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Glycaemic control of Type 2 diabetes in older patients visiting general practitioners: An examination of electronic medical records to identify risk factors for poor control

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ABSTRACT

Objective: To investigate factors associated with glycaemic control of diabetes in older patients in the general practice setting in metropolitan Melbourne, Australia.

Method: This retrospective study used the data from 10,257 patients aged ≥ 65 years with Type 2 diabetes from the Melbourne East Monash General Practice Database (MAGNET), 2009–2014. Poor glycaemic control was defined as HbA1c ≥ 9.0%. Univariate and multivariate analyses were conducted to assess the association between risk factors and glycaemic control.

Results: Of the total 10,257 patients, 6819 (66.5%) had their HbA1c recorded within a period of 2 years prior to their last GP visit. Between 4% and 6% had HbA1c level ≥ 9.0%. Robust predictors of poor glycaemic control were found to be decreasing age group (OR = 0.77, 95% CI: 0.65–0.90) and prescribed insulin (OR = 2.83, 95% CI: 2.41–3.32).

Conclusion: One third of older patients with Type 2 diabetes did not have HbA1c recorded in the previous 2 years, despite clinical guidelines recommending at least annual testing. Many older patients had good glycaemic control, however the findings indicate that those aged 65–74 and those prescribed insulin may require special care and management to achieve this.

1. Introduction

Diabetes in older Australians aged 65 years and over affects one in six, and both the rate and absolute numbers affected with this chronic disease will grow in the oncoming years [1,2]. Sixteen percent of Australians are aged 65 or over, which is forecasted to reach 20% in 2050 [3]. The rate of self-reported diabetes in people aged 65 and over has doubled in the last twenty years, from 8.5% in 1995 to 17.4% in 2014–15, and it is still growing [2]. The increasing prevalence largely results from increasing risk factors in the community (e.g. greater obesity), improving detection methods and better survival through improving management [4]. In the context of rapidly increasing longevity and subsequent demands on the health

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system, the obligation to optimise the health of older Australians with this chronic disease has never been greater.

Type 2 diabetes accounts for 85% of all diagnoses of diabetes mellitus [5]. Although it does not have a single cause, there are well-established risk factors including a positive family history, increasing age, and lifestyle factors such as obesity and hypertension. Maintaining blood glucose levels at normal or close to normal levels is the goal of treatment as better glycaemic control has been shown to reduce the risk of short and long term complications including hypo- and hyperglycaemia, microvascular disease (in the eyes and kidneys), and macrovascular disease (coronary artery disease, peripheral artery disease and stroke) [6]. The United Kingdom Prospective Diabetes study (UKPDS) [7] and the Diabetes Control and Complication Trial (DCCT) [8] have shown that intensive control of glucose results in a 25–70% reduction in the number and severity of microvascular complications. Glycosylated haemoglobin (HbA1c) reflects average glycaemia over the preceding 6–8 weeks, and it is regarded as the gold standard for assessing glycaemic control [9]. At present, the Royal Australian College of General Practitioners (RACGP) recommends that patients maintain blood glucose within 'optimal' levels, taking into account age and co-morbidities, and optimal is typically defined as having an Hb1Ac $\leq$ 7% [6].

In clinical practice, optimal long-term glycaemia is not easy to achieve as many factors have been shown to affect glycaemic control. Studies have reported that patients' demographic characteristics (e.g. gender and ethnicity), clinical measures (e.g. blood pressure and cholesterol) and health care provider-related factors (e.g. prescribed education) can all contribute to poor glycaemic control [10]. Clinical practice guidelines for Family Physicians/ General Practitioners (GP) management of Type 2 diabetes have been developed [6], although there is limited guidance regarding management of glycaemic control specifically for older patients [10,11]. Given that advancing age increases the risk of co-morbidities, the management of diabetes in older patients is particularly challenging [9]. Despite the need for evidence on the relationship between glycaemic control and health outcomes in older patients, there is limited research on this. This has in part been due to a lack of large datasets of routinely collected GP data in Australia and internationally that can be made available for such research.

