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Patient and practice factors associated with HbA1c testing frequency in patients with type 2 diabetes: a retrospective cohort study in Australian general practice

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ABSTRACT

Background. Better adherence to guideline-recommended glycated haemoglobin A1c (HbA1c) testing frequency is associated with better glycaemic control and lower risk of complications such as chronic kidney disease in patients with type 2 diabetes. This study investigates patient and practice factors associated with adherence to guideline-recommended HbA1c testing frequency. **Methods.** A cohort of type 2 diabetes patients who regularly visited general practices from 2012 to 2018 was identified from 225 Australian general practices. With the goal of ≤53 mmol/mol, Australian guidelines recommend HbA1c testing at least 6-monthly. Patient history of HbA1c tests from 2017 to 2018 was used to define adherence to guidelines, and the associations with patient and practice factors were examined by regression models. **Results.** Of the 6881 patients, 2186 patients (31.8%) had 6-monthly HbA1c testing. Patient age and anti-diabetic medications were associated with adherence to 6-monthly testing. When financial incentives are available to practices, a larger practice was associated with better adherence to 6-monthly testing. **Conclusions.** The identified key factors such as age, practice size, medication, and incentive payments can be used to target initiatives aimed at improving guideline-recommended monitoring care for patients with type 2 diabetes to enhance their health outcomes.

Keywords: adherence, diabetes mellitus, disease management, glycated haemoglobin A1c, incentive, monitoring, practice guideline, practice size.

Introduction

Type 2 diabetes mellitus (T2DM) is an increasingly prevalent chronic disease. To monitor and prevent the progression of T2DM, current clinical practice guidelines in the US, Europe, and Australia recommend regular glycated haemoglobin A1c (HbA1c) testing at least once every 6 months (Stone *et al.* 2010; National Institute for Health and Care Excellence 2016; The Royal Australian College of General Practitioners 2016; American Diabetes Association 2019). HbA1c is a marker of long-range blood glucose control over the preceding 8–12 weeks, unlike blood glucose testing, which can fluctuate hourly (Nathan *et al.* 2007). There is strong evidence supporting regular HbA1c testing, along with the importance of the regular monitoring of care and adherence to guidelines (Anjana *et al.* 2015; Imai *et al.* 2021).

One of the biggest challenges in T2DM management is to maintain the consistent and regular monitoring care, which may be impacted by a multitude of factors (Delamater 2006). Many studies have attempted to elucidate the drivers of good diabetes care. These can include patient and clinician factors, patient–clinician interactions, and treatment regimens (Lee *et al.* 2019). However, the majority of current research is centred on the evaluation of patient adherence to medical appointments or diabetes management programs, in which adherence to guideline-recommended monitoring frequency is not often assessed rigorously and thus remain unknown. Additionally, the studies are often based on small and specific cohort populations (i.e. tertiary care, insured patients) and thus may not represent the wider patient population. There is currently a lack of studies reporting key factors affecting best practice guidelines, which could yield a better understanding of any potential barriers or inhibiting factors.

In Australia, GPs play an essential role in providing continuity of care to patients with chronic diseases like T2DM (The Royal Australian College of General Practitioners 2016). Medicare, the universal healthcare scheme, ensures all Australian residents have access to GP care. Thus, electronic health records (EHR) from general practices contain a vast amount of key clinical information on Australian patients with diabetes, as exemplified in a recent study of the application of large-scale data to undertake comprehensive and rigorous evaluations on diabetes care (Imai *et al*. 2020).

The present study aimed to investigate patient and practice factors associated with adherence to clinical guidelines on HbA1c testing frequency, by using electronic data from 225 general practices in Victoria, Australia. The identification of factors associated with adherence to guideline-recommended monitoring care will be key in informing quality improvement initiatives including patient- and practice-targeted interventions.

