Chapter 4

Potential overtreatment and undertreatment of diabetes in different patient age groups in primary care after the introduction of performance measures

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Abstract

Objective

To assess whether after the introduction of diabetes performance measures decreases in undertreatment correspond with increases in overtreatment for blood pressure (BP) and glycaemic control in different patient age groups.

Methods

We conducted a cohort study using data from the Groningen Initiative to Analyze Type 2 Diabetes Treatment database. General practices were included when data were available from 1 year before to at least 1 year after the introduction of diabetes performance measures. Included patients had a confirmed diagnosis of type 2 diabetes. Potential overtreatment was defined as prescribing maximum treatment or a treatment intensification to patients with a sustained low-risk factor level. Potential undertreatment was defined as a lack of treatment intensification in patients with a sustained high-risk factor level. Percentages of over- and undertreated patients at baseline were compared with those in subsequent years, and stratified analyses were performed for different patient age groups.

Results

For BP, undertreatment significantly decreased from 61 to 57% in the first year after the introduction of performance measures. In patients >75 years of age, undertreatment decreased from 65 to ~61%. Overtreatment was relatively stable (~16%). For glycaemic control, undertreatment significantly increased from 49 to 53%, and overtreatment remained relatively stable (~7%).

Conclusions

The improvement of BP undertreatment after introduction of the performance measures did not correspond with an increase in overtreatment. The performance measures appeared to have little impact on improving glucose-regulating treatment. The trends did not differ among patient age groups.

Introduction

The quality of diabetes care, and in particular potential undertreatment of cardiometabolic risk factors, has received much attention in the past decade. Several improvements have been observed in the process as well as the outcomes of the care for patients with type 2 diabetes [1–3]. These improvements have been stimulated by quality assurance and pay-for-performance programs, which incorporate performance measurements focusing on achieving risk factor targets [4–6].

In clinical guidelines for diabetes management (DM), the general target for glycohemoglobin (HbA_{1c}) concentration is set at <7% (53 mmol/mol) and for systolic blood pressure (SBP) at <140 mmHg or even <130 mmHg for some patients [7,8]. However, the debate about the target levels being too strict has intensified, in particular with regard to the aged patients [9–12]. In addition, concerns have been raised that the introduction of performance measures may stimulate potential overtreatment since providers are rewarded with financial incentives for achieving strict targets [9,13]. Recently, Kerr et al. [14] reported that among veterans with diabetes, potential overtreatment for BP was approaching that of undertreatment. These findings may not be unique for BP treatment, and similar trends may be expected for glucose-regulating treatment.

One may expect that the influence of performance measures will differ in different settings as well as among general practices (GPs) [15]. Performance rates and the extent of potential overtreatment may vary among practitioners and facilities [14,16], and changing this performance is a complex process that is influenced by multiple factors [17]. Kerr et al. [14] found that facilities with low levels of undertreatment were more likely to have higher levels of overtreatment.

Our aim was to assess whether, after the introduction of performance measures in the Netherlands, decreases in potential undertreatment for BP and glycaemic control correspond with increases in potential overtreatment in patients with type 2 diabetes. In addition, we assessed whether under- and overtreatment differ for different patient age groups.

Methods

Study design

We conducted an observational, dynamic cohort study from 2007–2011 of patients with type 2 diabetes in GPs in the province of Groningen in the Netherlands. The GPs are all member of a diabetes care group (DCG). Such DCGs, comparable with accountable care organizations in the USA, were formed after the introduction of bundled payment in 2007 in the Netherlands [18]. The DCGs are responsible for the organization and

provision of diabetes care in accordance with the Dutch Diabetes Federation Health Care Standard [19]. Diabetes performance measures were instituted in this region from 2008 onwards as part of this program. GPs received yearly feedback comparing their own practice performance with performance measures of the whole region and with benchmarks set by the DCG. There were no personal incentives or penalties linked to this benchmarking. GPs entered the DM program at different time points (**Figure 4.1**) [20–24].

