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Population, general practitioner and practice characteristics are associated with screening procedures for microvascular complications in Type 2 diabetes care in Norway

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What's new?

- We found major gaps in microvascular complication screening in Norwegian general practice among people with Type 2 diabetes.
- Screening procedures for microvascular complications were associated with population, general practitioner (GP) and practice characteristics.

- People with short diabetes duration and with no oral anti-hyperglycaemic therapy were rarely screened for complications.
- Younger people (aged < 50 years), and people with macrovascular disease were less likely to have screening procedures performed.
- GP use of a structured diabetes form was associated with higher recordings of microvascular screening procedures.
- Practices with routines for annual diabetes review were more likely to record screening procedures.

Abstract

Aims To assess population, general practitioner (GP) and practice characteristics associated with the performance of microvascular screening procedures and to propose strategies to improve Type 2 diabetes care.

Methods A cross-sectional survey in Norway (281 GPs from 77 practices) identified 8246 people with a Type 2 diabetes duration of 1 year or more. We used multilevel regression models with either the recording of at least two of three recommended screening procedures (albuminuria, monofilament, eye examination) or each procedure separately as dependent variable (yes/no), and characteristics related to the person with diabetes, GP or practice as independent variables.

Results The performance of recommended screening procedures was recorded in the following percentages: albuminuria 31.5%, monofilament 27.5% and eye examination 60.0%. There was substantial heterogeneity between practices, and between GPs within practices for all procedures.

Compared with people aged 60–69 years, those aged < 50 years were less likely to have an albuminuria test performed [odds ratio (OR) 0.75, 95% CI 0.61 to 0.93] and eye examination (OR 0.79, 95% CI 0.66 to 0.95). People with macrovascular disease had fewer screening procedures recorded (OR 0.68, 95% CI 0.59 to 0.78). Use of an electronic diabetes form was associated with improved screening (OR 2.65, 95% CI 1.86 to 3.78). GPs with high workload recorded fewer procedures (OR 0.59, 95% CI 0.39 to 0.90).

Conclusions Performance of screening procedures was suboptimal overall, and in people who should be prioritized. Performance varied substantially between GPs and practices. The use of a structured diabetes form should be mandatory.

<H1>Introduction

Diabetes guidelines worldwide recommend regular screening to detect microvascular complications, because early detection and intervention is important to slow the progression of target organ disease [1–3]. Microvascular disease has significant associations with cardiovascular disease, especially for albuminuria [4–6]. An impaired monofilament test will identify those at moderate risk of foot ulceration, and early eye examination is important to prevent severe stages of retinopathy [7,8]. A urine albumin test and a 10-g monofilament test should be performed at the time of diagnosis of Type 2 diabetes and thereafter annually [1,2]. Eye examination should also be performed at diagnosis and repeated at least biannually [1,2].

Recently, we assessed the quality of care for ~ 9500 people with Type 2 diabetes in general practice in Norway in 2014 using data from the Rogaland–Oslo–Salten–Akershus–Hordaland study (ROSA 4 study) [9]. Measurements of HbA_{1c}, blood pressure, lipids and eGFR were available for 90% of people assessed, and the achievement of treatment targets were comparable with reports from

other countries. However, we found major gaps in screening procedures to detect microvascular complications. Fewer than a third had recorded a test for albuminuria, only one in four had recorded a monofilament test and ~ 60% had a biannual eye examination recorded. The reasons for this poor performance are not known. The results are substantially lower than reports from the National Diabetes Audit (UK), and the Scottish and Swedish diabetes registries [10–12]. Compared with these countries, general practitioners (GPs) in Norway have fewer economic incentives that promote microvascular screening. Furthermore, reporting to the consent-based Norwegian Diabetes Registry is not compulsory and only a minority of GPs send patient data to the registry.

Studies identifying healthcare factors that predict the performance of screening for microvascular complications in diabetes care are scarce. Such studies usually assess quality improvement strategies, the introduction of incentives, feedback to GPs or involvement of ancillary staff [13–16]. Our objectives were to identify person, GP and practice characteristics that are associated with the performance of screening procedures for microvascular complications in routine clinical practice, and if possible propose strategies that may improve Type 2 diabetes care.

<H1>Participants and methods

The ROSA 4 study is a large population-based cross-sectional study of diabetes care in Norwegian general practice that collected data from 2014 [9]. We invited GP practices located in five of Norway's 19 counties including urban and rural areas. We included some urban districts with low socio-economic status and a high proportion of ethnic minorities. In total, 282 GPs (77% of those invited) and 77 practices (73% of those invited) participated in the study. All GPs within a practice were included.

<H2>Sample size

We collected information from the electronic health records (EHR) of all adults with Type 2 diabetes (*n* = 10 248) registered on the participating GPs' lists [9]. We included people with Type 2 diabetes aged 18 years or more who had their main follow-up in general practice and a diabetes duration of > 1 year (*n* = 8 951) (Fig. 1). For regression analyses, we excluded 705 people with Type 2 diabetes due to missing data and one GP responsible for only one person with diabetes, leaving 8246 people with diabetes and 281 GPs in 77 practices for analysis.

Data were captured from electronic records and manually verified by research nurses from January 2015 to April 2016. Ethnicity and education were obtained by linkage to Statistics Norway. A questionnaire was used to gather information related to the GPs and the practices. The response rate after reminders reached 99% completed questionnaires for GPs and 100% for GP practices. The ROSA 4 survey was approved by the Regional Ethical Committee in Norway (2014/1374 REK Vest) and conforms to the Declaration of Helsinki.

The primary outcome was the recording of at least two of the three recommended procedures to detect microvascular complications: albuminuria and monofilament within the last 15 months (1 October 2013 to 31 December 2014) and an eye examination within the last 30 months (1 July 2012 to 31 December 2014). Eye examinations were performed by ophthalmologists, but GPs acted as gatekeepers referring people with diabetes to the ophthalmologists. We examined associations between the primary outcome and population, GP and practice characteristics from the electronic records and the two questionnaires. In addition, we examined associations between these characteristics and each procedure separately.

