Title: Patterns of type 2 diabetes monitoring in rural towns: How does frequency of HbA1c and lipid testing compare with existing guidelines?

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C.P. developed the study concept, supervised data collection and analysis and drafted the manuscript. L.P. developed the study concept, assisted in data collection, and assisted in drafting the manuscript. J.S. developed the study concept, assisted in data analysis planning, and assisted in drafting the manuscript. C.K. assisted in data collection, analysis planning and assisted in drafting the manuscript. J.R. assisted in data collection and contributed to the manuscript. K.F. assisted in data cleaning and analysis and contributed to the manuscript. K.S. and RSF developed the study concept and contributed to the manuscript. CP is the guarantor for this article.

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TITLE

Patterns of type 2 diabetes monitoring in rural towns: How does frequency of HbA1c and lipid testing compare with existing guidelines?

ABSTRACT

Objective

To indicate levels of monitoring of type 2 diabetes in rural and regional Australia by examining patterns of Glycated Haemoglobin (HbA1c) and blood lipid testing.

Design and Setting

Retrospective analysis of pathology services data from twenty regional and rural towns in eastern Australia over 24 months.

Participants

13,105 individuals who had either a single HbA1c result $\geq 7.0\%$ (53 mmol/mol); or two or more HbA1c tests within the study period.

Main outcome measures

Frequency of testing of HbA1c and blood lipids (cholesterol, low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol and triglycerides) were compared with guideline recommendations.

Results

58.3% of patients did not have the recommended six-monthly HbA1c tests and 30.6% did not have annual lipid testing. For those who did not receive tests at the recommended interval, the mean between-test interval was 10.5 months (95% CI=7.5-13.5) rather than 6 months for HbA1c testing; and 15.7 (95% CI=13.3-18.1) months rather than annually for blood lipids. For those with at least one out-of-range test result, 77% of patients failed to receive a follow-up HbA1c test and 86.5% failed to receive a follow-up blood lipid test within

the recommended 3 months. Patients less than 50 years of age, living in a more remote area and with poor diabetes control were less likely to have testing at the recommended intervals ($p<0.0001$).

Conclusions

Although poor diabetes testing is not limited to rural areas, more intensive diabetes monitoring is likely to be needed for patients living in non-metropolitan areas, particularly for some subgroups.

KEY WORDS

HbA1c; diabetes mellitus; rural health; vulnerable populations; patient care management

WHAT THIS PAPER ADDS

What is already known on this subject?

- Improving the control of blood glucose in people with Type 2 diabetes reduces the development or progression of diabetic complications.
- Achieving optimal diabetes management at a population level remains challenging, especially in rural and regional areas.
- This study was conducted to investigate monitoring of Type 2 diabetes in rural and regional Australia, and to assess whether national guidelines for diabetes management are being met.

What does this study add?

- A large number of rural and regional patients are not being tested at the recommended frequency, indicating poor diabetes management.
- Males, those under 50 years of age and those living more rurally are the least likely to have testing at the recommended intervals.
- Additional resources or strategies should be made available to rural and regional general practice, to provide best practice Type 2 diabetes care.

INTRODUCTION

Type 2 diabetes mellitus is a mainly preventable chronic disease affecting an estimated 700,000 Australians and can result in premature death and irreversible long-term

complications such as heart disease, stroke, blindness and amputation.¹ Key metabolic markers have been linked to a range of health outcomes for people with diabetes.² There is an association between good blood glucose control and improved quality of life.²

Monitoring HbA1c levels in type 2 diabetics may give an indication of patient control of average blood glucose levels over time.³ Regular testing of cholesterol levels is also important to reduce cardiovascular events associated with diabetes.⁴⁻⁶ Diabetes Australia⁷ and the National Health and Medical Research Council (NHMRC)⁸ both recommend annual testing for blood lipids, and testing of HbA1c levels at least six-monthly in diabetic patients. Both also recommend re-testing after three months when test results are outside nominated normal ranges. However, studies show that only 22.7% of those diagnosed with diabetes received the recommended annual 'cycle of care' at a general practice.⁹