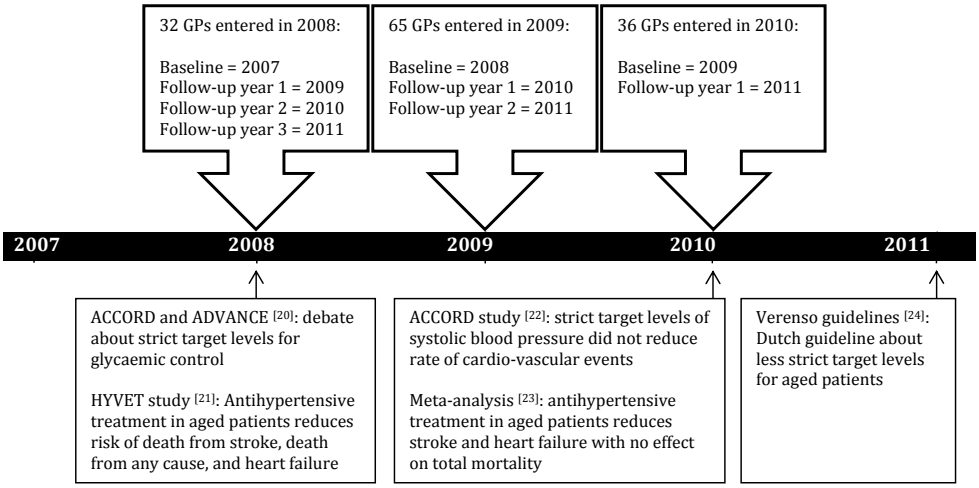


Figure 4.1. Time flow of study with key publications and national guidelines relevant for the treatment of (aged) patients with high blood pressure or glycohemoglobin levels.

Study population and data collection

Data were collected from the Groningen Initiative to Analyze Type 2 Diabetes Treatment database including almost all regional patients with type 2 diabetes (<1% opted out). The cohort of patients was based on the GPs of which data were available for 1 year before up to at least 1 year after entry in the DM program.

Based on the GPs' entry date in the DM program, the following cohort years were created: year before entry (baseline year), year of entry, 1 year after entry, and, if available, 2 and 3 years after entry. For practices entering in the second half of a calendar year, the next year was used as year of entry.

Per cohort year, patients were included who had a confirmed diagnosis of type 2 diabetes before January 1. Routinely collected data of the patients, including full prescription data, laboratory test results, and physical examinations, were extracted from electronic medical records using validated procedures [25]. In the Netherlands, no approval from an ethics committee is needed for studies using data from anonymous medical records.

Outcome measures

Primary outcome measures were potential over- and undertreatment. The definitions of potential overtreatment were based on those suggested by Kerr et al. [14] and validated by assessing the association between overtreatment and experiencing an adverse drug event. The definitions of potential undertreatment were derived from practice guidelines [7,14,26–28]. We defined separate definitions for BP- and glucose-lowering treatment. The first measurement of SBP or HbA_{1c} in a year was taken as index date. Treatment status and changes in treatment were assessed relative to this index measurement.

Potential overtreatment was defined as:
SBP <130 mmHg *and* receiving ≥3 BP-lowering drugs *or* an increase in dose within 120 days after the index date *or* a start of a new BP-lowering drug class within 120 days after the index date *and without* next SBP measurement ≥130 mmHg within 120 days after the index date;
HbA_{1c} <6.5% (48 mmol/mol) *and* receiving ≥3 glucose-lowering drugs *or* insulin *or* an increase in dose within 120 days after the index date *or* a start of a new glucose-lowering drug class within 120 days after the index date *and without* next HbA_{1c} measurement ≥6.5% (48 mmol/mol) within 120 days after the index date.

Potential undertreatment was defined as:
SBP ≥140 mmHg *and* not on ≥3 BP-lowering drugs *without any* increase in dose within 120 days after the index date, start of a new BP-lowering drug class within 120 days after the index date, or switch to another BP-lowering drug class within 120 days after the index date *and without* next SBP measurement <140 mmHg in the period up to 120 days after the index date;
HbA_{1c} ≥7% (53 mmol/mol) *and* (not on ≥3 glucose-lowering drugs *or* insulin *without any* increase in dose within 120 days after the index date, start of a new glucose-lowering drug class within 120 days after the index date, or switch to another glucose-lowering drug class within 120 days after the index date *and without* next HbA_{1c} measurement <7% (53 mmol/mol) in the period up to 120 days after the index date.