<H3> *Person variables*

For people with diabetes we collected data on gender, age, diabetes duration, ethnicity (Western Europe vs. others), registered current smoker (yes/no), education (primary school, high school/apprenticeship certification, university), bariatric surgery, macrovascular complications (angina, myocardial infarction, stroke or percutaneous coronary intervention/coronary artery bypass surgery), eGFR calculated by the Chronic Kidney Disease Epidemiology collaboration (CKD-EPI) equation [17], HbA_{1c}, LDL-cholesterol, BP and medication (anti-hyperglycaemic, anti-hypertensive and lipid-lowering therapy). We used the last registered value from the past 3 years for eGFR and LDL-cholesterol, and from the last 15 months for HbA_{1c} and BP, and dichotomized as follows: eGFR < 45 ml min^{-1} 1.73 m^{-2}, HbA_{1c} ≥ 64 mmol/mol (≥ 8.0%), LDL > 3.5 mmol/l and BP > 140/85 mmHg. In the multivariable analyses, missing values for these variables were defined as 'not registered with risk factors'. We did not include BMI in the main analyses because nearly 50% had no weight recorded the last 15 months.

<H3>*GP variables*

GP variables were gender, age, specialist in general practice, days in clinical practice (> 3 vs. ≤ 3 days/week), country of birth (Norway vs. other), country of graduation as medical doctor (Norway vs. other), ≤ 5 years practising as a GP in Norway, number of people with Type 2 diabetes on the GPs' list, total number of people on GPs' list per day worked each week, and use of a structured, electronic form (Noklus diabetes form) in the follow-up. The GP was defined as a user of the form if he/she had used the form in 10 or more people or in > 50% of the people with Type 2 diabetes on their list. We lacked information on number of years practising in Norway for 11 GPs (3.9%). The missing data were imputed based on the year of Norwegian authorization (known for all GPs).

<H3>*Practice variables*

Practice variables were county, urban location (municipalities with > 80% of the population living in densely populated areas according to data from Statistics Norway), practice size (number of GPs per office), total number of people on the list per full-time employed nurse/medical secretary, ancillary staff with diabetes competency (either a specialized diabetes nurse or staff attending a diabetes course within the past 3 years), ancillary staff with responsibility for at least one of the three microvascular procedures, and the use of a reminder system for the annual diabetes care review.

<H2>Statistical analyses

Descriptive statistics are presented as medians, 10th and 90th percentiles for continuous variables, otherwise as percentages. A Venn diagram is presented for the main outcomes. We used multilevel logistic regression models with the recording of at least two of the three procedures to detect microvascular complications as the dependent variable (yes/no) and characteristics related to people with diabetes (level 1), GPs (level 2) and the GP practices (level 3) as independent variables. In addition, we performed analyses with each procedure separately. We report ORs with 95% CIs and with corresponding *P*-values from χ^2 tests. Continuous independent variables were assessed for linearity of effects, and analysed on a categorized scale if this assumption was not met. Variance inflation factors were estimated to check for multicollinearity. Presented results are from univariable analyses and from multivariable analysis with all independent variables on all levels included in the model. All models were fitted using adaptive Gaussian quadrature with seven integration points. For level 2 and 3 variables, a *P*-value ≤ 0.05 was considered to be statistically significant; however, due to the large sample size, we used $P \leq 0.01$ for level 1 (people with diabetes) variables. The partition of variance in the three levels was estimated by intra-cluster correlation coefficients , and we also estimated the proportion change in cluster variance by introduction of explanatory variables [18].

The software program STATA version 15.1 was used with functions xtmelogit and estat icc. The Venn diagram was constructed using Python version 3.7 with package Matplotlib.

<H1>Results

We included 8246 people with Type 2 diabetes attending 281 GPs in 77 practices for analyses. An overview of recorded procedures is shown in Table 1 and Fig. 2. Thirty-five per cent of people with diabetes had two or more screening procedures performed, and approximately one-quarter had none of the recommended procedures performed. Individual, GP and practice characteristics are summarized in Tables 2 and 3, whereas associations between various characteristics and screening procedures are presented in Tables 4–7. Partitions of variation in performance of screening procedures between practices and between people with diabetes, GPs, and practices are given for various models in Table S1.

<H2>Characteristics of people with Type 2 diabetes associated with microvascular screening procedures

People aged < 50 years had procedures recorded less often than those aged 60–69 years. People aged ≥ 80 years had procedures performed less frequently with the exception of eye examination. Longer diabetes duration was associated with increased recording of microvascular screening. The odds for having recorded procedures increased by 14% per 5 years of diabetes duration (OR 1.14), and even more for eye examination (OR 1.26). People from ethnic minorities and people with a lower level of education were less likely to have two screening procedures performed.

People with macrovascular complications had reduced odds of recorded screening procedures (OR 0.68), as had registered current smokers (OR 0.68).

Users of anti-hyperglycaemic agents had two times the odds of having at least two screening procedures recorded compared with people on diet only. Those on anti-hypertensive or lipid-lowering therapies also achieved the primary outcome more often. Blood pressure above intervention thresholds (> 140/85 mmHg) was associated with having microvascular screening procedures recorded.

<H2>GP characteristics associated with microvascular screening procedures

GPs using a structured electronic diabetes form in the follow-up of people with diabetes had an OR of 2.65 for performing at least two microvascular screening procedures compared with non-users, and an OR of 4.51 for performing a monofilament test. GPs who were specialists in general practice had higher odds of recording two or more microvascular procedures (OR 1.50), especially for the albuminuria test (OR 1.73). GP workload seemed to affect the recording of procedures. If GPs had a total list size of 250–350 people per clinical day worked each week, they had significantly lower odds of recording screening procedures compared with GPs responsible for < 250 persons. Their odds of performing a monofilament test were halved, OR 0.52. Further, screening procedures were reduced with 21% per 10 years increase in the age of the GP (OR 0.79). GP gender, ethnicity or number of days in clinical practice per week did not have a significant effect on the recording of microvascular screening procedures.