This study seeks to address these issues by utilising the Melbourne East Monash General Practice Database (MAGNET) platform to explore the following research question: What are the factors recorded in the electronic medical records associated with different degrees of glycaemic control (excellent/good to fair/poor) in older patients aged 65 years and over with Type 2 diabetes attending GP clinics in the inner east of Melbourne?

2. Method

This study is reported in accordance with the REporting of studies Conducted using Observational Routinely collected health Data (RECORD) Statement [12].

Study population.

2.1. Design and setting

A retrospective study using data collected from MAGNET [13], which comprises data routinely collected from the computerised medical records of patients attending 50 GP clinics within the inner eastern Melbourne region in Australia. This is a well-established and dense urban area which has ample access to health care and other services typically available in major capital cities in high income countries. It is populated by mostly medium to higher socioeconomic residents.

2.2. Patient sample

The main sample consisted of 10,257 patients aged 65 years or older, with a recorded diagnosis of Type 2 diabetes, and who had visited a study GP clinic between 2009 and 2014. This was 12.8% (10,257/80,401) of the same age group who saw a study GP in the same period.

We extracted information recorded in their patient electronic files from the previous two years prior to their last GP visit. This data was used in the analyses.

For some analyses we excluded 14% (1414 of 10,257) of the main sample because this group had no study clinic measurements (see risk factor list below) recorded in their electronic medical record. These patients were spread across 44 of the 50 clinics, and ranged between 0.4 and 30% of clinic patient loads, with the exception of one clinic that had all data missing from 45.2% (310/686) of patients.

2.3. Type 2 diabetes identification

Patients were identified as having Type 2 diabetes if they had one or more of the following: (1) a diagnosis of Type 2 diabetes in their clinical record; (2) prescribed hypoglycaemic drugs; or (3) at least two HbA1c measurements $\geq$ 6.5%, or two fasting blood glucose (FBG) measurements $\geq$ 7 mmol/L, within the past 2 years of their last visit.

2.4. The primary outcome

The primary outcome was glycaemic control as a categorical variable (3 categories) which was defined by categorising an HbA1c value as 'excellent' ($\leq$7.0%), 'good to fair' (7.1–8.9%), and 'poor' ($\geq$9.0%).

2.5. Risk factors

These analyses used patient data from the previous 2 years from their last visit; therefore this data were extracted from 2007 to 2014. In this study, possible risk factors for poor glycaemic control included demographics, current and past diagnoses, Medicare Benefit Schedule (MBS) items relating to chronic disease management, diabetes-related prescriptions, clinical measurements and pathology results (see Table 2 for the list of risk factors).

A socio-economic variable for each patient was determined using their residential address and the quintile of Index of Relative Socio-Economic Disadvantage (IRSD). Psychological illness included depression, anxiety, dementia,

and chronic pain disorders. Macrovascular disease included hypertension, coronary disease, cerebrovascular disease, and peripheral vascular disease; and microvascular disease included renal impairment, chronic kidney disease, neuropathy and retinopathy. GP management care plans were based on the claiming of MBS items for chronic disease care plans (GP Management Plans (721), Team Care Arrangements (723) and care plan reviews (725, 727 pre-May 2010; 732 post-May 2010). Medications to treat diabetes, specifically oral hypoglycaemic drugs and/or insulin, were included.

Other clinical and biochemical factors (body mass index (BMI), blood pressure (BP), total cholesterol, serum creatinine, and estimated Glomerular Filtration Rate (eGFR)) were also included. The categories for BMI were: (a) underweight: <18.5 kg/m^2; (b) normal: 18.5–25 kg/m^2; (c) overweight: 25.1–29.9 kg/m^2; and (d) obese: ≥30 kg/m^2; the nominated ideal target for BP control was set at <130/80 mmHg [6]; the ideal target for total cholesterol was <4.0 mmol/L; the normal range for serum creatinine was 60–110 μmol/L for men and 45–90 μmol/L for women. eGFR over 60 mls/min/1.73 m^2 was considered to be normal for an older population. Extreme values were considered as entry errors, and excluded from analysis. Recording of clinical and biological measurements were also coded as dichotomous variables (Yes/No).