We used a period of 120 days to assess changes in treatment after the index date to capture clinical actions that were postponed to the next regular visit, which is commonly after 3 months in the Netherlands [28,29]. The therapeutic groups of BP- and glucose-lowering treatment included seven and eight drug classes, respectively (**Table 4.1**). The start of a drug was defined as a new drug prescription for a drug that had not been prescribed in 270 days before the start of the first prescription after the index date. A stop was defined as no repeat prescription within 270 days after the start date of

the last prescription. Stops before 7 days after index date were not considered as stops related to the measurement at index date. When a drug class was started within 7 days after the stop date of another drug class, the stop was considered a switch.

The following combined changes were considered as no change when assessing over- or undertreatment: a dose decrease combined with a dose increase, addition of a drug class combined with a dose decrease, and stop of a drug combined with a dose increase.

Table 4.1. Characteristics of general practices and patients in the year of entry to the disease management program

Characteristic	N
General practices	133
Median number of patients with type 2 diabetes per general practice (IQR)	117 (91-162)
Total number of patients with type 2 diabetes	14,876
Female patients (%)	7,674 (51.6)
Mean age of patients in years at systolic blood pressure measurement (SD)	66.8 (12.2)
Median diabetes duration at systolic blood pressure measurement (IQR)	5 (2-9)
Number of patients without prescription of blood pressure-lowering drug in 6 months up to index date	3,077 (23.8)
*Drug classes of blood pressure-lowering drugs**	
ACE-inhibitors (%)	5,117 (39.6)
Angiotensin-II-antagonists (%)	2,673 (20.7)
Drugs acting on the renin–angiotensin system (%)	4 (0.0)
Diuretics (%)	5,854 (45.3)
β-blockers (%)	5,133 (39.7)
Calcium-channel blockers (%)	2,679 (20.7)
Centrally-acting antihypertensives (%)	235 (1.8)
Number of patients without prescription of glucose-lowering drug in 6 months up to index date	2,525 (18.6)
*Drug classes of glucose-lowering drugs**	
Insulin (%)	1,940 (14.3)
Biguanides (%)	8,693 (64.2)
Sulfonamides (%)	5,356 (39.5)
Alpha glucosidase inhibitors (%)	14 (0.1)
Thiazolidinediones (%)	588 (4.3)
Dipeptidyl peptidase 4 inhibitors (%)	92 (0.7)
Repaglinide (%)	5 (0.0)
Exenatide or liraglutide (%)	6 (0.0)

SD = standard deviation; IQR = interquartile range
* Number of patients who have been prescribed the drug class in the 6 months up to index date

Analysis

Characteristics of the patient population were assessed for the year of entry to the DM program. Age and diabetes duration of the patients were calculated on the index date. For patients without an index date, the average index date of the other patients was used to assess their age and diabetes duration. The validation of the definition of potential overtreatment was performed using χ^2-statistics.

Percentages of potential over- and undertreatment to BP- and glucose-lowering treatment were assessed in all patients and in eligible patients only. Eligible patients for overtreatment are patients with low-risk factor levels without an apparent need for intensified treatment, whereas eligible patients for undertreatment include those with high-risk factor levels, who are not on maximum treatment, and in whom additional treatment is usually indicated. Maximum treatment was defined as a prescription of three or more drug classes or insulin (only for the glucose-lowering drugs) in 6 months before and up to the index date.

Percentages of over- and undertreatment in the baseline year were compared with those in the subsequent years using z-approximation for differences between proportions. Subsequently, stratified analyses were conducted for the age groups <60, 60–75, and >75 years [3]. Sensitivity analyses were conducted using more relaxed definitions for overtreatment — that is, including only patients with levels of SBP <120 mmHg and HbA_{1c} <6% (42 mmol/mol) as eligible for overtreatment.