<H2>Practice characteristics associated with microvascular screening procedures

Practices using reminders for people who did not attend scheduled diabetes appointments or had established routines for annual diabetes care review had almost double the odds of recording two or more screening procedures (OR 1.92), in particular the albuminuria test (OR 2.57) and the monofilament test (1.75). Practices in which ancillary staff were involved in screening procedures, had a 58% higher odds of having recorded an eye examination (OR 1.58). Two counties stood out regarding the recording of procedures with three to four times higher odds than the reference county (Oslo).

<H2>Variation explained

Respectively, 22% and 37% of the variation in the probability of having two or more microvascular procedures recorded was due to systematic differences between practices and between GPs within practices. The heterogeneity was larger for the albuminuria test and smaller for eye examination. After adjustment for population factors, the residual cluster variation for the main outcome (two or more procedures) was reduced by inclusion of GP and practice factors, with the most substantial reduction occurring at practice level. With regard to the separate procedures, we were able to explain the least of the cluster variance for the albuminuria test, whereas for eye examination we were able to explain all of the systematic differences between practices.

<H1>Discussion

This is the first study identifying several important associations with microvascular screening procedures and population, GP and practice characteristics in routine clinical practice for people with Type 2 diabetes. Performance of screening procedures to detect microvascular complications was low in our population, compared with reports from Sweden, Scotland and the UK; albuminuria (73%–75%), foot examination (80%–95%) and eye examination (87%–90%) [10–12].

<H2> Characteristics of people with Type 2 diabetes

Consistent with a previous study [19], the youngest people with diabetes had fewer screening procedures recorded. The explanation might be that GPs think that these people are too young to have developed complications. However, in Sweden excess mortality has been shown in people with Type 2 diabetes and age < 55 years [20].

Because > 50% of the people with diabetes had adequate glucose control in our study, GPs may consider microvascular screening to be unnecessary and downgrade screening procedures in a busy working day. However, microvascular complications are present also in newly diagnosed and well-regulated people, with and without medication [21–23]. The prevalence of albuminuria, neuropathy and retinopathy were ~ 10% each in newly diagnosed persons in the UK [21] and the percentage of microvascular complications were similar regardless of mean HbA_{1c} levels at baseline; i.e. in the group with mean HbA_{1c} as low as 44 mmol/mol (6.2%) vs. the group with mean HbA_{1c} 58 mmol/mol (7.5%).

We found that people with diabetes at high risk of developing complications, such as current smokers and people with macrovascular complications were also less likely to have microvascular screening procedures performed. Their comorbidities might demand more attention during a regular consultation, and consequently microvascular screening procedures may be omitted.

<H2>GP characteristics

A quarter of GPs used a structured diabetes form as part of their routine practice, and they recorded microvascular procedures more often than their counterparts, in particular the monofilament test. The Noklus diabetes form probably works as a reminder to the GPs to perform the recommended processes of care. Additionally, most GPs that used the electronic form in our study, also chose to send data to the Norwegian Diabetes Registry for Adults, and consequently got regular feedback on

process indicators and results. A systematic review of randomized controlled trials have shown that feedback to GPs improves process outcomes such as foot and eye examinations [14], although another randomized study showed no effect on the performance of eye examinations [24]. Using a simple web-based diabetes-specific form in the Netherlands showed increased recordings of process indicators compared with the GPs using only electronic records [25].

GPs with a high number of people on their patient list had fewer recordings of microvascular screening procedures, in particular the monofilament test, possibly because they find it time-consuming. A recent report from the Norwegian Directorate of Health showed that GPs have an increasing number of administrative tasks and long working days with an average of 56 h per week including emergency service [26]. Our observations also suggest that older GPs tend to omit performance or documentation of microvascular screening procedures. Comparable data on GP associations are sparse.

<H2>Practice characteristics

Practices with good routines for an annual diabetes care review and a system for sending reminders to people who do not meet for scheduled appointment were more likely to perform microvascular screening procedures. This implies that structure in diabetes care is important.

Previous studies have shown improved process indicators when nurses assisted GPs [27,28]. In this study, we did not find any significant associations with the number of ancillary staff that could unburden the GPs workload. Staff with diabetes competency or specific tasks related to microvascular complication screening were positively associated with the processes of care, but had no significant impact in our multivariable analyses with the exception of eye examination. However, in the UK, Scotland and Sweden with high reported performance of microvascular screening procedures in general practice, nurses play an important role in diabetes care [10–12]. In these

countries, keys to success might have been the support of political and financial systems, the county council's decision to support registration in a diabetes registry, and the involvement of local nurses or team-based district nurses [29,30].

<H2>Strengths and limitations

Our study presents real-life data from general practice. The data quality is good because research nurses read all the EHRs to verify electronically captured variables and collected additional information from the records. The response rate among GPs and practices were quite high, and all GPs within a practice were included. Thus, our data set reflects the quality of diabetes care in general practice. Further, we had the possibility to adjust for patient characteristics (including education and ethnicity) when assessing GP and practice characteristics. We analysed a comprehensive number of explanatory variables at three different levels (population, GP and practice). We also included the elderly > 80 years to give us a broad spectrum of complication screening in general practice.

One of the strengths of our study is also our main limitation; the use of EHR. Routinely collected data may be inaccurate, and we have missing data. The missing data can be caused by true missing variables, inconsistency between care provided and care recorded, or selective performance of processes. We excluded 705 people (7.9%) due to missing data in one or more of the following variables: diabetes duration (*n* = 562), ethnicity (*n* = 5), education (*n* = 168). The people for whom diabetes duration had not been recorded (6.3%) were older with a median age of 68 years, had fewer screening procedures performed (two or more screening procedures; 14.8%), and generally more incomplete health records. We suspect that at least some of these people had newly diagnosed diabetes, thus would not have been included in our analyses. Ethnicity and education were gathered from Statistics Norway, thus this missingness was unlikely to be related to diabetes

care. We may have underestimated the effect of current smoking, chronic kidney disease, high HbA_{1c}, hypertension and hyperlipidaemia as we chose to categorize these variables and define missing values to be 'not registered with risk factor'. Finally, the observational design of our study prevents us from making claims regarding causal relationships.