2.6. Missing data analysis and multiple imputation method

The number (and percentage) of missing data were reported for the primary outcome and each risk factor. For variables with <5% missing data we explored the viability of using these to generate multiple imputations for variables with greater levels of missing data (>5%). The breakdown of missing primary outcome data by each risk factor displayed any patterns of 'not missing at random' (NMAR). NMAR were further explored in variables with much missing data by conducting a series of logistic regressions with 'missingness' (yes/no) as the outcome, and independent variables being those with minimal (<5%) missing data. These multivariate logistic regressions were conducted with uncorrelated independent variables, using correlation coefficients of >0.4 to signify correlation. Significant associations, with p-values < 0.05 arising from these logistic regressions, provided evidence that data is NMAR. Variables showing NMAR properties were imputed using the relevant associated variables having minimal missing data.

There were five patient risk factor variables with little missing data (<5%), which were gender, medication status, age group, IRSD quintiles and care plan status, and these variables were not correlated with each other (Pearson's correlation coefficients < 0.4). There were seven patient variables with significant amounts of missing data (eight variables if blood pressure is broken down to systolic and diastolic components). The pattern of missing data in each of these seven variables was found to be associated with medication status, age group, and care plan status. Missing blood pressure, BMI and smoking data were additionally associated with IRSD quintiles. Missing creatinine and eGRF data were additionally associated with gender. Because the pattern of missing data was associated with at least three of the five patient variables with very little missing data, these five variables were used to impute to account for the missing data. Then, we used multiple imputation by chained equations to impute missing values [14]. Fifty cycles of regression switching were undertaken and 20 imputed datasets were generated.

2.7. Statistical analysis

The distribution of glycaemic control (3 groups: Excellent, Good to fair, Poor) was examined across different patient groups (Chi-square test for significance). Then, the glycaemic control was treated as ordinal since our defined HbA1c groups have a natural ordering (excellent to poor). Multilevel mixed-effects ordered logistic regression to account for clustering with patients' most frequently visited practices was used to explore determinants between these three adjacent levels of HbA1c groups.

The regression was then performed on the imputed data. Effect estimates were calculated as odds ratios (ORs) with 95% confidence intervals (CIs). Given the largeness of the data set (approximately 10,000), a more conservative p value of 0.01 was used [15]. All data were analysed using Stata Version 13.1 (StataCorp LP).

The study was approved by the Monash University Human Research Ethics Committee (approval number: 2014001820).

3. Results

In total, 80,401 patients aged 65 years or older visited a GP in the inner eastern Melbourne region during the study period from 2009 to 2014. 10,257 (12.8%) were identified as having Type 2 diabetes, of which 5086 (49.6%) were female (Table 1). The mean age at the patients' last GP visit was 77.5 (SD 8.1) years, with 4160 (40.6%) aged 65–74 years and 2259 (22.0%) aged 75–84 years. In patients with Type 2 diabetes, 7238 (70.6%) had been diagnosed with macrovascular disease, and 4449 (43.4%) with microvascular disease. In terms of treatment, 6097 (59.4%) patients had only been prescribed oral hypoglycaemic medications within a period of 2 years prior to their last GP visit. Only 411 (5.1%) patients reported that they were current smokers.

Among the patients with Type 2 diabetes, 3438 (33.5%) had no HbA1c measurement recorded, and for those that did, 2475 (24.2%) had a level > 7.0% recorded for their most recent HbA1c measurement (Table 1). BMI was recorded for 4913 (48.9%) patients, with 3674 (35.9%) found to be overweight or obese. Recording of blood pressure, creatinine, cholesterol and eGFR results were missing for approximately 25% of patients.

Table 2 shows the association between patient characteristics and diabetes control. Chi-square tests suggested differences between groups for six of the 14 factors listed (at p < 0.001). For example, proportionally there appeared to be less people with macrovascular disease (62.6%) and 'excellent' glycaemic control, compared to the 66.0% without macrovascular disease and 'excellent' control. Poor glycaemic control was highest among those aged 65–74 (288, 6.7%). Table 2 also shows the association between glycaemic control and patients' most recent clinical and biochemical measures. Patients taking a combination of oral hypoglycaemic agents

Table 1 – Characteristics, clinical and biological measures of the n = 10,257 study population: 2009–2014.