The influence of the introduction of diabetes performance measures at GP level was assessed by comparing the percentages of over- and undertreated patients at baseline with 1 year after entry. GPs were divided into three groups, namely those with a ≥5% increase, ≥5% decrease, or stable percentage of patients with over- or undertreatment between the two measurements. We used χ^2-statistics to test for associations between changes in over- and undertreatment at the GP level.

The analyses were conducted using Stata version 12 (Stata Corp., College Station, TX), and P-values <0.05 were considered statistically significant.

Results

In total, 133 GPs entered the DM program: 32 in the cohort of 2008, 65 in 2009, and 36 in 2010. This resulted in 133 GPs with follow-up data of at least 1 year, 97 GPs with follow-up data of 2 years, and 32 GPs with follow-up data of 3 years after entering the program (**Figure 4.1**). The patient population at year of entry consisted of 14,876 patients with a mean age of 67 years and 52% females (**Table 4.1**). Of the BP-lowering drugs, the diuretics were the most commonly prescribed drug class (45%), followed by the β-blockers (40%) and the ACE inhibitors (40%). Metformin (64%) and sulfonylurea derivatives (40%) were the most commonly prescribed glucose-lowering

drugs. Potential overtreatment was associated with more possible adverse drug events related to the specific drug classes of BP and glucose-lowering treatment (**Appendix 5**; supplemental table 1).

For all patients with SBP measurements, potential overtreatment was observed in 3.2–3.8% in the study period, whereas potential undertreatment was seen in 18.6–25.4%. For all patients with HbA_{1c} measurements, potential overtreatment was seen in 2.0–2.4% and undertreatment in 14.8–16.5%.

BP-lowering treatment

Potential overtreatment among eligible patients with an SBP <130 mmHg was 15.9% at baseline and remained relatively stable in the years after entry to the DM program (P > 0.05) (**Table 4.3**). This pattern was similar for the different patient age groups (**Figure 4.2**). Potential overtreatment mainly involved patients receiving maximum treatment of BP-lowering drugs (~14% of eligible patients), which was generally more common in patients >75 years of age (data not shown). Intensification of treatment occurred in ~3% of the eligible patients (**Table 4.3**) and was comparable among the patient age groups (data not shown). Similar non-significant patterns of overtreatment were found in patients with an SBP <120 mmHg, being the more relaxed definition of overtreatment (**Appendix 5**; supplemental table 2).

Potential undertreatment of eligible patients with an SBP ≥140 mmHg was extensive but decreased from 60.7% in the baseline year to 56.9–50.7% in the years after entry (**Table 4.3**). The percentages were significantly (P < 0.05) different for all 3 years after entry in the DM program in comparison with the baseline year and were largely due to the improvements in patients aged ≤75 years (**Figure 4.2**). In patients >75 years of age, undertreatment decreased from 64.7% to ~61% in the years after entry. In general, potential undertreatment of BP treatment was more common in aged patients.

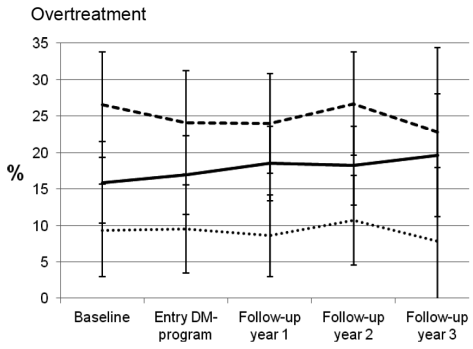
Table 4.3. Numbers of potential overtreatment and undertreatment for patients with SBP or HbA_{1c} measurements