GPs in two counties recorded more procedures than those in other counties. This may be explained by the fact that two opinion-leading diabetologists have for many years organized education sessions for GPs and ancillary staff in these areas.

<H2>Implications

Our findings of the advantage of using a structured electronic form as a reminder at the annual diabetes review is, in our view, likely to be a general finding independent of country. In particular, it will be of interest in countries without a comprehensive diabetes register and where GPs not are paid for performance. Further, we find poorer performance of screening for microvascular complications in the youngest, people with diabetes of short duration and people with severe macrovascular complications. If replicated in other studies, these findings would send a serious signal to the diabetes community about suboptimal care in these groups.

Although we have included a lot of variables related to demographics and the health of people with diabetes, we have no knowledge of other factors (psychological, motivational and practical) that may have reduced the likelihood of procedures being performed. Furthermore, there was substantial residual heterogeneity between practices and between GPs. A qualitative study comprising interviews with people with diabetes, GPs and others involved in diabetes care could provide further knowledge about why so many people with diabetes are not being screened for microvascular complications.

<H1>Conclusion

There is considerable potential for improvement in complication screening in Norwegian general practice. We found worse performance of microvascular screening procedures in people not on anti-hyperglycaemic drugs and those with diabetes of short duration despite guidelines recommending microvascular screening at the time of diabetes diagnosis. In addition, microvascular screening was low in people aged < 50 years, smokers, those from minority ethnic groups, people with a low level of education, and those with macrovascular disease. The GPs' use of a structural, electronic diabetes form was a strong positive predictor of screening procedures, as were specialists in general practice, and GP practices with established routines for an annual diabetes care review. We suggest that diabetes care in general practice can be improved by establishing good routines for annual review and by making use of a structured electronic form (or similar tool) mandatory.

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Competing interests

None declared.

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Author contributions

ÅB participated in the data collection, quality-checked, analysed the data, and drafted, reviewed and edited the manuscript. JGC and AKJ conceived the study protocol and analysis plan, applied to the Regional Ethics Committee, invited GPs and GP practices, contributed to the discussion, and reviewed and edited the manuscript. SSa, GT, TC, ATT, TJB, KFL, TVM and BG conceived the study protocol and analysis plan, invited GPs and GP practices, contributed to the discussion, and reviewed and edited the manuscript . In addition, ATT quality-checked the data. ID performed statistical analyses, contributed to the discussion, reviewed and edited the manuscript. KN quality-checked the data, contributed to the discussion, reviewed and edited the manuscript. SSk, SC contributed to the discussion, reviewed and edited the manuscript. ÅB is the guarantor of this work, and as such had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analyses.

References

1 10. Microvascular Complications and Foot Care: Standards of Medical Care in Diabetes-2018. *Diabetes Care* 2018; **41(Suppl 1)**: S105–S118.

2 Helsedirektoratet. Nasjonal faglig retningslinje for diabetes 2016. Available at https://helsedirektoratet.no/retningslinjer/diabetes Last accessed 1 August 2018.

3 National Istitute for Health and Care Excellence. *Type 2 Diabetes in Adults: Management* [NG28]. Available at https://www.nice.org.uk/guidance/ng28/chapter/1-Recommendations Last accessed 1 August 2018.

4 Brownrigg JR, Hughes CO, Burleigh D, Karthikesalingam A, Patterson BO, Holt PJ *et al*. Microvascular disease and risk of cardiovascular events among individuals with type 2 diabetes: a population-level cohort study. *Lancet Diabetes Endocrin* 2016; **4**: 588–597.

5 Bakris GL, Molitch M. Microalbuminuria as a risk predictor in diabetes: the continuing saga. *Diabetes Care* 2014; **37**: 867–875.

6 Fung CS, Wan EY, Chan AK, Lam CL. Association of estimated glomerular filtration rate and urine albumin-to-creatinine ratio with incidence of cardiovascular diseases and mortality in chinese patients with type 2 diabetes mellitus – a population-based retrospective cohort study. *BMC Nephrol* 2017; **18**: 47.

7 Scanlon PH, Aldington SJ, Stratton IM. Delay in diabetic retinopathy screening increases the rate of detection of referable diabetic retinopathy. *Diabet Med* 2014; **31**: 439–442.

8 Crawford F, Cezard G, Chappell FM, Murray GD, Price JF, Sheikh A *et al*. A systematic review and individual patient data meta-analysis of prognostic factors for foot ulceration in people with diabetes: the international research collaboration for the prediction of diabetic foot ulcerations (PODUS). *Health Technol Assess* 2015; **19**: 1–210.

9 Bakke A, Cooper JG, Thue G, Skeie S, Carlsen S, Dalen I *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 Res care* 2017; **5**: e000459.

10 Healthcare Quality Improvement Partnership. *National Diabetes Audit 2015*. Available at http://www.hqip.org.uk/resources/national-diabetes-audit-2013-2014-2014-2015-report-1-care-processes-and-treatment-targets/ Last accessed 1 August 2018.

11 Nationella Diabetesregistret. *Nationella Diabetesregistret 2014*. Available at https://www.ndr.nu/pdfs/Arsrapport_NDR_2014.pdf Last accessed 1 August 2018.

12 Scottish Diabetes Survey 2014. *Scottish Diabetes Survey 2014*. Available at http://www.diabetesinscotland.org.uk/Publications/SDS2014.pdf Last accessed 1 August 2018.

13 Calvert M, Shankar A, McManus RJ, Lester H, Freemantle N. Effect of the quality and outcomes framework on diabetes care in the United Kingdom: retrospective cohort study. *BMJ* 2009; **338**: b1870.

14 Guldberg TL, Lauritzen T, Kristensen JK, Vedsted P. The effect of feedback to general practitioners on quality of care for people with type 2 diabetes. A systematic review of the literature. *BMC Fam Pract* 2009; **10**: 30.

15 Welch G, Allen NA, Zagarins SE, Stamp KD, Bursell SE, Kedziora RJ. Comprehensive diabetes management program for poorly controlled Hispanic type 2 patients at a community health center. *Diabetes Educ* 2011; **37**: 680–688.