Characteristic	No. (%)	Clinical and biological measures	No. (%)
Gender [n = 10,252]		**HbA1c** [n = 10,257]	
Male	5166 (50.4)	≤7.0	4344 (42.4)
Female	5086 (49.6)	7.1–8.9	2070 (20.2)
Age group [n = 10,257]		≥9.0	405 (4.0)
65–74	4160 (40.6)	Not recorded	3438 (33.5)
75–84	3838 (37.4)	**BMI** [n = 10,257]	
≥85	2259 (22.0)	Underweight	61 (0.6)
Psychological illness[a] [n = 10,257]		Normal weight	1718 (11.5)
No	8367 (81.6)	Overweight	1831 (17.9)
Yes	1890 (18.4)	Obese	1843 (18.0)
Macrovascular disease[b] [n = 10,257]		Not recorded	5344 (52.1)
No	3019 (29.4)	**Blood pressure** [n = 10,257]	
Yes	7238 (70.6)	<130/80	2296 (22.4)
Microvascular disease[c] [n = 10,257]		≥130/80	5578 (54.4)
No	5808 (56.6)	Not recorded	2383 (23.2)
Yes	4449 (43.4)	**Creatinine** (umol/L) [n = 10,257]	
Medication [n = 10,257]		Below normal	207 (2.2)
Oral hypoglycaemic agents only	6097 (59.4)	Normal	5238 (51.1)
Oral hypoglycaemic agents and insulin	1007 (9.8)	Above normal	2201 (21.5)
No prescribed medications	3153 (30.7)	Not recorded	2611 (25.5)
Smoking status [n = 8,112]		**Cholesterol** (mmol/L) [n = 10,257]	
non-smoker	7701 (94.9)	<4.0	2871 (28.0)
current smoker	411 (5.1)	≥4.0	3631 (35.4)
IRSD* **(quintiles)** [n = 10,164]		Not recorded	3755 (36.6)
1–3 (greater disadvantage)	1582 (15.6)	**eGFR** (ml/min/1.73 m^2) [n = 10,257]	
4–5 (least disadvantage)	8582 (84.4)	<60	2757 (26.9)
Care Plan [n = 10,257]		≥60	4926 (48.0)
No	8227 (80.2)	Not recorded	2574 (25.1)
Yes	2030 (19.8)		

* Index of relative socio-economic disadvantage.
[a] Psychological illness includes depression, anxiety, dementia, and chronic pain disorders.
[b] Macrovascular disease includes hypertension, coronary disease, cerebrovascular disease, peripheral vascular disease, and high-risk foot issues.
[c] Microvascular disease includes renal impairment, chronic kidney disease, neuropathy and retinopathy.

and insulin had the highest level of poor glycaemic control (140, 13.9%), as did patients who had high creatinine levels (168, 6.4%), had a cholesterol ≥ 4.0 mmol/L (364, 6.3%), or had an eGFR < 60 ml/min/1.73 m^2 (191, 6.4%).

Table 3 shows the determinants of poor glycaemic control in our study population after adjustment for clustering. Significant differences were apparent in only two of the 14 factors listed. Compared with the 65–74 age group control (OR = 0.77, 95% CI:0.65–0.90, $p = 0.002$), patients aged over 85 years had lower odds of having a poorer level of glycaemic control, that is, more likely to have good to fair or excellent glycaemic control. Moreover, insulin in combination with oral hypoglycaemic agents was significantly associated with an increased odds of having poorer control (OR = 2.83, 95% CI: 2.41–3.32, $p < 0.001$). Clinical and biochemical factors were not significant predictors of poor glycaemic control.