	Baseline	Entry DM-program	Follow-up year 1	Follow-up year 2	Follow-up year 3
Blood pressure-lowering overtreatment					
With SBP measurement (% of all patients)	11,517 (84.4)	12,927 (86.9)	14,579 (89.8)	11,702 (91.2)	4,573 (94.2)
Mean age in years (SD)	67.1 (12.0)	67.0 (12.0)	67.0 (11.9)	67.0 (12.0)	67.1 (11.5)
Percent females	52.9	51.9	51.6	51.9	50.8
Median DM duration (range IQR)	4 (6)	5 (7)	5 (7)	5 (7)	5 (7)
Mean SBP (SD)	144.0 (20.4)	144.7 (20.6)	144.2 (20.0)	142.7 (19.4)	142.6 (19.2)
N SBP <130 mmHg	2,451	2,618	2,969	2,542	1,000
N SBP <130 mmHg with Potential overtreatment (% of eligible patients)	389 (15.9)	413 (15.8)	472 (15.9)	443 (17.4)	162 (16.2)
N classes >=3†	331 (13.5)	366 (14.0)	408 (13.7)	381 (15.0)	136 (13.6)
N intensified†	82 (3.3)	69 (2.6)	87 (2.9)	81 (3.2)	36 (3.6)
Glucose-lowering overtreatment					
With HbA_{1c} measurement (% of all patients)	12,117 (88.8)	13,548 (91.1)	14,999 (92.4)	11,884 (92.6)	4,499 (92.7)
Mean age in years (SD)	66.9 (12.0)	66.9 (12.0)	66.9 (12.0)	66.9 (12.0)	67.0 (11.6)
Percent females	52.8	51.8	51.6	51.7	50.6
Median DM duration (range IQR)	4 (6)	5 (7)	5 (7)	5 (7)	5 (7)
Mean HbA_{1c} (SD)	6.9 (1.0)	7.0 (1.0)	7.0 (1.0)	7.0 (1.0)	7.0 (0.9)
N HbA_{1c} <6.5% (48 mmol/mol)	3,980	4,150	4,510	3,518	1,209
N HbA_{1c} <6.5% (48 mmol/mol) with potential overtreatment (% of eligible patients)	296 (7.4)	310 (7.5)	341 (7.6)	239 (6.8)	103 (8.5)
N classes >=3†	46 (1.2)	**28 (0.7)***	**25 (0.6)***	**20 (0.6)***	**4 (0.3)***
N insulin use†	178 (4.5)	181 (4.4)	193 (4.3)	126 (3.6)	58 (4.8)
N intensified†	77 (1.9)	102 (2.5)	**130 (2.9)***	**100 (2.8)***	**45 (3.7)***
Blood pressure-lowering undertreatment					
With SBP measurement and not on max treatment (% of all patients)	8,387 (61.5)	9,250 (62.2)	10,373 (63.9)	8,246 (64.3)	3,178 (65.5)
Mean age in years (SD)	65.9 (12.3)	65.8 (12.4)	65.6 (12.2)	65.6 (12.3)	65.6 (11.7)
Percent females	51.6	50.8	50.4	50.9	49.8
Median DM duration (range IQR)	4 (6)	4 (6)	4 (6)	5 (6)	5 (7)
Mean SBP (SD)	142.7 (19.6)	143.5 (19.7)	142.9 (19.1)	141.3 (18.5)	141.0 (18.2)
N SBP ≥140 mmHg not on max treatment	4,826	5,449	5,924	4,430	1,676
N SBP ≥140 mmHg not on max treatment with potential undertreatment (% of eligible patients)	2,931 (60.7)	3,209 (58.9)	**3,370 (56.9)***	**2,466 (55.7)***	**850 (50.7)***
Glucose-lowering undertreatment					
With HbA_{1c} measurement and not on max treatment (% of all patients)	10,219 (74.9)	11,413 (76.7)	12,593 (77.6)	9,969 (77.7)	3,712 (76.5)
Mean age in years (SD)	66.7 (12.0)	66.7 (12.0)	66.7 (11.9)	66.7 (11.9)	66.8 (11.5)
Percent females	51.9	50.8	51.0	51.2	50.6
Median DM duration (range IQR)	4 (5)	4 (6)	4 (6)	4 (6)	4 (6)
Mean HbA_{1c} (SD)	6.8 (1.0)	6.9 (0.9)	6.8 (0.9)	6.8 (0.9)	6.9 (0.9)
N HbA_{1c} ≥7% (53 mmol/mol) not on max treatment	3,652	4,187	4,405	3,479	1,368
N HbA_{1c} ≥7% (53 mmol/mol) not on max treatment with potential undertreatment (% of eligible patients)	1,796 (49.2)	2,145 (51.2)	**2,335 (53.0)***	**1,962 (56.4)***	**725 (53.0)***