Methods

Study period and population

The study period was 1 year from July 2017 to June 2018 (Fig. 1). Regular patients were selected using the definition of an active patient by The Royal Australian College of General Practitioners (RACGP) (The Royal Australian College of General Practitioners 2015), and is a patient who had attended a general practice three or more times in the past 2 years at the time of visit. As patients can visit different general practices in Australia, there was the potential that patients received diabetes care outside of the general practices in our study. To minimise such cases, we limited study patients to active patients who had a record of HbA1c testing during the study period. Patients included in this study were thus active patients who: (1) regularly attended (as per the RACGP definition) a general practice during the period from July 2012 to June 2018 and had a diagnosis of T2DM before July 2012; (2) had a record of at least one HbA1c test from July 2012 to June 2018; (3) were aged ≥18 years in 2012; and (4) had at least 5 years of history of diabetes prior to the study period as a means of excluding newly diagnosed cases.

Data and definitions

Study data involved de-identified electronic health records collected from a total of 225 general practices situated in the state of Victoria, Australia. Outcome Health, as the data custodian, routinely gathers the electronic data from general practices into the Population Level Analysis and Reporting (POLAR) Aurora research platform in a de-identified format (Pearce *et al*. 2019). Further details of the data extracted from POLAR are outlined elsewhere (Imai *et al*. 2020).

For this study, patients with T2DM were identified based on the Systematised Nomenclature of Medicine-Clinical Terms (SNOMED) code, 'diabetes mellitus type 2 (disorder)', in the diagnosis data. Similarly, the identification of potentially diabetes-related complications, including ischaemic heart disease (coronary heart disease) and chronic kidney disease, used the SNOMED codes that are under the group of 'acute ischaemic heart disease (disorder)' and 'chronic kidney disease (disorder)'.

Patient anti-diabetic medications were identifiable from the Anatomical Therapeutic chemical Classification code in the prescription data (A10: Drugs used in diabetes). In this study, treatment regimen at baseline was categorised into three groups based on the prescription records prior to July 2017: no medication (no prescription records); oral glucose-lowering agent only (A10-B); and insulin injection (A10-A) including the combination with oral agents.

Patients who received diabetic monitoring care under the Service Incentive Program (SIP) were identifiable from the records of the Medicare Benefits Schedule (MBS) item numbers (2517–2526, 2620–2635) in service data during the study period. The financial incentive program was 'pay-for-performance' in which a direct payment from the Australian government was provided to GPs for completing required monitoring care for patients with T2DM (e.g. annual HbA1c and kidney function tests). The SIP was introduced in 2001 and discontinued in mid-2019 (Kecmanovic and Hall 2015).

Practice size was defined by the total number of patient visits during the study period (from July 2017 to June 2018). The general practice size was scaled from 1 to 10 (smallest to largest) based on the deciles of the total patient visits within the study practices.

Socioeconomic status (SES) is a scale from 1 (most disadvantaged) to 10 (most advantaged). The SES index as of 2017 was identified by linking patient's postcode with the Census of Population and Housing: Socio-Economic Indexes for Areas (Australian Bureau of Statistics 2018).

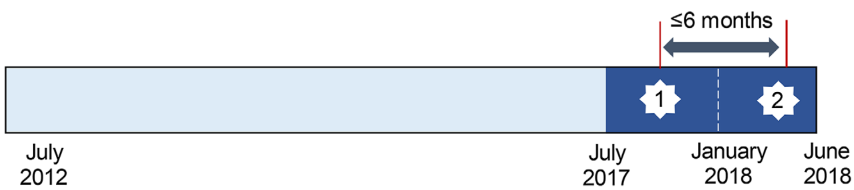

Fig. 1. Study period and adherence to HbA1c testing.

Adherence to guideline-recommended HbA1c testing

As Australian clinical guidelines (The Royal Australian College of General Practitioners 2015; The Royal Australian College of General Practitioners 2016) recommend HbA1c testing at least every 6 months in patients with T2DM, we examined the testing adherence for each study patient as the outcome of this study (0: not adherent, 1: adherent). Patients were considered adherent to the guideline-recommended testing if they had at least one HbA1c test in both the first (July–December 2017) and second half (January–June 2018) of the study period, with the average intervals of ≤6 months (+15 days) (Fig. 1).

Statistical analyses

First, we performed a descriptive analysis of patient and practice characteristics at baseline (July 2017). In the initial preliminary analysis, descriptive statistics such as the proportions of patients, the mean with the standard deviation (s.d.), or median with the interquartile range (IQR) stratified by patient adherence, were examined for categorical and continuous variables, respectively.

