Contents available at ScienceDirect

Diabetes Research and Clinical Practice

journal homepage: www.elsevier.com/locate/diabres

Detecting the hidden burden of pre-diabetes and diabetes in Western Sydney

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ARTICLE INFO

Article history:
Received 17 December 2018
Received in revised form 26 February 2019
Accepted 12 April 2019
Available online 18 April 2019

Keywords:
Diabetes
Testing
General Practice
Community
Hospital
Epidemiology

ABSTRACT

Aims: Examining pre-diabetes and diabetes rates using glycated haemoglobin (HbA_{1c}) in emergency department (ED) and in general practice (GP) in western Sydney.
Methods: Epidemiological study of HbA1c measurements in individuals ≥18 years receiving a blood test (1) in the hospital setting of the ED at Blacktown/Mt Druitt hospital (1/06/2016 to 31/05/2018) and (2) in primary care involving Bridgeview Medical Practice (BVMP) (1/03/2017 to 01/02/2018) as well as other general practices (June 2018 only).
Results: Totals of 55,568 individuals from ED and 5911 individuals from GP. The prevalence of diabetes in tested individuals was 17.3% (n = 9704) in ED and 17.4% (n = 1027) in GP. The prevalence of pre-diabetes in ED was 30.2% (n = 16,854) and 26.6% (n = 1576) in GP.

Regression controlling for age, season, and gender revealed a weekly increase of 1.1% in odds for diabetes and 1.5% for pre-diabetes ($p < 0.001$), in line with the yearly absolute increase of 1% in rate for both tested and coded hospital patients. In BVMP the rate of diabetes rose by 22% during the testing period from 8.9% to 11%.
Conclusions: There exists a high burden of diabetes both in hospitals and general practice. Testing in ED and general practice revealed similarly high burdens of diabetes across different areas of the healthcare system. In the appropriate hospital and primary care setting, HbA1c can be used to identify individuals with diabetes that may benefit from targeted intervention.

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https://doi.org/10.1016/j.diabres.2019.04.019
0168-8227/

1. Introduction

Diabetes has become a leading cause of morbidity across the world, with rates increasing dramatically over the last two decades [1]. Australia has had similar rises, going from a diabetes prevalence rate of 2.4% in the late 90 s [2] to more than 6% today [3]. This is likely to be an underestimate of the true prevalence as the proportion of people living with undiagnosed diabetes is thought to lie between one-fifth to one-third of the people with diabetes [1,4].

Geographic variability can influence the rates of diabetes. At the small-area level, indices of social disadvantage have been found to be strongly predictive of increased diabetes rates, with various social factors such as green space, income, and access to fresh food implicated in the inequity [5–7]. Western Sydney is such an area, and has been identified as a diabetes hotspot with rates of diabetes double that of the more socio-economically advantaged suburbs to the city's east [5].

Informed estimates of the diabetes burden on the health system are very important [8]. Firstly, the provision of services relies on understanding the burden: we cannot treat what we do not see. Diabetes in particular involves very high costs to the health system [9,10], with the true cost increasing due to the undiagnosed population. Targeting services effectively also relies on understanding the population at hand. It is also important to identify people with pre-diabetes, who are at an elevated risk of developing diabetes within the next 10 years [11].

A pilot study undertaken in the ED of Blacktown hospital in Western Sydney noted that 33% of individuals with glycated haemoglobin A1c (HbA1c) results consistent with diabetes were unaware that they were affected [4]. As a result, glycated haemoglobin (HbA_{1c}) has been routinely measured since mid-2016 in all blood samples obtained through the EDs of Blacktown and Mt Druitt Hospitals. GPs and individuals with abnormal tests are sent letters notifying them of the results along with recommendations for lifestyle intervention. To further understand the burden in our health district, we approached Bridgeview Medical Practice (BVMP) due to its size and proximity to Blacktown hospital to replicate the previously described HbA1c testing process in order to obtain comparative data. After 1 year of testing at BVMP, the scope for testing was widened in the month of June 2018 to include a number of other general practices within the Western Sydney Local Health District to provide a better estimate across the health district.

This paper presents the results from the two HbA1c testing initiatives: 24 months of data from the EDs of Blacktown and Mt Druitt hospitals, and 12 months of data from general practices within the health district. We describe the rates of diabetes in these settings, as well as the trend over time in the hospital.

2. Methods

Assessment of HbA1c was routinely undertaken on all blood samples sent to the laboratory from individuals that presented to the ED at Blacktown or Mt Druitt Hospital, irrespective of their reason for attending hospital. This test is added on in the laboratory unless (1) the individual is <18 years of age; (2) HbA1c had previously been measured within the last 3 months; (3) the appropriate blood sample was not available or adequate; (4) haemoglobin values were outside of the laboratory reference value (90–200 g/L) and (5) the blood sample was required for another test that took priority. Steps 1–3 were mirrored in the general practices. HbA1c was measured using a turbidimetric inhibition immunoassay (TINIA) on a Siemens Dimension Vista 1500 platform. Coefficient of Variation was 2.9% and 2.4% at HbA1c levels of 5.7% and 10.1% respectively. The data presented is for a 2 year period beginning the 1st of June 2016. This protocol was mirrored in 11 GP practices during the month of June 2018, as well as the prior 11 months in one practice (BVMP). In ED this represented approximately 35% of individuals presenting each day, with a similar proportion tested in general practice. This study was approved by the Human Research Ethics Committee of the Western Sydney Local Health District.