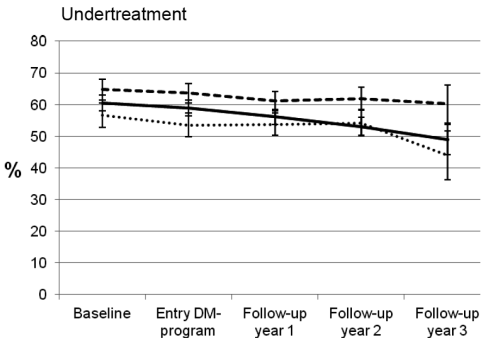
Baseline = Year before entry to the disease management program; Entry DM-program = Entry to disease management program; Follow-up year 1 = 1 year after entry; Follow-up year 2 = 2 years after entry; Follow-up year 3 = 3 years after entry; SBP = Systolic blood pressure; HbA_{1c} = glycohemoglobin; SD = standard deviation; IQR = interquartile range.

† Percentages do not sum to the percentages of patients with potential overtreatment because patients can be included in multiple categories of overtreatment. * Percentages of overtreatment or undertreatment in years of participation in the disease management program that significantly differ from the baseline year (P<0.05).

Systolic blood pressure measurement

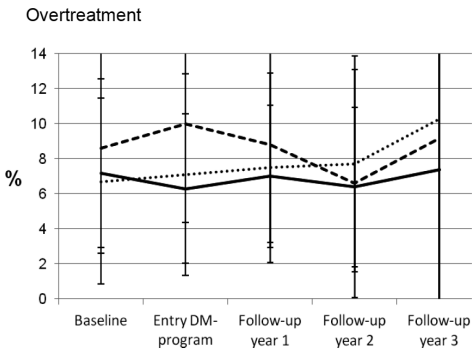


<60	Ref.	0.894	0.574	0.326	0.406
60-75	Ref.	0.503	0.104	0.152	0.083
>75	Ref.	0.348	0.320	0.953	0.283

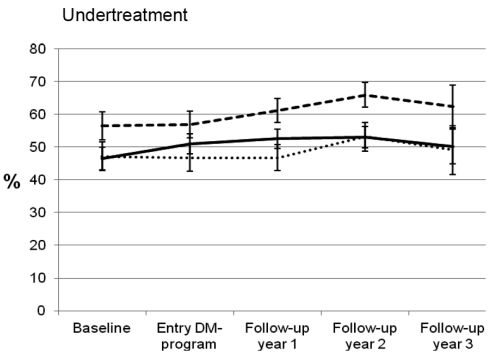


<60	Ref.	0.114	0.140	0.204	**<0.001***
60-75	Ref.	0.242	**0.001***	**<0.001***	**<0.001***
>75	Ref.	0.534	**0.045***	0.153	0.097

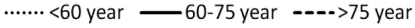
HbA1c measurement



<60	Ref.	0.771	0.469	0.427	**0.039***
60-75	Ref.	0.237	0.711	0.316	0.913
>75	Ref.	0.261	0.861	0.119	0.729



<60	Ref.	0.871	0.853	**0.008***	0.530
60-75	Ref.	**0.007***	**<0.001***	**<0.001***	0.100
>75	Ref.	0.863	**0.035**	**<0.001***	0.056



Baseline = Year before entry to the disease management program; Entry DM-program = Entry to disease management program; Follow-up year 1 = 1 year after entry; Follow-up year 2 = 2 years after entry; Follow-up year 3 = 3 years after entry. * Percentages of overtreatment or undertreatment in years of participation in the disease management program that significantly (P < 0.05) differ from the baseline year (reference year).

Figure 4.2. Trends in percentages of over- and undertreated patients based on eligible patients, and P-values of the comparison of baseline year with subsequent years.