Potentially associated factors identified by the descriptive study were then incorporated and examined for model fitness in a semi-parametric generalised linear mixed model (GLMM) with binomial distribution for in-depth analyses. For a continuous variable (e.g. age), the linearity assumption was assessed by using generalised additive mixed models (GAMM) before being fitted into a GLMM. If a continuous variable was identified as being non-linearly associated with the outcome, the variable was then included in a GLMM with the smoothing function with the natural cubic splines. The optimal degrees of freedom for the spline function were determined by sensitivity analysis using the Akaike Information Criterion. As the use of service incentives for GPs could be related to practice size, if either of cycle of care and practice size was included in the model, we examined the interaction term between these two variables by using the log-likelihood ratio test. A variable for general practice identification was included as a random effect. The same variable selection process was used for both primary and subgroup analyses.

Ethics approval

Outcome Health obtained ethical approval to use de-identified data extracted from general practices for research purposes (The Royal Australian College of General Practitioners (RACGP) National Research and Evaluation Ethics Committee (NREEC) 17-008). Ethical approval for data access and analysis for the study was also obtained from Macquarie University Human Research Ethics Committee (5201700872).

Results

Study patients

We identified 30 447 patients who had a diagnosis of T2DM before July 2012 and were aged ≥18 years in 2012 from the start of the dataset. Of the total patients, 20 889 patients had regularly visited a general practice as active patients from July 2012 and July 2018. Among the active patients, 6900 patients had a record of HbA1c testing. After excluding 19 patients for missing demographic data, 6881 patients were selected as the study cohort (Fig. 2).

For our sensitivity analysis, we compared the demographic characteristics between the study cohort (n = 6881) and excluded patients (n = 23 547; 19 patients were not included due to missing demographic data). The demographic distributions by age, gender, SES, chronic disease (ischaemic heart disease (IHD) and/or chronic kidney disease (CKD)) status, residential remoteness, and practice size appeared similar between the two groups (Supplementary Fig. S1).

Patient characteristics and testing adherence

Table 1 shows the demographic characteristics of the study patients. The average patient age was 71.0 years (s.d. 11.4) and there were slightly more male patients than female patients in this cohort. The majority of the study patients resided in major cities (82.4%), used pharmacological diabetic treatment (77.3%), and had no other chronic illness (coronary heart disease or chronic kidney disease; 87.3%). In total, 35.5% of the study patients received monitoring care by incentivised GPs during the study period.

6-monthly HbA1c testing

Of the total 6881 patients, 3085 patients had two or more HbA1c tests from July 2017 to June 2018. The other 2174 patients (31.6%) had only one HbA1c test and 1622 patients (23.6%) had no HbA1c testing. Among 3085 patients who had two or more HbA1c tests, 2186 patients (31.8% of total) had a HbA1c test at least every 6 months. The overall median HbA1c

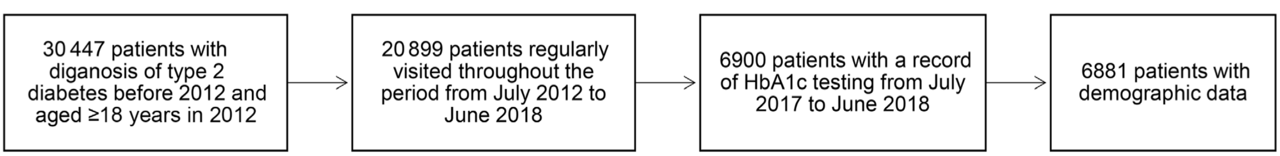

Fig. 2. Selection process of the study population.

Table 1. Patient demographic characteristics and HbA1c testing adherences at baseline.