4. Discussion

Overall, 12% of older patients attending a GP clinic had a recorded diagnosis of Type 2 diabetes. Glycaemic control was excellent for the majority (64%), good to fair in 30%, and poor in 6%. Factors associated with good glycaemic control were older age, absence of microvascular disease, not prescribed insulin and being within a normal weight range, as well as having normal levels of creatinine, cholesterol and eGFR. The robust predictors of good glycaemic control were found to be increasing age and non-insulin patients. Disappointingly, one third did not have an HbA1c measurement available in the 2 years prior to their most recent consultation, despite clinical guidelines recommending at least annual testing.

Of the 80,401 patients aged 65 years and that visited a GP between 2009 and 2014, 10,257 (12%) were found to have Type 2 diabetes. The observed prevalence of Type 2 diabetes in this age group is consistent with a 2011–2013 national health survey of the health of people living in Australia from 2011 [16]. Currently, there are several sets of guidelines published which can be accessed by GPs to guide their management of Type 2 diabetes [6,17,18]. The guidelines recommend maintaining HbA1c levels below a maximum threshold, which, depending on the guideline, range from 6% to 7% for newly diagnosed and uncomplicated patients. Recently, a cross-sectional Australian study conducted by Esterman et al explored the association of good glycaemic control in patients with diabetes and with completing an annual cycle of care (ACC) [19]. They found that only around half of those with diabetes is reaching the glycaemic target of HbA1c < 7% [20]. In the present study, we found around two thirds of older patients with HbA1c records had achieved the recommended glycaemic goal, and

Table 2 – Patients' demographic characteristics, clinical and biological measures associated with glycaemic control (n = 10,257) with missing data imputed by multivariate multiple imputation. Chi-square compares proportions within the subgroups for each of the 14 factors listed. * Significant at p < 0.01.

Characteristic	No. (%)			Chi-square P-value
	excellent HbA1c ≤ 7.0%	Good to fair HbA1c: 7.1–8.9%	Poor HbA1c ≥ 9.0%	
Patient characteristics				
Gender				
Male	3313 (64.1)	1558 (30.2)	295 (5.7)	0.836
Female	3277 (64.4)	1532 (30.1)	277 (5.5)	
Age group				
65–74	2614 (62.8)	1266 (30.4)	280 (6.7)	0.001*
75–84	2476 (64.5)	1170 (30.5)	192 (5.0)	
≥85	1503 (66.4)	656 (29.0)	572 (5.6)	
Smoking status				
Non-smoker	5191 (63.9)	2469 (30.4)	452 (5.7)	0.452
Current smoker	1402 (65.4)	623 (29.0)	120 (5.6)	
IRSD[#]				
1–3 (greater disadvantage)	994 (62.8)	482 (30.5)	106 (6.7)	0.076
4–5 (least disadvantage)	5547 (64.6)	2576 (30.2)	459 (5.4)	
Care Plan [n = 6,819]				
No	5299 (64.4)	2471 (30.0)	457 (5.5)	0.854
Yes	1294 (63.7)	621 (30.6)	115 (5.7)	
Psychological illness				
No	5374 (64.2)	2528 (30.2)	465 (5.6)	0.943
Yes	1219 (64.5)	564 (29.8)	107 (5.7)	
Macrovascular disease				
No	1991 (66.0)	867 (28.7)	161 (5.3)	0.074
Yes	4602 (62.7)	2225 (30.7)	411 (5.6)	
Microvascular disease				
No	3857 (66.4)	1659 (28.6)	292 (5.0)	<0.001*
Yes	2736 (61.2)	1433 (32.2)	280 (6.3)	
Treatment				
Oral hypoglycaemic agents only	3859 (63.3)	1922 (31.5)	316 (5.2)	<0.001*
Oral hypoglycaemic agents and insulin	375 (37.2)	492 (48.9)	140 (13.9)	
No prescribed medication	2359 (74.8)	678 (21.5)	116 (3.7)	
BMI				
Underweight	99 (66.4)	41 (27.5)	9 (6.1)	0.016
Normal weight	2713 (66.7)	729 (28.4)	125 (4.9)	
Overweight	2451 (64.5)	1143 (30.1)	205 (5.4)	
Obese	2330 (62.3)	1179 (31.5)	233 (6.2)	
Blood pressure				
<130/80	1929 (64.8)	879 (29.5)	169 (5.7)	0.676
≥130/80	4664 (64.1)	2213 (30.4)	403 (5.5)	
Creatinine (umol/L)				
Below normal	278 (65.6)	131 (30.9)	15 (3.5)	<0.001*
Normal	4764 (65.9)	2073 (28.7)	389 (5.4)	
Above normal	1548 (59.5)	886 (34.1)	168 (6.4)	
Cholesterol (mmol/L)				
<4.0	2858 (63.4)	1439 (31.9)	208 (4.7)	<0.001*
≥4.0	3735 (64.9)	1653 (28.7)	364 (6.3)	
eGFR (ml/min/1.73 m^2)				
<60	1825 (60.6)	995 (33.0)	194 (6.4)	<0.001*
≥60	4768 (68.3)	2097 (30.2)	378 (5.5)	

