diabetes late complications.[31] To our knowledge, large studies on level of care and disease severity in individuals with T1D are scarce.

The present study shows an overall adherence in the Salten region to the Norwegian diabetes guidelines recommendation

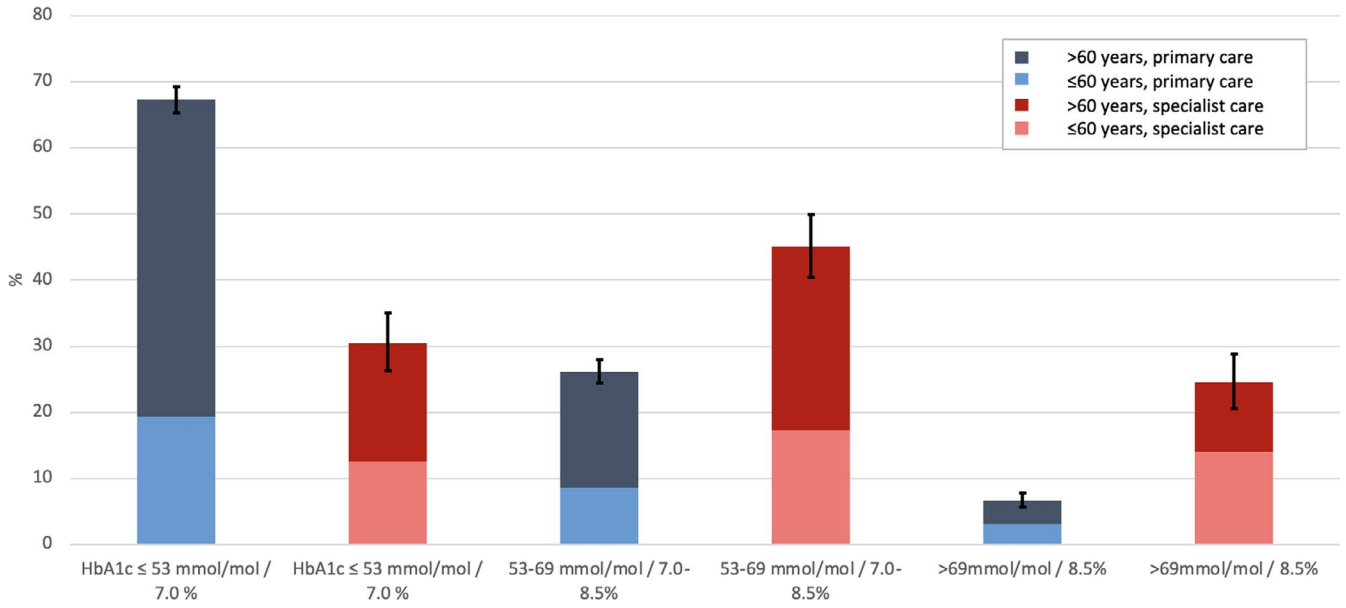

FIGURE 2 HbA_{1c} in people with type 2 diabetes in primary versus specialist/shared care. Error bars represent 95% confidence intervals

that individuals with T2D and poor glycaemic control or complicating co-morbidities should be treated in specialist care.[12] This may partly be a result of a longstanding, systematic co-operation between the hospital and the GPs in the local municipalities. Nevertheless, 46% of patients with HbA_{1c} values >69 mmol/mol (8.5%) treated in primary care were younger than 60 years. Although factors such as the individuals' preferences and medical or social disabilities can influence the decision of level of care, these findings are worrisome. Effective use of resources and a more efficient healthcare service will benefit both individuals and the society. Individual assessments are necessary when deciding level of care. GPs may have a more holistic approach to diabetes care, whereas fragmented healthcare delivery can affect the individual's experience negatively.[32]

The strengths of the present study include a data collection ensuring complete and accurate data on all adults with T2D and T1D and all GPs in a well-defined geographical area, resulting in an adequate sample size. Linkage to 'Statistics Norway' ensured information on education level. Further, in Norway, individuals have equal access to healthcare, and the study was done in the absence of financial incentives related to pay-for-performance. Our study is limited by its cross-sectional design, as we do not have information on the development of risk profile over time, in particular not the risk profile at the time of referral and during treatment in specialist care. In addition, factors such as co-morbidity, the individual's preferences, frailty and social conditions may influence the decision to refer and care for people with T2D in specialist care, not shown in this study. Excluding 56 individuals with T2D treated in specialist care only due to lack of information on GP and practice characteristics from the regression analyses may have introduced some selection bias. Salten is fairly representative of Norway, except for a lower proportion of immigrants born outside Norway than the Norwegian average in 2014 (7.1% vs. 12.4%). The study findings might be generalizable to other parts of Norway and possibly to countries with a similar system. Generalization of these results to other countries with a different organization of healthcare should be made with caution.