	Overall		Overall adherence (≤6-month interval)			
			Yes		No	
Overall, *n* (%)	6881		2186	(31.8)	4695	(68.2)
Gender, *n* (%)						
Female	3127	(45.4)	995	(31.8)	2132	(68.2)
Male	3754	(54.6)	1191	(31.7)	2563	(68.3)
IHD/CKD, *n* (%)						
Yes	874	(12.7)	282	(32.3)	592	(67.7)
No	6007	(87.3)	1904	(31.7)	4103	(68.3)
Residence, *n* (%)						
Major city	5672	(82.4)	1764	(31.1)	3908	(68.9)
No	1209	(17.6)	422	(34.9)	787	(65.1)
Treatment, *n* (%)						
No medication	1560	(22.7)	283	(18.1)	1277	(81.9)
Oral agents only	4017	(58.4)	1364	(34.0)	2653	(66.0)
Insulin	1304	(18.9)	539	(41.3)	765	(58.7)
GP incentives, *n* (%)						
No	4440	(64.5)	1207	(27.2)	3233	(72.8)
Yes	2441	(35.5)	979	(40.1)	1462	(59.9)
Age, mean (s.d.)						
Years	71.0	(11.4)	70.8	(10.4)	71.2	(11.9)
SES, median (IQR)						
Decile	7.0	(5.9)	7.0	(5.9)	7.0	(5.9)
Practice size, median (IQR)						
Decile	7.0	(4.9)	8.0	(5.9)	7.0	(4.9)

testing frequency in the study sample was 1.0 (IQR; one to two times).

Table 1 shows 6-monthly testing adherence by patient demographic and practice factors. Testing adherence was noticeably different by treatment regimen and GP incentives. Patients with no pharmacological treatments were much less likely to be adherent to the guidelines (18.1%) than people with treatments (34.0% in the oral glucose-lowering drugs only group; 41.3% in the insulin therapy group). Patients who were monitored by incentivised GPs had higher testing adherence (40.1%) than patients who were not (27.2%). We did not observe noticeable differences in the testing adherence by age, residence location, chronic disease, and practice size, except for gender and SES.

As per the initial descriptive analysis, variables other than gender and SES were assessed for model fitness and subsequently the covariates for age, medication, service incentives for GPs, and practice size were selected, with the smoothing function for age with 3 degrees of freedom based on our sensitivity analysis.

The regression analysis identified that patient age was significantly associated with testing adherence in the inverted U-shaped relationship (Fig. 3*a*). The estimated adherence probability slightly increased up to the age of 75 years, but declined after the peak. For instance, testing adherence probability increased from 14.8% (95% CI: 12.2–17.9%) to 17.5% (95% CI: 14.6–20.9%) as age increases from 60 to 75 years, whereas the estimated probability dropped to 12.9% (95% CI: 10.6–15.7%) when the patient'sage is 85 years.

Testing adherence also significantly changed by treatment regimen (Fig. 3*b*), with the lowest adherence probability in patients with no antidiabetic prescriptions (17.3% [95% CI; 14.4–20.7%]).

The highest adherence probability was observed in patients on insulin therapy (36.1% [95% CI; 31.5–41.0%]), followed by patients on oral agents only (29.9% [95% CI; 26.1–33.8%]), although the difference between these two regimens was not significant.

The interaction term between GP incentives and practice size was identified as significant (χ^2 = 5.62, d.f. = 1, P = 0.018). As presented in Fig. 3*c*, we did not observe the difference in the adherence probability by practice size without the GP incentives (0% [95% CI: 0–1.7%]); however, when GPs were incentivised, the adherence probability in patients increased with practice size (2.2% increase (95% CI: 1.2–3.1%) by one size (i.e. decile) increment of the practice size). The results also indicated that the association between the GP incentives and testing adherence became more significant as practice size increased (Fig. 3*c*). For instance, the testing adherence probabilities by GP incentives in the small practice (first decile) were not different (difference of adherence probabilities: 4.0% [95% CI: −2.2–10.3%]), whereas the differences of the estimated probabilities in the median (fifth decile) and largest (10th decile) practices were 9.8% (95% CI: 6.2–13.4%) and 18.1% (95% CI: 13.4–23.0%), respectively.

Discussion

This study is one of the first in Australia to utilise electronic general practice data to rigorously evaluate patient and practice factors associated with adherence to guideline-recommended HbA1c testing in patients with T2DM. One of the critical findings in this study was low testing adherence. We identified that 31.8% of study patients had HbA1c testing at guideline-recommended 6-monthly intervals. As low HbA1c testing adherence in patients with T2DM has been documented in other studies (Renard *et al*. 2013; Lian and Liang 2014; Anjana *et al*. 2015), it reinstates the need for effective interventions to improve the continuity of care for certain groups of patients.