Glucose-lowering treatment

Potential overtreatment among eligible patients with an HbA_{1c} <6.5% (48 mmol/mol) was observed in 7.4% of the patients at baseline (**Table 4.3**). This percentage did not significantly change in the years after entry in the DM program. In patients <60 years of age, overtreatment was 6.7% at baseline, which increased to 7.5–10.3% in the years after entry (**Figure 4.2**). The percentage of patients with an HbA_{1c} <6.5% (48 mmol/mol) receiving intensification of glucose-lowering treatment was significantly higher in later years (1.9% in the baseline year and ~3% in the years after entry). However, the percentage of patients receiving maximum treatment decreased significantly in later years (1.2% in the baseline year and 0.3–0.6% in the years after entry; **Table 4.3**). The increase in intensification over time was particularly seen in patients <60 years of age, whereas the decrease in receiving maximum treatment was seen in all patient age groups. Insulin use was generally more common in patients >75 years of age (data not shown). The pattern of overtreatment was similar for patients with the more relaxed definition of <6% (42 mmol/mol) for HbA_{1c} (**Appendix 5**; supplemental table 2).

Potential undertreatment of patients with an HbA_{1c} ≥7% (53 mmol/mol) increased from 49.2% at baseline to 53.0% in the first year after entry (**Table 4.3**). The percentages were significantly higher in all 3 years after entry in the DM program compared with the baseline year. This increase was largest in the second year after entry, a pattern that was observed in all three age groups (**Figure 4.2**). Overall, potential undertreatment for glycaemic control was more common in aged patients.

GP level

A decrease in undertreatment for SBP was seen for 44% (N = 57) of the GPs, while for only 29% (N = 38) an increase in overtreatment for SBP was seen. Of the 57 GPs that showed a decrease in undertreatment, 26 also showed a decrease in overtreatment (46%), whereas only 20 (35%) showed an increase in overtreatment. This association between improvements in under- and overtreatment at the GP level for SBP was statistically significant (P = 0.02; **Appendix 5**; supplemental table 3). For HbA_{1c}, 25% of the GPs had a decrease in undertreatment, and the same number had an increase in overtreatment. No significant associations were seen between changes in under- and overtreatment at the GP level for HbA_{1c} (P = 0.13; **Appendix 5**; supplemental table 3).

Discussion

During the entire period from 2007–2011, potential overtreatment was much less common than potential undertreatment for both BP and glycaemic control. Following the introduction of diabetes performance measures, in the period 2008–2010, there was a significant decrease in potential undertreatment and a relatively stable level

of potential overtreatment for BP. For HbA_{1c}, we observed a relatively stable level of overtreatment and an unexpected increase in potential undertreatment after the introduction of performance measures. These results hardly differed among the patient age groups, although levels of potential undertreatment for both BP and HbA_{1c} were generally higher in aged patients.

There can be good reasons to deviate from guideline recommendations for individual patients. Regarding overtreatment, there are currently no minimum levels for BP or HbA_{1c}, and measures of overtreatment have been criticized [30]. We used the same cut-off levels of overtreatment for all patient age groups, since the prevailing guidelines during the study period did not distinguish different target levels across age groups. Using different levels for defining potential overtreatment, we found similar results. We observed a decrease in the percentages of patients on maximum treatment. However, we also observed a small increase over time in treatment intensification rates in patients already having low HbA_{1c} levels. This finding was particularly seen in younger patients, which implies that GPs need to be more cautious with intensifying treatment in this specific patient group. Potential overtreatment was more common in BP-lowering treatment than in glucose-lowering treatment. However, the need for additional treatment with BP-lowering drugs may be appropriate in patients needing these drugs for (cardiovascular) comorbidities [14]. Since aged patients more often have comorbidities than younger patients [31], this may also explain why being on maximum treatment was more common in aged patients.

We can only speculate why potential undertreatment for HbA_{1c} increased in the years after the introduction of performance measures. This finding could be a temporary effect caused by changes in the underlying patient population. The performance measures were introduced as part of a DM program that also included a new payment system. Financial incentives related to this program may have led to unintended shifts of patients. Concerns have been expressed about increasing numbers of patients with preliminary stages of diabetes and patients being moved from specialist to primary care for financial reasons [32]. In contrast, our finding that this increase was especially seen in aged patients suggests that this is not the most likely explanation. An alternative explanation would be the intensifying call for using less strict target levels of <7.5 (58 mmol/mol) to <8.5% (69 mmol/mol) for HbA_{1c} and <150 mmHg to <160 mmHg for SBP for aged patients in recent years [24,33]. Our definition of undertreatment was based on the 2006 guidelines that promoted treatment for strict target levels in general. Although these guidelines were changed after our study period in 2013 [34], it is likely that norms about less intensive treatment in aged patients were already starting to percolate in practice during the study period [29]. Given the current debate and introduction of guidelines that recommend less strict targets in aged patients, future studies need to apply age-specific definitions of overtreatment as well as undertreatment.