16 Wong CKH, Fung CSC, Yu EYT, Wan EYF, Chan AKC, Lam CLK. Temporal trends in quality of primary care for patients with type 2 diabetes mellitus: a population-based retrospective

cohort study after implementation of a quality improvement initiative. *Diabetes Metab Res Rev* 2018; 34 doi: 10.1002/dmmr.2952.

17 Levey AS, Stevens LA, Schmid CH, Zhang YL, Castro AF 3rd, Feldman HI *et al*. A new equation to estimate glomerular filtration rate. *Ann Intern Med* 2009; **150**: 604–612.

18 Austin PC, Merlo J. Intermediate and advanced topics in multilevel logistic regression analysis. *Stat Med* 2017; **36**: 3257–3277.

19 Moreton RBR, Stratton IM, Chave SJ, Lipinski H, Scanlon PH. Factors determining uptake of diabetic retinopathy screening in Oxfordshire. *Diabet Med* 2017; **34**: 993–999.

20 Tancredi M, Rosengren A, Svensson AM, Kosiborod M, Pivodic A, Gudbjornsdottir S *et al*. Excess mortality among persons with Type 2 diabetes. *N Engl J Med* 2015; **373**: 1720–1732.

21 Azam M, Marwood L, Ismail K, Evans T, Sivaprasad S, Winkley K *et al*. Diabetes complications at presentation and one year by glycated haemoglobin at diagnosis in a multiethnic and diverse socioeconomic population: results from the South London Diabetes Study. *J Diabetes Res* 2015; **2015**: 587673.

22 Colagiuri S, Lee CM, Wong TY, Balkau B, Shaw JE, Borch-Johnsen K. Glycemic thresholds for diabetes-specific retinopathy: implications for diagnostic criteria for diabetes. *Diabetes Care* 2011; **34**: 145–150.

23 Sandbaek A, Griffin SJ, Sharp SJ, Simmons RK, Borch-Johnsen K, Rutten GE *et al*. Effect of early multifactorial therapy compared with routine care on microvascular outcomes at 5 years in people with screen-detected diabetes: a randomized controlled trial: the ADDITION-Europe Study. *Diabetes Care* 2014; **37**: 2015–2023.

24 Guldberg TL, Vedsted P, Kristensen JK, Lauritzen T. Improved quality of Type 2 diabetes care following electronic feedback of treatment status to general practitioners: a cluster randomized controlled trial. *Diabet Med* 2011; **28**: 325–332.

25 Barkhuysen P, de Grauw W, Akkermans R, Donkers J, Schers H, Biermans M. Is the quality of data in an electronic medical record sufficient for assessing the quality of primary care? *J Am Med Inform Assoc* 2014; **21**: 692–698.

26 Helsedirektoratet. *Fastlegeres tidsbruk 2018*. Available at https://www.regjeringen.no/no/dokumenter/fastlegers-tidsbruk/id2592992/ Last accessed 1 August 2018.

27 Lenz ER, Mundinger MO, Hopkins SC, Lin SX, Smolowitz JL. Diabetes care processes and outcomes in patients treated by nurse practitioners or physicians. *Diabetes Educ* 2002; **28**: 590–598.

28 Petek D, Mlakar M. Quality of care for patients with diabetes mellitus type 2 in 'model practices' in Slovenia – first results. *Zdravstveno varstvo* 2016; **55**: 179–184.

29 Hallgren Elfgren IM, Tornvall E, Grodzinsky E. The process of implementation of the diabetes register in primary health care. *Int J Qual Health Care* 2012; **24**: 419–424.

30 Vamos EP, Pape UJ, Bottle A, Hamilton FL, Curcin V, Ng A *et al*. Association of practice size and pay-for-performance incentives with the quality of diabetes management in primary care. *CMAJ* 2011; **183**: E809–E816.

FIGURE 1. Flow chart depicting the exclusion process for people with diabetes in the ROSA 4 study to fit criteria for the regression analysis of the present study. ROSA 4 (Rogaland-Oslo-Salten-Akershus-Hordaland study in 2014); GP, general practitioner; LADA, latent autoimmune diabetes of the adult; MODY, maturity onset diabetes of the young.

FIGURE 2. Venn diagram of 8246 people with Type 2 diabetes and a test for albuminuria, monofilament and/or eye examination.

<H1>Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Variance components for three-level logistic regression models including explanatory factors relating to people with diabetes, general practitioners and practices.

Table 1 Recorded microvascular screening procedures in the 8246 people with Type 2 diabetes in Norway included in the study

Microvascular screening procedures	*N* (%)
Albuminuria test	2596 (31.5)
Monofilament test	2264 (27.5)
Eye examination	4946 (60.0)
No. of recorded procedures*	
0	2332 (28.3)
1	3033 (36.8)
2	1870 (22.7)
3	1011 (12.3)

*Tests for albuminuria, monofilament and/or eye examination.

Table 2 Characteristics of people with Type 2 diabetes included in the study

Characteristics	Missing observations *n* (%)	Median (10–90 percentiles) or percentage
N = 8246		
Men	–	55.0
Age (years)	–	66 (48–82)
< 50		12.1
50–59		19.9
60–69		29.9
70–79		24.6
≥ 80		13.5
Born in Western Europe	–	84.9
Education		
Primary school	–	36.6
High school/craftsmanship	–	44.9
University	–	18.4
Diabetes duration (years)	–	7 (2–18)
Current smoker	1 524 (18)	22.1/18.0*
BMI (kg/m^2)	4 434 (54)	29.1 (23.5–37.4)
Bariatric surgery	12 (0.1)	1.6/1.6*
Macrovascular complications†	21 (0.3)	27.3/27.3*
Coronary heart disease	9 (0.1)	22.2
Stroke	8 (0.1)	7.2
Peripheral arterial surgery	24 (0.3)	2.0
eGFR (ml min^{-1} 1.73 m^{-2})	375 (4.5)	85.2 (52.0–105.7)
eGFR <45 ml min^{-1} 1.73 m^{-2}		6.4/6.1*
HbA_{1c} (mmol/mol)	828 (10)	51 (40–68)
HbA_{1c} (%)		6.8 (5.8-8.4)
HbA_{1c} ≥ 64 mmol/mol (≥ 8.0%)		17.0/15.3*
SBP (mmHg)	984 (12)	135 (116–156)
BP >140/85 mmHg		35.6/31.4*
LDL (mmol/l)	1 242 (15)	2.6 (1.6-4.0)
> 3.5		19.2/16.3*
Anti-hyperglycaemic therapy		
Diet only	-	30.9
Agents without insulin	-	54.1
Agents combined with insulin	-	15.0
Anti-hypertensives	-	66.8
Lipid-lowering therapy	-	56.1
Noklus diabetes form used‡	18 (0.2)	24.2/24.1*

*Percentages of 8246 people with missing values are defined as 'not registered with risk factor'.