One of the factors associated with HbA1c testing adherence was age. We identified that testing adherence increased with

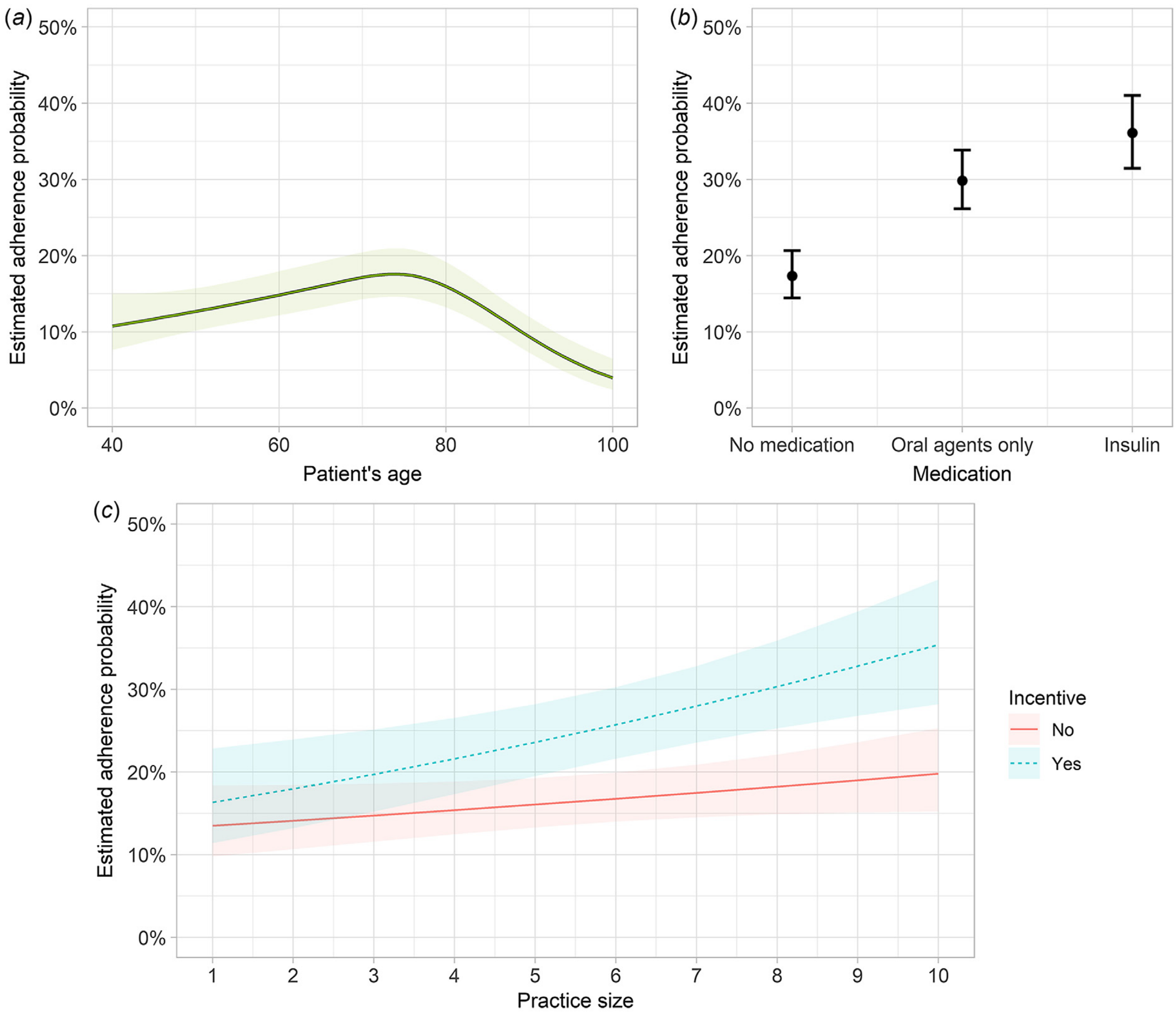

Fig. 3. Estimated probabilities of 6-monthly testing adherence. (*a*) patient's age, (*b*) treatment regimen, and (*c*) practice size and incentive. Solid lines and dots present the point estimates. Shades and bars represent 95% CI.