In contrast, undertreatment of both BP- and glucose-lowering treatment was more common in aged patients than in younger patients throughout the whole study period. GPs appear to be more restrictive in prescribing drugs in aged patients. A study about the prescription of β-blockers in patients with coronary artery disease found a similar result [35]. Several patient-related reasons for potential undertreatment have been proposed [36,37], some of which are likely to differ among age groups. Aged patients have, for instance, more often comorbidities [31] and an increased risk of adverse drug events that may restrict the therapeutic options, and their treatment preferences and needs may also differ from younger patients [38]. Future studies are needed to investigate the reason behind the difference in undertreatment among age groups.

Our study does not support the concerns about increasing overtreatment after the introduction of performance measures. Previously, Kerr et al. [14] found an association between low levels of undertreatment and high levels of overtreatment within veterans affairs facilities. In our study, most improvements (i.e., reductions) in undertreatment were observed for BP treatment. We found that decreases in undertreatment were significantly associated with decreases in overtreatment, which refutes the hypothesis that GPs felt pressured to prescribe more treatment in general after the introduction of performance measures. This dissimilarity between our findings and those of Kerr et al. [14] may be due to differences in the studied patient population or to slightly different definitions of over- and undertreatment, but are more likely due to differences in the way the performance measures have been implemented (e.g., different financial incentives) and in the organization of the healthcare system. The system that was intended to reduce undertreatment may have been less enforced in our country, which is then expected to result in less aggressive treatment in general. Indeed, we observed less overtreatment but also more undertreatment in our patient population in comparison with the population in the study of Kerr et al. [14]. The level of undertreatment in the years after the implementation of performance measures, being ~20% of all patients with a BP measurement and 16% of all patients with an HbA_{1c} measurement, was much higher than the level of 6% for BP as seen in the study of Kerr et al. [14].

Strengths of our study comprise the large unrestricted cohort of patients with diabetes and the detailed longitudinal information on risk factors and drug prescribing. This allowed us to assess changes in prescribed treatment relative to risk factor levels. During the study period, risk factors were assessed in 84–94% of the patients. Data were collected from electronic medical records, and all included GPs prescribe electronically using the electronic medical records system. In the Netherlands, each patient is registered with a single GP who is the gatekeeper and obliged to keep adequate medical records, including out-of-hours prescriptions made by other practitioners.

The study is limited by its observational design and the dynamic cohort captured. Due to the rolling cohorts, year 1 covered the period 2009–2011, whereas year 3 was

restricted to 2011 (**Figure 4.1**). Therefore, changes observed in year 3 can be due to changing norms over time as well as sustained or delayed effects of the program. The findings on which we base our conclusions, however, were observed already in the first year after the introduction of performance measures and consistent for all year cohorts. Our outcome measures have been derived from guideline recommendations and have only in part shown associations with clinical outcomes (**Appendix 5**; supplemental table 1) [39,40]. We included the first measurement of SBP and HbA_{1c} in a year and assessed whether the levels of a follow-up measurement in the 120 days after the index date returned to control. It is possible that GPs base the treatment changes on a longer period. A previous study showed, however, that an extended period of 180 days does not significantly lead to a higher number of changes after elevated levels [28]. Finally, we only had information about changes in drug treatment. Therefore, actions related to nondrug treatment, including lifestyle and medication adherence, were not accounted for when assessing potential undertreatment.

In summary, the introduction of performance measures reduced undertreatment for BP, which did not correspond with an increase in overtreatment. It seemed that the performance measures had little impact on improving glucose-regulating treatment. There were no clear differences in trends among different patient age groups. During the whole period, undertreatment was higher in aged patients than in younger patients, possibly reflecting concerns about the need for intensive medication treatment in aged patients.

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