[#] Index of relative socio-economic disadvantage.

the percentage of the population that reaches ideal glycaemic targets increases with age. Similar findings were also reported by the Mapping Glycaemic Control Across Australia (MGCAA) project [20].

Furthermore, according to the RACGP guidelines of general practice management of Type 2 diabetes 2016–2018, the measurement of HbA1c at least once every year is recommended as the minimum requirement to complete an

Table 3 – Multiple ordered logistic regression analysis on the factors that predict poor glycaemic control (n = 8843). This sample excludes the 14% who had no recorded measures and remaining missing data was imputed by multivariate multiple imputation. * Significant at p < 0.01.

Factor	Adjusted odds ratio	95% CI	p-value
Gender			
Male	Ref*		
Female	1.01	0.91–1.13	0.807
Age group			
65–74	Ref		
75–84	0.87	0.77–0.97	0.037
≥85	0.77	0.65–0.90	0.002*
Psychological disease			
No	Ref		
Yes	0.93	0.82–1.06	0.325
Macrovascular disease			
No	Ref		
Yes	1.01	0.88–1.15	0.664
Microvascular disease			
No	Ref		
Yes	1.04	0.88–1.22	0.663
Medication			
Oral antidiabetic agents only	Ref		
Oral antidiabetic agents and insulin	2.83	2.41–3.32	<0.001*
Not prescribed medication	0.54	0.47–0.61	<0.001*
Smoking status			
Non-smoker	Ref		
Current smoker	1.26	0.97–1.63	0.080
ISRD#			
1–3	Ref		
4–5	0.91	0.79–1.06	0.233
Care Plan			
No	Ref		
Yes	0.92	0.81–1.04	0.152
BMI			
Underweight	Ref		
Normal weight	0.73	0.51–1.60	0.727
Overweight	0.99	0.55–1.76	0.965
Obese	1.02	0.58–1.82	0.937
Blood pressure (mmHg)			
<130/80	Ref		
≥130/80	1.03	0.93–1.16	0.511
Creatinine (umol/L)			
Below normal	Ref		
Normal	1.02	0.76–1.39	0.883
Above normal	1.14	0.79–1.63	0.480
Cholesterol (mmol/L)			
<4.0	Ref		
≥4.0	1.01	0.89–1.13	0.917
eGFR (ml/min/1.73 m^2)			
<60	Ref		
≥60	0.89	0.72–1.12	0.336

Index of Relative Socio-economic Disadvantage.
* Ref = reference.

annual diabetes 'cycle of care' [6]. However, as reported in other studies of routinely collected primary health care data, one third of cases in our sample did not have an HbA1c measurement available in the 2 years prior to their most recent consultation [21]. Other clinical and biochemical variables also had quite high 'non-recorded' levels. Recording of blood pressure, creatinine, cholesterol and eGFR results were missing for approximately one quarter of patients. These patterns of absent data may relate to more difficult cases being managed by endocrinologists so that the clinical data are not automatically 'extractable' from within the scanned specialist letters. Other explanations for low levels of recording might be that the parameter was not correctly entered into the appropriate field in the electronic health record, or that the tests were not conducted at all. However, unsatisfied guideline adherence in general practices offering diabetes care was also reported by studies in other countries. Therefore, active strategies to improve guideline implementation to clinical practice should be developed to improve patient outcomes.