In conclusion, the present study shows that on the whole, people with T2D were appropriately allocated to primary and specialist care according to age, hyperglycaemia and vascular complications. However, surprisingly many individuals with T1D were treated exclusively in primary care. The use of a structured diabetes form and diabetes nurses may support T2D follow-up in primary care leading to better organization of diabetes healthcare for the benefit of the individual. Further longitudinal studies on better risk stratification as a guide for allocation of individuals between primary and specialist care should be performed.

ACKNOWLEDGEMENTS

The authors thank Elin Røst, research nurse in Salten, Ståle Nymo at Nordland Hospital and Karianne Fjeld Løvaas at the Norwegian Organization for Quality Improvement of Laboratory Examinations, Haraldsplass Deaconess Hospital, Bergen, for participating in the study.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ORCID

Kristina B. Slåtsve https://orcid.org/0000-0003-0627-7716
Tor Claudi https://orcid.org/0000-0002-0076-169X

TABLE 4 Odds ratio (OR) for treatment in specialist care for different patient characteristics, risk factors and general practitioner and practice variables of people with type 2 diabetes

	Type 2 diabetes			
	Unadjusted results		Adjusted results	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Patients characteristics				
Age (years)	0.97 (0.96, 0.97)	<0.001	—	—
Men	1.40 (1.11, 1.76)	0.004	—	—
Diabetes duration (years)	1.11 (1.09, 1.13)	<0.001	—	—
Education	—	0.097	—	—
Primary school	0.87 (0.67, 1.12)	0.271	—	—
High school/craftmanship	1	—	—	—
University	1.23 (0.91, 1.65)	0.170	—	—
Cardiovascular risk factors				
HbA_{1c}, %	1.81 (1.66, 1.97)	<0.001	1.54 (1.39, 1.71)	<0.001
Systolic blood pressure, mmHg	0.99 (0.98, 1.00)	0.021	0.99 (0.99, 1.00)	0.207
Diastolic blood pressure, mmHg	0.98 (0.97, 0.99)	0.002	0.96 (0.95, 0.98)	<0.001
LDL cholesterol, mmol/L	0.85 (0.75, 0.97)	0.012	0.95 (0.81, 1.10)	0.473
Prescribed medication				
Antihypertensive agents	1.22 (0.94, 1.58)	0.128	1.50 (1.11, 2.02)	0.008
Insulin	12.52 (9.77, 16.05)	<0.001	9.87 (7.30, 13.36)	<0.001
Lipid lowering medication	2.45 (1.90, 3.16)	<0.001	2.96 (2.17, 4.03)	<0.001
Acetylsalicylic acid	1.36 (1.09, 1.70)	0.007	1.92 (1.44, 2.55)	<0.001
Complications				
Coronary heart disease	1.35 (1.05, 1.72)	0.018	1.99 (1.47, 2.68)	<0.001
Stroke	0.62 (0.38, 1.01)	0.052	0.69 (0.40, 1.18)	0.172
PTA/arterial surgery	3.19 (1.89, 5.37)	<0.001	3.32 (1.81, 6.10)	<0.001
History of foot ulcer	7.47 (4.38, 12.72)	<0.001	5.55 (2.94, 10.48)	<0.001
Retinopathy	5.05 (3.77, 6.77)	<0.001	2.78 (1.97, 3.93)	<0.001
General practitioner and practice characteristics				
Age (years)	1.01 (1.00, 1.02)	0.010	1.01 (1.00, 1.02)	0.043
Men	1.12 (0.89, 1.41)	0.345	1.15 (0.89, 1.49)	0.298
Medical education in Norway	0.83 (0.64, 1.07)	0.150	0.88 (0.65, 1.17)	0.378
Specialist in general practice	1.05 (0.84, 1.32)	0.665	0.86 (0.67, 1.12)	0.262
Workload (no patients on list)	1.00 (1.00, 1.00)	0.325	1.00 (1.00, 1.00)	0.129
No. of people with T2D per GP	0.99 (0.98, 1.00)	0.001	0.99 (0.98, 1.00)	0.007
Diabetes nurse employed	0.68(0.54, 0.85)	0.001	0.64 (0.50, 0.82)	<0.001
User of a structured diabetes form	0.62 (0.49, 0.79)	<0.001	0.53 (0.40, 0.69)	<0.001
Urban location	1.42 (1.12, 1.79)	0.004	1.53 (1.18, 1.98)	0.001