age up to 75 years, yet decreased after that. Although the reasons for the non-linear relationship with age remains uncertain, this finding was not surprising considering that there are more physical and cognitive challenges in elderly patients. Factors such as accessibility to transport and multi-morbidity often arise as obstacles for elderly patients seeking healthcare services (van Gaans and Dent 2018). Health literacy – the ability to obtain, process, and understand health information and services required to make appropriate health decisions (Network of the National Library of Medicine 2020) – has also been identified by previous studies as being associated with age in an inverted U-shaped pattern (Kutner *et al.* 2006; Kobayashi *et al.* 2015);therefore, it may partially explain the result of lower adherence in older people.

In this study, the service incentive for GPs was associated with better 6-monthly testing adherence only in larger practices. We believe this was related to a better resourced environment in larger practices, as an Australian GP survey (Kecmanovic and Hall 2015) found that the higher capacity of administrative support was a key factor for practices to seek the financial incentives due to the time and costs of claiming. Although existing studies report mixed results about the general effects of practice size on quality of care (Ng and Ng 2013), some also suggest that large practices may provide better patient care because they are more likely to have practice nurses to support diabetes management, as well as the economies to effectively use information technologies and multidisciplinary supports to deliver coordinated care to patients with complex needs (Crosson 2005; Casalino 2006). The availability of greater organisational resources may support larger practices to actively utilise the incentives and enhance the provision of monitoring care that aligns with guideline recommendations.

The prescription of anti-diabetic medication, particularly with last-line insulin therapy, was significantly associated with adherence to 6-monthly HbA1c testing, which confirms the finding of earlier studies (Lee *et al.* 2019). One possible reason for the association between pharmacological treatments and adherence to monitoring care is a better understanding of the benefits of controlling diabetes in patients requiring medications. Existing literature suggests patient involvement in care is based on the balance of their perceived benefits (e.g. alleviating symptoms) and disadvantages (e.g. time and efforts involved) (Donovan and Blake 1992; Vahdat *et al.* 2014). Thus, patients may more actively engage in care when the disease progresses to the extent that pharmacological interventions are required and the benefits of attending care outweighs the disadvantages.

There are several limitations to be considered in this study. One is that our target population was active T2DM patients with regular practice visits, which potentially suggests the selection of patients with higher health literacy and better healthcare-seeking behaviours than the general diabetes population. This subsequently indicates that we might have overestimated testing adherence; however, because the estimated patient testing adherence was low, our findings highlight the significance of the inadequacy of patient adherence to regular HbA1c testing. Furthermore, our sensitivity analysis found no obvious differences in the demographics between patients who were selected and excluded based on the criteria of regular practice visits. Another important limitation is that due to data unavailability, we could not assess some factors that might influence patient behaviour. These factors include details such as weights, family history, and lifestyle factors (e.g. smoking). Lastly, we did not examine other potential factors related to testing adherence such as bulk billing and use of a GP management plan. Further studies are required to understand the effects of other factors.

Despite these limitations, there are important strengths of this study, foremost among which is the large sample size and comprehensiveness of the study data. A recent study reported the advantage of using these data for evaluations on the quality of care for T2DM patients, not only for its sample size, but also due to the representation of the samples approximating the Australian diabetes population. Furthermore, the study data originated from electronic patient data, enabling us to evaluate the quality of monitoring care longitudinally and to an extent not previously thought possible in Australia (e.g. incentives effects on diabetes monitoring care) prior to this study. Although the service incentive program for diabetes care was terminated in mid-2019, this study was able to deliver important insights, which may inform future initiatives.

Overall, this study identified several critically important factors associated with patient and practice adherence to the gold standard for monitoring care for T2DM – guideline-recommended HbA1c testing. This evidence could potentially be translated into the initiation of more efficient strategies and policies to improve diabetes monitoring care, and ultimately patient outcomes for patients with T2DM. Findings from this study can be used in the development of quality improvements in identifying patients at risk for reduced adherence to HbA1c testing and may help to inform interventions targeting patients with these factors.

Supplementary material

Supplementary material is available online.

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Data availability. Data sharing is not applicable as no new data were generated or analysed during this study.

Conflicts of interest. None declared.

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