Although the problem is not confined to rural areas, diabetes prevalence, rates of diabetes-related care activity, hospital admissions and complications for diabetes are generally higher in rural and regional areas compared to metropolitan areas.^{1, 10, 11} The proportion of Australian diabetic patients meeting targets for lipids, cholesterol and blood pressure levels is very low,¹² and this proportion is even lower in rural areas compared with urban areas.¹³ A recent study has also shown that in a population of those at risk of coronary heart disease, there was a significant under-diagnosis of diabetes in outer regional Victoria compared to a metropolitan area.¹⁴ The role of the general practitioner (GP) is critical in rural settings, as there may be less access to specialist services. The present study aims to describe the patterns of testing for HbA1c and blood lipids among patients with diabetes in a sample of regional and rural general practices in Australia, and compare rates of testing with those recommended by Diabetes Australia and the NHMRC as follows:

- i) The proportion of all possible type 2 diabetes mellitus cases in rural towns who received six-monthly HbA1c tests, and the proportion who received 12-monthly cholesterol and triglyceride tests
- ii) The mean and longest duration between consecutive tests for those who did not receive tests at the recommended frequency.

- iii) The proportion of all possible type 2 diabetes mellitus cases in rural towns with an HbA1c or blood lipid test outside the recommended range who received a follow-up three-monthly test
- iv) The longest duration between tests for those who did not receive the follow-up three-monthly test subsequent to an out-of-range result.

METHODS

Community and Case Sample Selection

Figure 1 illustrates case sample selection and data collection from rural and regional pathology services. The complete method is described elsewhere.¹⁵ Laboratory test results reported for each individual included HbA1c, blood lipids (cholesterol, low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol and triglycerides). Demographic data was also collected. The data presented here relates to the baseline period of the intervention trial described in Paul et al 2013.¹⁵ A study case of type 2 diabetes was defined as having either a single HbA1c test where the result was higher than the recommended level of 7.0% (53 mmol/mol);⁸ or two or more HbA1c tests within the study period, and at least 6 months between such a test and the close of the data collection period.

A very small number of cases (n=700) were associated with a single test in the final six months of the study period and were removed from the sample. This may produce a slight over-estimation of the true proportion of patients receiving testing at an appropriate frequency.

Outcome Variables

Test frequency algorithms were developed according to NHMRC⁸ and were reviewed by authors JS & LP. The guidelines and algorithms regarding frequency used the following principles:

- A one-month 'window' of tolerance was allowed for test frequencies.
- Test frequency algorithms identified cases where an interval of more than 4, 7 or 13 months (as relevant) between any two tests had occurred, or a subsequent test had not occurred at all.

- When an HbA1c test result was above 7.0% (53 mmol/mol), i.e. 'out of control', or a lipid test result was outside the recommended range, the subsequent test should occur within three months.
- The longest interval between consecutive tests for test results over 7.0% (53 mmol/mol) was calculated in terms of mean and range number of months, to explore intervals between consecutive tests.

Analysis

Logistic regression was used to identify patient and provider characteristics associated with suboptimal testing for each of HbA1c and cholesterol (age group, gender, number of diabetic patients per GP, HbA1c result on first test in the study period, and geographic location, i.e. inner regional versus outer regional or rural on the basis of postcode).

Univariate logistic regression was used to give the crude odds ratios and multiple logistic regression to give adjusted odds ratios using the variables (age group etc) listed above. All analyses were carried out using SAS 9.3 (SAS Institute, Cary NC). For brevity, only significant associations are presented.

RESULTS

Case Sample

The mean age was 66.0 years (SD=14.0), with mean age by postcode varying from 55 years to 69.8 years. Overall, 53% of the sample was male.