Abbreviations: CI, confidence interval; GP, general practitioner; IQR, interquartile range; PTA, percutaneous transluminal angioplasty; T2D, type 2 diabetes.
Adjusted results: adjusted for age, sex, diabetes duration and education.

Knut T. Lappegård https://orcid.org/0000-0002-9976-7791
Anne K. Jenum https://orcid.org/0000-0003-0304-7800
Kjersti Nøkleby https://orcid.org/0000-0001-9806-8668
John G. Cooper https://orcid.org/0000-0002-1753-635X
Sverre Sandberg https://orcid.org/0000-0001-9521-5087
Tore J. Berg https://orcid.org/0000-0003-4406-2396

REFERENCES

1. Cho NH, Shaw JE, Karuranga S, et al. IDF diabetes atlas: global estimates of diabetes prevalence for 2017 and projections for 2045. *Diabetes Res Clin Pract*. 2018;138:271-281.
2. Cobin RH. Subspecialist care improves diabetes outcomes. *Diabetes Care*. 2002;25:1654-1656.

3. Gaede P, Lund-Andersen H, Parving HH, Pedersen O. Effect of a multifactorial intervention on mortality in type 2 diabetes. *N Engl J Med*. 2008;358:580-591.
4. World Health Organization. *Global health risks: mortality and burden of disease attributable to selected major risks. Report*. Geneva, Swizerland: World Health Organization; 2009. Report No.: 9244563878.
5. Odegard PS, Capoccia K. Medication taking and diabetes: a systematic review of the literature. *Diabetes Educ*. 2007;33:1014-1029.
6. Stone MA, Charpentier G, Doggen K, et al. Quality of Care of People With Type 2 Diabetes in Eight European Countries. Findings from the Guideline Adherence to Enhance Care (GUIDANCE) study. *Diabetes Care*. 2013;36(9):2628-2638.
7. Donker GA, Fleming DM, Schellevis FG, Spreeuwenberg P. Differences in treatment regimes, consultation frequency and referral patterns of diabetes mellitus in general practice in five European countries. *Fam Pract*. 2004;21:364-369.
8. Brown AF, Ettner SL, Piette J, et al. Socioeconomic position and health among persons with diabetes mellitus: a conceptual framework and review of the literature. *Epidemiol Rev*. 2004;26:63-77.
9. Tatulashvili S, Fagherazzi G, Dow C, Cohen R, Fosse S, Bihan H. Socioeconomic inequalities and type 2 diabetes complications: a systematic review. *Diabetes Metab*. 2019;46:89-99.
10. Slåtsve KB, Claudi T, Lappegård KT, et al. The total prevalence of diagnosed diabetes and the quality of diabetes care for the adult population in Salten, Norway. *Scand J Public Health*. 2020;140349482095100.
11. Bakke Å, Cooper JG, Thue G, et al. Type 2 diabetes in general practice in Norway 2005–2014: moderate improvements in risk factor control but still major gaps in complication screening. *BMJ Open Diabetes Research & Care*. 2017;5:e000459.
12. Helsedirektoratet. Diabetes - Nasjonal faglig retningslinje 2018, [Cited 2020 Nov 24]. https://Helsedirektoratet.no/diabetes
13. Sørensen M, Arneberg F, Line TM, Berg TJ. Cost of diabetes in Norway 2011. *Diabetes Res Clin Pract*. 2016;122:124-132.
14. Kanavos P, Aardweg S, Schurer W. *Diabetes Expenditure, Burden of Disease and Management in 5 EU Countries*. London School of Economics. 2012.
15. Stedman M, Lunt M, Davies M, et al. Cost of hospital treatment of type 1 diabetes (T1DM) and type 2 diabetes (T2DM) compared to the non-diabetes population: a detailed economic evaluation. *BMJ Open*. 2020;10:e033231.
16. Health NDo. Norwegian directorate of health priority guidelines in endocrinology. Diabetes Norway: Norwegian directorate of health; 2015 [Cited 2020 Nov 24]. https://www.helsedirektoratet.no/veiledere/prioriteringsveiledere/endokrinologi-og-endokrinkirurgi/tilstander-for-endokrinologi-og-endokrinkirurgi
17. McAlister FA, Majumdar SR, Eurich DT, Johnson JA. The effect of specialist care within the first year on subsequent outcomes in 24,232 adults with new-onset diabetes mellitus: population-based cohort study. *Quality safety in health care*. 2007;16:6-11.