†Composite variable of either coronary heart disease, stroke and/or peripheral arterial surgery.

‡If the Noklus diabetes form was ≥ 50% completed.

Table 3 Characteristics of the general practitioners and practices included in the study

Characteristics	Missing observations *n* (%)	Median (10–90 percentiles) or percentage
GP (*N* = 281)		
Men	–	55.2
Age	–	50 (34–64)
Born in Norway	–	81.1
Medical education in Norway	–	70.8
Years as a GP in Norway	11 (3.9)	18 (3–35)
≤ 5		18.1/19.9*
Specialist in general practice	–	67.3
No. of people with Type 2 diabetes	–	34 (14–60)
< 25		23.5
25–49		47.0
≥ 50		29.5
Clinical days per week	–	4 (3–5)
< 3		6.4
3–4		54.1
> 4		39.5
Clinical days per week > 3	–	81.5
No. of people on list	–	1217 (792–1564)
Total no. of persons on GPs list per day worked each week	–	296 (218–392)
< 250		25.6
250–350		54.8
> 350		19.6
User of Noklus diabetes form†	–	26.0
Practice (*N* = 77)		
County		
Oslo	–	15.6
Akershus	–	13.0
Hordaland	–	13.0
Rogaland	–	24.7
Nordland	–	33.8
Urban location	–	80.5
No. of GPs per office	–	3.0 (1.0–6.2)
No. of people with Type 2 diabetes	–	120 (56–233)
No. of people on list per office	–	4171 (1479–8103)
No. of people on list per full-time ancillary staff‡	–	1427 (805–1989)
Ancillary staff		
Any nurse employed	–	42.9
Diabetes specialized nurse employed	–	19.5
Ancillary staff attending diabetes course§	–	42.1
Duties related to microvascular complication screening¶	–	18.2
Diabetes competency	–	49.4
Routine annual diabetes review/reminders	–	24.7

*Percentage after imputation.

†GP defined as a user of the form if used in ≥ 10 people with diabetes or > 50% of people with diabetes on the GP's list.

‡Ancillary staff: nurses and medical secretaries.

§Attendance at a diabetes course within the last 3 years.

¶Foot examination, checking that albuminuria test or eye examination has been performed as recommended in national guidelines.

Diabetes competency: diabetes specialist nurse or attendance at a diabetes course within the last 3 years.

Table 4 Characteristics of people with Type 2 diabetes with odds ratios (OR) for having two or more microvascular screening procedures performed

Characteristics	Univariable analysis		Multivariable analysis	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
N = 8 246				
Men	0.98 (0.88–1.09)	0.73	0.94 (0.83–1.05)	0.28
Age (years)				
< 50	0.61 (0.50–0.73)	<0.001	0.79 (0.65–0.98)	0.028
50–59	0.94 (0.81–1.10)	0.45	1.08 (0.92–1.27)	0.36
60–69	1		1	
70–79	1.02 (0.88–1.17)	0.83	0.99 (0.85–1.15)	0.89
≥ 80	0.53 (0.44–0.63)	<0.001	0.57 (0.46–0.69)	<0.001
Born in Western Europe	1.28 (1.08–1.53)	0.005	1.29 (1.07–1.57)	0.009
Education				
Primary school	1		1	
High school/apprenticeship	1.24 (1.10–1.40)	<0.001	1.19 (1.04–1.35)	0.008
University	1.25 (1.07–1.45)	0.005	1.21 (1.03–1.42)	0.022
Diabetes duration per 5 years	1.21 (1.16–1.25)	<0.001	1.14 (1.09–1.20)	<0.001
Registered as current smoker*	0.74 (0.64–0.85)	<0.001	0.68 (0.59–0.79)	<0.001
Registered with bariatric surgery*	0.46 (0.29–0.73)	0.001	0.50 (0.31–0.82)	0.006
Registered with macrovascular complications*†	0.82 (0.73–0.93)	0.002	0.68 (0.59–0.78)	<0.001
Registered with chronic kidney disease*‡	0.75 (0.60–0.94)	0.011	0.78 (0.61–1.00)	0.050
Registered with high HbA_{1c}*§	1.36 (1.17–1.57)	<0.001	1.02 (0.86–1.20)	0.84
Registered with hypertension*¶	1.20 (1.07–1.35)	0.002	1.20 (1.06–1.36)	0.003
Registered with hyperlipidaemia*	0.82 (0.71–0.95)	0.007	0.99 (0.84–1.16)	0.87
Anti-hyperglycaemic therapy				
Diet only	1		1	
Agents without insulin	2.61 (2.28–2.99)	<0.001	2.19 (1.89–2.53)	<0.001
Agents combined with insulin	3.17 (2.65–3.78)	<0.001	2.40 (1.94–2.95)	<0.001
Anti-hypertensives	1.58 (1.40–1.78)	<0.001	1.22 (1.07–1.40)	0.004
Lipid-lowering therapy	1.94 (1.73–2.17)	<0.001	1.60 (1.41–1.83)	<0.001

*Missing observations are defined as 'not registered with risk factor'.

†Composite variable of either coronary heart disease, stroke and/or peripheral arterial surgery.

‡eGFR <45 ml min^{-1} 1.73 m^{-2}.