Frequency of testing among all Type 2 Diabetes cases

12.7% of the identified 13,105 cases received only one HbA1c test, while 34.6% received 4 or more tests in the two year period (see Table 1). The mean number of tests per case was 3.1 (SD=1.6) (see Table 1). 58.3% of cases did not receive the recommended HbA1c test every six months, including those who received only one test. Overall, 47.2% had an interval of more than 6 months between consecutive HbA1c tests on average.

For those who did not receive six-monthly tests, but had two or more tests, the mean longest duration between consecutive tests was 10.5 months (SD=3.0). Of those with an HbA1c result of 7.1-8.0% (54-64 mmol/mol) and $\leq 7.0\%$ (53 mmol/mol) in the first 6 months

of the study, 33.7% and 27.6% respectively had more than three subsequent tests (see Table 2). In the case of those with an HbA1c result above 8.0% (64 mmol/mol) in the first six months, 16.9% had no subsequent test, compared with 2.3% of those whose early HbA1c result was $\leq 7.0\%$ (53 mmol/mol).

With regards to lipid testing, 416 of the Type 2 Diabetes cases (3.2%) did not have a total cholesterol test result within the two year study period (see Table 1). Of the 13,105 cases: 4,012 (30.6%) had a gap of more than 13 months between consecutive total cholesterol tests, received only one test, or did not have a total cholesterol test result. For those who did not receive annual tests, and had two or more tests, the mean longest duration between consecutive cholesterol tests was 15.7 months (SD=2.4).

Follow-up testing for out-of-range results for HbA1c and total cholesterol

As indicated in Table 3, less than one-third of identified cases with at least one out-of-range test result received a subsequent consecutive test within the recommended 3 month follow-up interval.

Almost three-quarters (74.2%) of cases that had at least one HbA1c test result above 7.0% had a subsequent HbA1c test during the two year period. Table 4 describes the lowest result of subsequent tests at any time in the 2 year study period.

Less than two-thirds of cases were within the recommended range on their most recent tests for: total cholesterol (38.8% within range), HDL cholesterol (59.8%), LDL cholesterol (62.1%) and triglycerides (44.1%). The mean results for each test were as follows: total cholesterol: 4.37mmol/L (SD=1.10; Reference Interval (RI)= <4.0 mmol/L), HDL cholesterol: 1.18mmol/L (SD=0.34; RI= ≥ 1 mmol/L); LDL cholesterol was 2.31mmol/L (SD=0.89; RI= <2.5 mmol/L), triglycerides: 1.88mmol/L (SD=1.42; RI= <1.5 mmol/L). Reference intervals provided by the RACGP.¹⁶ These data are provided in supplementary Table 1.

Socio-demographic factors associated with receiving tests less frequently than recommended

As shown in Table 5, being less than 50 years of age increased the odds of sub-optimal testing frequency for both HbA1c and total cholesterol. Those living in an outer regional or rural postcode were more likely than those living in an inner regional postcode to have suboptimal test frequencies for both HbA1c and total cholesterol. Those with their earliest HbA1c test result $>7.0\%$ (53 mmol/mol) were more likely to be classified as having suboptimal test frequency than those with a result $\leq 7.0\%$. Males were more likely to be classified as having inappropriate test frequency for total cholesterol.

DISCUSSION

Test frequency

The data suggests that testing for markers of diabetes control in rural and regional areas occurs less frequently than recommended. Forty-two percent of the sample cases had regular six-monthly HbA1c tests while 31% had annual blood lipid testing. A failure to have regular tests in itself does not cause poor diabetes outcomes. However, such findings reflect missed opportunities for instituting important changes to care or management and maintaining the lifestyle habits necessary for optimal diabetes control.