18. van Bruggen R, Gorter K, Stolk R, Zuithoff P, Verhoeven R, Rutten G. Overall quality of diabetes care in a defined geographic region: different sides of the same story. *Br J Gen Pract*. 2008;58:339-345.
19. Greenfield S, Kaplan SH, Kahn R, Ninomiya J, Griffith JL. Profiling care provided by different groups of physicians: effects of patient case-mix (bias) and physician-level clustering on quality assessment results. *Ann Intern Med*. 2002;136:111-121.
20. De Berardis G, Pellegrini F, Franciosi M, et al. Quality of care and outcomes in Type 2 diabetic patients. *A comparison between general practice and diabetes clinics*. 2004;27:398-406.
21. Ho M, Marger M, Beart J, Yip I, Shekelle P. Is the quality of diabetes care better in a diabetes clinic or in a general medicine clinic? *Diabetes Care*. 1997;20:472-475.
22. Lauffenburger JC, Lewey J, Jan S, Lee J, Ghazinouri R, Choudhry NK. Association of potentially modifiable diabetes care factors with glycemic control in patients with insulin-treated Type 2 diabetes. *JAMA Network Open*. 2020;3(1):e1919645.
23. Giorda C, Picariello R, Nada E, et al. The impact of adherence to screening guidelines and of diabetes clinics referral on morbidity and mortality in diabetes. *PLoS One*. 2012;7:e33839.
24. Post PN, Wittenberg J, Burgers JS. Do specialized centers and specialists produce better outcomes for patients with chronic diseases than primary care generalists? A systematic review. *Int J Qual Health Care*. 2009;21:387-396.
25. Baldo V, Lombardi S, Cocchio S, et al. Diabetes outcomes within integrated healthcare management programs. *Primary Care Diabetes*. 2015;9:54-59.
26. Bonora E, Monami M, Bruno G, Zoppini G, Mannucci E. Attending diabetes clinics is associated with a lower all-cause mortality. A meta-analysis of observational studies performed in Italy. *Nutr Metab Cardiovasc Dis*. 2018;28:431-435.
27. Bakke Å, Dalen I, Thue G, et al. Variation in the achievement of HbA_{1c}, blood pressure and LDL cholesterol targets in type 2 diabetes in general practice and characteristics associated with risk factor control. *Diabet Med*. 2020;37:1471-1481.
28. Bryden KS, Dunger DB, Mayou RA, Peveler RC, Neil HAW. Poor prognosis of young adults with Type 1 diabetes: a longitudinal study. *Diabetes Care*. 2003;26:1052-1057.
29. Honkasalo MT, Linna M, Sane T, Honkasalo A, Elonheimo O. A comparative study of two various models of organising diabetes follow-up in public primary health care – the model influences the use of services, their quality and costs. *BMC Health Services Research*. 2014;14:26.
30. Zgibor JC, Songer TJ, Kelsey SF, et al. The association of diabetes specialist care with health care practices and glycemic control in patients with type 1 diabetes: a cross-sectional analysis from the Pittsburgh epidemiology of diabetes complications study. *Diabetes Care*. 2000;23:472-476.
31. Zgibor JC, Songer TJ, Kelsey SF, Drash AL, Orchard TJ. Influence of health care providers on the development of diabetes complications. *Long-term follow-up from the Pittsburgh Epidemiology of Diabetes Complications Study*. 2002;25:1584-1590.
32. Harris ML, Kuzulugil D, Parsons M, Byles J, Acharya S. "They were all together … discussing the best options for me": Integrating specialist diabetes care with primary care in Australia. *Health Soc Care Community*. 2020;14.Dec.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Slåtsve KB, Claudi T, Lappegård KT, et al. Factors associated with treatment in primary versus specialist care: A population-based study of people with type 2 and type 1 diabetes. *Diabet Med*. 2021;38:e14580. https://doi.org/10.1111/dme.14580