Good glycaemic control existed in patients aged 85 years and above (compared to the 65–74 years age group), while poorer control was associated with taking oral hypoglycaemics plus insulin, findings that are consistent with previous studies [22,23]. A study conducted by Puneta et al. [24] reported that elderly patients were more likely to have better glycaemic control even after adjusting for the duration of Type 2 diabetes and the degree of obesity. They also found glycaemic goals were more often achieved by patients in the older subgroups regardless of the presence of a cardiovascular disease. Given that diabetes is progressive and glucose levels can increase with age [25], the reasons why patients aged 75 years and over have better glycaemic control is not clear. It may be that compared with patients aged 65–74 years there is an increased emphasis on diabetes management and adherence to medication regimens, improved lifestyle factors and dietary restrictions [26]. It also could be due to the "survivor effect" where those with poorer control do not make it into the older age cohort [27]. Therefore, the management of Type 2 diabetes in elderly people should take into account the observed, age-related pattern of the disease. Moreover, about 60% of patients aged 65 years and over in the present study were prescribed oral hypoglycaemics or insulin. This group of patients may be at a more advanced stage of the disease which requires more aggressive treatment to achieve glycaemic control. In addition, insulin therapy is usually commenced in patients with T2DM where glycaemic control has deteriorated despite the use of non-insulin therapy [28].

There is been some evidence supporting a relationship between control of HbA1c and various clinical and biochemical measurements. A systematic review reported a difference in the mean BMIs of poorly and well controlled diabetes, whereas an increase in blood pressure was not associated with poorer control in an adult population [10]. However, a Singapore study found blood pressure was significantly associated with poor glycaemic control in an older population, but co-morbidities and BMI were less likely to be associated with poor glycaemic control [22]. In the present study, after controlling for patients' demographic characteristics and medication treatment, none of the clinical and biochemical measures were found to be associated with glycaemic control. However, our finding suggested a higher prevalence of comorbid conditions in older patients with Type 2 diabetes, especially microvascular and microvascular complications. There is evidence that comorbidities may affect disease progression, alter the outcomes of acute and chronic complications, and complicate diabetes management [29]. In addition, older patients with comorbidities are also more likely to have associated falls, cognitive impairment, chronic pain, and depression. Therefore, to improve long-term outcomes for older patients with Type 2 diabetes, therapeutic strategies for patients suffering from multimorbidity need to prioritise treatment across conditions according to need, and take a coordinated, team-based approach to diabetes management that sits within a wider chronic care model [30].

There are several limitations to this study. We used a combination of methods for identifying patients, including the use of oral hypoglycaemic medications as a proxy for identifying those with Type 2 diabetes. Utilising these different inclusion criteria improved the chances of identifying patients with Type 2 diabetes, however, some inaccuracies in case identification may still exist. In addition, data may not have been entered into the appropriate fields in the medical software, making it inaccessible for the purposes of data extraction. An example is pathology test results residing in scanned medical specialist letters, or clinical measurements, diagnoses or lifestyle factors such as diet and physical activity entered into the free text notes in the record. Finally, there were no data on the duration of diabetes, which has been identified as an important risk factor for glycaemic control [10,22].

5. Conclusions

Among patients with Type 2 diabetes who are aged 65 years and over and attending GP clinics in metropolitan Melbourne, about one quarter had less than optimal glycaemic control, although data access in clinical information systems remains an issue. Patients aged between 65 and 74, and those who are taking a combination of oral hypoglycaemics and insulin had poorer glycaemic control. There are several implications arising from this study. First, there is a need for further GP guideline development and training to ensure optimal Type 2 diabetes management for different sub-groups of older patients. Second, improvements are needed by medical software vendors to support the identification of diabetes diagnoses within a patient record, as currently these results show that considerable missing data fields indicate that the software does not fulfil the needs in general practice.

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Declaration of Competing Interest

This study was funded by the Royal Australian College of General Practitioners (RACGP). DM currently serves on different committees within the RACGP. LT, DM and PS have previously been awarded research grants from the RACGP.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.diabres.2019.06.004.

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