Follow-up testing and control

The results indicate that follow-up testing after elevated results of both an HbA1c or total cholesterol test occurred much later than the recommended 3 months, if at all. This suggests an elevated test result does not generally result in closer monitoring as recommended. It must be acknowledged that the mean age of our sample was 66 years, and for older patients a HbA1c level of 8.0% (64 mmol/mol) rather than 7.0% (53 mmol/mol) may indicate a need for increased monitoring or altered diabetes management.¹⁷⁻¹⁹ For those who had a test result above 7.0% , only a minority (24.5%) subsequently demonstrated an improved result of 7.0% or lower. A large group (47.8% of those with 2 tests over 7.0%) had a second test result of 8.1% (65 mmol/mol) or higher. This suggests that even allowing for those of older age, a sizeable minority of the sample do not have their diabetes under consistent control. Therefore, interventions to improve the management and control of diabetes for patients attending rural practices are warranted. The apparent pattern of poor control of blood lipids is particularly concerning given cardiovascular complications can be reduced by improved control of cholesterol.

Socio-demographic characteristics

Patients less than 50 years of age, men, those living in a more remote area and people with poor diabetes control were less likely to have testing at the recommended intervals. Rates of diabetes and diabetes complications are higher in rural areas compared to metropolitan areas,²⁰ and these new data support the view that rural and remote patients with diabetes may require additional resources or strategies to access best practice care. Without additional efforts it appears unlikely that this geographical inequality in diabetes care will be resolved. Community-level campaigns, strategies implemented across health care systems, and organisation of care within individual primary care practices should be directed towards these groups as a priority.

Limitations

The data may be a slight underestimate or overestimate of the true proportion of cases meeting the specified guidelines. Firstly, there is no reliable method for assessing the proportion of testing which may have occurred outside of the dataset. Possible scenarios include: HbA1c results not being recorded by Medicare when multiple tests are performed, and individuals receiving care/pathology requests from out-of-area specialists or hospital admissions during the study period. Secondly, individuals having only one HbA1c test below 7.0% have been excluded from the sample, possibly eliminating some 'true' cases. Thirdly, cross-matching errors are possible. Fourthly, method of town selection excluded very small towns thus could not be considered representative of all non-metropolitan towns. Lastly, it should be acknowledged that the breadth and depth of best-practice diabetes care cannot be fully captured by pathology-based tests, and it is possible that some patients were not advised about their diabetes status following a test. Despite these limitations, and given that the Medicare system does not fully capture all such tests, the study data provide the best-available picture of regional testing patterns over a two-year period.

Conclusion

While the findings from this study must be considered in light of a number of limitations, and they do not compare metropolitan versus non-metropolitan areas, there remains a need to improve the care and management of type 2 diabetes in non-metropolitan areas, to

ensure vulnerable patient groups receive the levels of care designed to limit negative health impacts.

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TABLES

TABLE 1: *Number of HbA1c and cholesterol tests per case and mean gap between tests during the 2 year study period (n=13,105)*

Number of HbA1c tests per case	N	%	Mean gap	
			between tests (months)	SD of gap (months)
1 test	1667	12.7		
2 tests	3977	30.3	8.8	4.7
3 tests	2926	22.3	6.8	2.1
4 or more tests	4535	34.6	4.7	1.2
Total	13105	100.0	6.7	3.5

Number of cholesterol tests per case				
0 test	416	3.2		
1 test	2544	19.4		
2 tests	3678	28.1	9.3	4.7
3 tests	2699	20.6	6.9	2.2
4 or more tests	3768	28.7	4.6	1.4
Total	13105	100.0	6.9	3.7

TABLE 2: Comparison of highest HbA1c level in the first 6 months of the study period with subsequent number of HbA1c tests

Number of HbA1c tests in the subsequent 18 months	HbA1c tests in the first 6 months of data collection				Total <i>n</i> (%)
	Highest result ≤7.0% (53 mmol/mol)	Highest result 7.1-8.0% (54- 64 mmol/mol)	Highest result ≥8.1% (65 mmol/mol)	No subsequent test	
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	
0 test	95 (2.3)	229 (12.2)	327 (16.9)	0	651 (5.0)
1 to 3 tests	2889 (70.1)	1012 (54.1)	1052 (54.4)	4277 (82.6)	9230 (70.4)
Over 3 tests	1137 (27.6)	631 (33.7)	556 (28.7)	900 (17.4)	3224 (24.6)
Total	4121 (100)	1872 (100)	1935 (100)	5177 (100)	13105 (100)