§HbA_{1c} ≥64 mmol/mol (≥8.0%).

¶Blood pressure > 140/85 mmHg (missing observations are defined as 'not registered with risk factor').

LDL >3.5 mmol/l (missing observations are defined as 'not registered with risk factor').

Table 5 Characteristics of general practitioners and practices with odds ratios (OR) for having two or more microvascular screening procedures performed

Characteristic	Univariable analysis		Multivariable analysis	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
GP (*N* = 281)				
Men	0.82 (0.63–1.07)	0.15	0.78 (0.58–1.04)	0.091
Age per 10 years	0.77 (0.68–0.88)	<0.001	0.79 (0.66–0.93)	0.005
Born in Norway	1.23 (0.83–1.83)	0.31	1.25 (0.78–2.00)	0.35
Medical education in Norway	1.24 (0.90–1.70)	0.18	0.99 (0.67–1.44)	0.94
≤5 years as a GP in Norway*	0.82 (0.56–1.19)	0.29	1.15 (0.70–1.89)	0.58
Specialist in general practice	1.31 (0.95–1.80)	0.10	1.50 (1.00–2.25)	0.049
No. of people with Type 2 diabetes per GP				
< 25	1		1	
25–49	1.57 (1.07–2.32)	0.021	1.66 (1.09–2.53)	0.018
≥ 50	1.04 (0.67–1.60)	0.88	1.27 (0.76–2.12)	0.35
Clinical days per week > 3	1.09 (0.73–1.62)	0.67	0.71 (0.46–1.08)	0.11
Total no. of people on GP's list per day worked each week				
< 250	1		1	
250–350	0.63 (0.42–0.96)	0.030	0.59 (0.39–0.90)	0.015
> 350	0.51 (0.31–0.84)	0.009	0.55 (0.32–0.94)	0.029
User of a structured diabetes	3.02 (2.12–4.30)	<0.001	2.65 (1.86–	<0.001

form			3.78)	
Practice (*n*=77)				
County				
Oslo	1		1	
Akershus	1.35 (0.60–3.03)	0.47	1.25 (0.58–2.67)	0.57
Hordaland	1.79 (0.79–4.04)	0.16	1.78 (0.82–3.88)	0.15
Rogaland	3.59 (1.74–7.37)	0.001	2.71 (1.35–5.46)	0.005
Nordland	5.68 (2.89–11.17)	<0.001	4.14 (1.87–9.16)	<0.001
Urban location	0.51 (0.26–1.03)	0.062	1.51 (0.77–2.96)	0.24
No. of GPs per office	1.01 (0.87–1.18)	0.87	1.04 (0.92–1.18)	0.52
Ancillary staff†				
Total no of people on list per full-time staff†	0.74 (0.56–0.97)	0.032	1.07 (0.82–1.41)	0.61
Duties related to microvascular complication screening‡	2.63 (1.34–5.16)	0.005	1.15 (0.62–2.12)	0.66
Diabetes competency§	2.35 (1.39–3.97)	0.001	1.09 (0.69–1.74)	0.71
Routines of annual diabetes review/reminders	2.19 (1.17–4.08)	0.014	1.92 (1.10–3.34)	0.021

Multivariable results are adjusted for all characteristics listed. All models include random intercepts for practices and for general practitioners within practices.

*Imputed for 11 GPs.

†Ancillary staff: nurses and medical secretaries.

‡Foot examination, or checking that albuminuria test and/or eye examination have been performed as recommended in national guidelines.

§Diabetes competency: diabetes specialist nurse or attendance at a diabetes course in the last 3 years.

Table 6 Characteristics of people with Type 2 diabetes with odds ratios (OR) for having a test for albuminuria, monofilament or eye examination performed

	Albuminuria		Monofilament		Eye examination**	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
N = 8246						
Men	1.07 (0.95–1.22)	0.26	1.00 (0.88–1.13)	0.97	0.85 (0.76–0.94)	0.002
Age (years)						
< 50	0.75 (0.61–0.93)	0.009	0.79 (0.63–0.99)	0.039	0.79 (0.66–0.95)	0.012
50–59	0.94 (0.79–1.11)	0.46	1.08 (0.91–1.29)	0.37	0.99 (0.85–1.14)	0.85
60–69	1		1		1	
70–79	0.89 (0.76–1.04)	0.16	0.95 (0.81–1.12)	0.54	1.15 (1.00–1.32)	0.056
≥ 80	0.50 (0.40–0.62)	<0.001	0.63 (0.51–0.78)	<0.001	0.92 (0.77–1.10)	0.38
Born in Western Europe	1.14 (0.93–1.38)	0.20	1.34 (1.08–1.66)	0.008	0.92 (0.79–1.09)	0.34
Education						
Primary school	1		1		1	
High school/apprenticeship	1.10 (0.96–1.26)	0.15	1.03 (0.90–1.19)	0.62	1.24 (1.11–1.39)	<0.001
University	1.06 (0.90–1.26)	0.47	1.06 (0.89–1.26)	0.54	1.24 (1.07–1.44)	0.004
Diabetes duration per 5 years	1.05 (1.00–1.10)	0.078	1.12 (1.07–1.18)	<0.001	1.26 (1.20–1.31)	<0.001
Registered as current smoker*	0.78 (0.67–0.91)	0.002	0.79 (0.67–0.92)	0.003	0.66 (0.58–0.75)	<0.001
Registered with bariatric surgery*	0.60 (0.36–1.00)	0.049	0.51 (0.30–0.87)	0.014	0.67 (0.45–1.00)	0.050
Registered with macrovascular complications*†	0.69 (0.60–0.80)	<0.001	0.72 (0.62–0.83)	<0.001	0.82 (0.72–0.92)	0.001
Registered with chronic kidney disease*‡	0.93 (0.72–1.21)	0.60	0.77 (0.60–1.00)	0.052	0.74 (0.60–0.93)	0.008
Registered with high HbA_{1c}*§	1.11 (0.93–1.31)	0.25	0.99 (0.83–1.18)	0.92	0.94 (0.81–1.09)	0.40
Registered with hypertension*¶	1.34 (1.18–1.52)	<0.001	1.15 (1.01–1.31)	0.036	1.06 (0.95–1.19)	0.29
Registered with hyperlipidaemia*	1.09 (0.93–1.29)	0.28	1.07 (0.90–1.26)	0.46	0.89 (0.77–1.02)	0.085
Anti-hyperglycaemic therapy						
Diet only	1		1		1	
Agents without insulin	1.72 (1.48–1.99)	<0.001	2.12 (1.81–2.48)	<0.001	1.89 (1.67–2.13)	<0.001
Agents combined with insulin	1.29 (1.03–1.60)	0.026	2.86 (2.29–3.57)	<0.001	2.40 (1.98–2.90)	<0.001
Anti-hypertensives	1.31 (1.13–1.51)	<0.001	1.20 (1.04–1.39)	0.016	1.04 (0.93–1.18)	0.48
Lipid-lowering therapy	1.54 (1.34–1.76)	<0.001	1.41 (1.23–1.62)	<0.001	1.38 (1.23–1.55)	<0.001