TABLE 3: Frequency of follow-up testing for out-of-range results

	At least one out of range result <i>n</i> (%)	Subsequent test within 3 months <i>n</i> (%)	Longest gap to subsequent consecutive test (months) Mean (SD)
HbA1c	7931 (60.5)	1824 (22.9)	8.0 (3.3)
Total Cholesterol	8649 (66.0)	1168 (13.5)	8.6 (3.5)

TABLE 4: *Subsequent test results for cases with an elevated HbA1c result (>7.0%)*

At least one elevated result	At least 1 subsequent test	Lowest subsequent test result in study period (n=5885)		
		<u>< 7.0%</u>	<u>>7.0 - <8.0</u>	<u>>8.0</u>
		n (%)	n (%)	n (%)
7931 (60.5)	5885 (74.2)	1075 (18.3)	2511 (42.7)	2299 (39.1)

TABLE 5: *Socio-demographic factors associated with receiving HbA1c and total cholesterol tests less frequently than recommended (logistic regression results)*

Predictor	<u>Suboptimal test?</u>		<u>Odds of suboptimal testing</u>		
	Yes	No	Crude	Adjusted	Adjusted p-

	(n=7646)	(n=5459)			value
HbA1c					
Age					
Under 50	1352 (66%)	705 (34%)	ref	ref	<.0001
50 to 79	5538 (57%)	4188 (43%)	0.69 (0.62, 0.76)	0.74 (0.66, 0.81)	
80 and Over	756 (57%)	566 (43%)	0.70 (0.60, 0.80)	0.76 (0.66, 0.88)	
Postcode					
Inner regional	498 (51%)	483 (49%)	ref	ref	<.0001
Outer regional/rural	7148 (59%)	4976 (41%)	1.39 (1.22, 1.59)	1.40 (1.23, 1.60)	
Earliest HbA1c result					
7.0% or less	3696 (55%)	2990 (45%)	ref	ref	<.0001
7.1 to 8.0%	1819 (59%)	1258 (41%)	1.17 (1.07, 1.28)	1.16 (1.06, 1.27)	
8.1% and over	2131 (64%)	1211 (36%)	1.42 (1.31, 1.55)	1.35 (1.24, 1.48)	
Total Cholesterol					
	Yes	No			
	(n=9093)	(n=4012)			
Age					
Under 50	1172 (57%)	885 (43%)	ref	ref	<.0001
50 to 79	7009 (72%)	2717 (28%)	0.51 (0.47, 0.57)	0.52 (0.47, 0.57)	
80 and Over	912 (69%)	410 (31%)	0.60 (0.51, 0.69)	0.61 (0.52, 0.70)	
Postcode					
Inner regional	757 (77%)	224 (23%)	ref	ref	<.0001
Outer regional or rural	8336 (69%)	3788 (31%)	1.54 (1.32, 1.79)	1.56 (1.33, 1.82)	
Sex					
Female	4289 (70%)	1800 (30%)	ref	ref	<.0001

Male	4802 (69%)	2200 (31%)	1.09 (1.01, 1.18)	1.10 (1.02, 1.18)
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FIGURE LEGENDS

Figure 1: *Process of elimination to identify cases for further analysis. Briefly, potential cases were identified by two pathology companies using samples collected in rural/regional towns in Australia. Cases were cross-checked by gender and birthdates and matching cases were merged. Unclear possible matches were removed. A Type 2 Diabetes study case was defined as having either a single HbA1c result >7%, or two or more HbA1c tests within the study period. Ineligible cases were removed. Samples with poor data quality or sole test in the final 6 months were removed, leaving 13,105 cases that were analysed for frequency of HbA1c and blood lipid testing.*

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