Results from multivariable analyses include all characteristics. The models also include random intercepts for practices and for general practitioners within practices.

*Missing observations are defined as "not registered with risk factor".

†Composite variable of either coronary heart disease, stroke and/or peripheral arterial surgery.

‡eGFR < 45 ml min^{-1} 1.73 m^{-2}.

§HbA_{1c} ≥ 64 mmol/mol (≥8.0%).

¶Blood pressure > 140/85 mmHg (missing observations are defined as 'not registered with risk factor').

LDL > 3.5 mmol/l (missing observations are defined as 'not registered with risk factor').

**Multivariable analysis for eye examination is performed without random effects on practice level due to no unexplained variation.

Table 7 Characteristics of general practitioners and practices with odds ratios (OR) for having a test for albuminuria, monofilament or eye examination performed

Characteristic	Albuminuria		Monofilament		Eye examination¶	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
GP (*N* = 281)						
Men	0.90 (0.62–1.30)	0.57	0.76 (0.56–1.03)	0.076	0.83 (0.68–1.01)	0.067
Age per 10 years	0.76 (0.61–0.94)	0.012	0.84 (0.71–1.00)	0.052	0.91 (0.82–1.02)	0.098
Born in Norway	1.01 (0.55–1.84)	0.98	1.40 (0.86–2.27)	0.17	1.10 (0.83–1.47)	0.51
Medical education in Norway	0.88 (0.54–1.43)	0.60	1.21 (0.81–1.81)	0.34	1.14 (0.89–1.45)	0.29
≤5 years as a GP in Norway*	1.34 (0.71–2.54)	0.91	1.22 (0.73–2.01)	0.45	0.98 (0.71–1.35)	0.89
Specialist in general practice	1.73 (1.01–2.96)	0.046	1.12 (0.74–1.69)	0.59	1.29 (1.00–1.66)	0.047
No. of people with Type 2 diabetes per GP						
< 25	1		1		1	
25–49	1.38 (0.81–2.35)	0.23	1.32 (0.86–2.04)	0.20	1.49 (1.13–1.98)	0.006
≥ 50	1.20 (0.63–2.29)	0.59	1.00 (0.59–1.68)	0.99	1.38 (1.00–1.92)	0.051
Clinical days per week >3	0.89 (0.51–1.55)	0.67	0.74 (0.48–1.14)	0.17	0.79 (0.60–1.03)	0.085
Total no. people on GP's list per clinical day						
<250	1		1		1	
250–350	0.85 (0.48–1.49)	0.57	0.52 (0.34–0.80)	0.003	0.82 (0.64–1.06)	0.12
>350	0.64 (0.32–1.31)	0.23	0.52 (0.31–0.89)	0.016	0.83 (0.61–1.14)	0.26
User of a structured diabetes form	1.45 (0.90–2.33)	0.13	4.51 (3.17–6.40)	<0.001	1.38 (1.11–1.71)	0.004

Practice (*N* = 77)						
County						
Oslo	1		1		1	
Akershus	1.18 (0.34–4.08)	0.80	1.65 (0.85–3.22)	0.14	0.82 (0.60–1.13)	0.23
Hordaland	0.73 (0.20–2.67)	0.64	2.27 (1.14–4.50)	0.019	2.43 (1.74–3.38)	<0.001
Rogaland	3.43 (1.11–10.60)	0.032	3.28 (1.76–6.11)	<0.001	1.78 (1.31–2.44)	<0.001
Nordland	5.40 (1.47–19.89)	0.011	2.44 (1.22–4.91)	0.012	3.24 (2.27–4.63)	<0.001
Urban location	1.74 (0.58–5.27)	0.32	1.06 (0.59–1.92)	0.84	0.92 (0.66–1.27)	0.61
No. of GPs per office	1.35 (1.08–1.67)	0.007	0.93 (0.84–1.04)	0.23	1.01 (0.95–1.06)	0.85
Ancillary staff†						
Total no. of people on list per full-time staff	1.05 (0.67–1.65)	0.82	1.15 (0.92–1.45)	0.23	1.01 (0.90–1.13)	0.84
Duties related to microvascular complication screening‡	0.65 (0.24–1.78)	0.40	1.30 (0.77–2.21)	0.33	1.58 (1.20–2.08)	0.001
Diabetes competency§	1.05 (0.49–2.27)	0.89	1.15 (0.77–1.72)	0.49	1.02 (0.83–1.25)	0.87
Routines of annual follow-up/reminders	2.57 (1.04–6.33)	0.040	1.75 (1.07–2.84)	0.025	1.13 (0.87–1.45)	0.36

Results from multivariable analyses include all characteristics. The models also include random intercepts for practices and for general practitioners within practices.

*Imputed value for 11 GPs.

†Ancillary staff: nurses and medical secretaries.

‡oot examination, or checking that albuminuria test and/or eye examination have been performed as recommended in national guidelines.

§Diabetes competency: diabetes specialist nurse or attendance at a diabetes course within the last 3 years.

¶Multivariable analysis for eye examination is performed without random effects on practice level due to no unexplained variation.