Test results were obtained from the CERNER system in hospital and by the PEN Clinical Audit Tool in general practice. Results were analysed using SPSS for proportion and trend calculations. The least-squares method was used to obtain an estimate of the goodness of fit for the trend data comparing the proportion of positive tests in ED across weekly averages in the time period. A multivariate Poisson regression model was developed comparing the correlation between diabetes rates and time with adjustments for age, gender, and season. Comparison of the costs of hospital stay was calculated using an ANOVA with Bonferroni correction using NWAU (Nationally-Weighted Activity Unit [12]).

Hospital coding data included all individuals admitted to either Blacktown or Mt Druitt hospital with a code of non-gestational diabetes (ICD-10, E08-E14) between the financial years of 2015 and 2017, consisting of 25,778 records.

The American Diabetes Association criteria was used to define the categories of prediabetes (HbA1c 5.7–6.4% or 39–46 mmol/mol) and diabetes (HbA1c $\geq$ 6.5% or 48 mmol/mol) [13]. As the definition of prediabetes based on HbA1c is yet to be defined, the data for pre-diabetes based on International Expert Committee (IEC) criteria [14] (HbA1c 6.0–6.4% or 42–46 mmol/mol) is also presented for comparative analysis.

3. Results

The samples included 55,568 presentations from the emergency departments and 5911 individuals from the general practices. Data for the ED was collected over a 2 year period beginning the 1st of June 2016. Limited demographic details were available for all individuals; in the ED, the average age was 51.3 years with a 45:55 ratio of male to female individuals. In primary care, the average age was 47.7 years with a male to female ratio of 49:51.

The proportion of individuals with results consistent with diabetes, pre-diabetes, and a normal range is given for both settings in Fig. 1. In ED 17% of tests were consistent with diabetes, and 30% consistent with pre-diabetes. High rates were also recorded in GP with 17% consistent with diabetes, and 27% consistent with pre-diabetes. The data by testing location is given in Table 1.

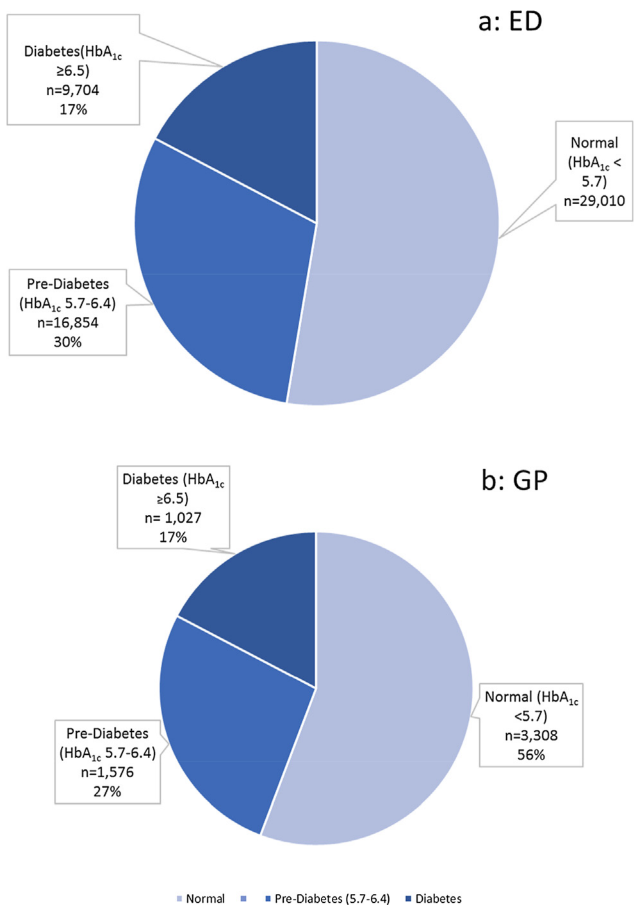

Fig. 1 – Distribution of pre-diabetes and diabetes in the ED cohort (a) and in General Practice (b).

Fig. 2 illustrates the proportion of individuals with diabetes presenting each week over the 2 year period of testing in the ED. There was a 1% year-on-year increase in the rate of diabetes ($R^2 = 0.1$) represented by the red trend line in the figure.

Multivariate regression, adjusted for age, season, and gender, demonstrated an odds ratio of 1.015 (CI 1.012–1.027, $p < 0.000001$) and 1.011 (95% CI 1.008–1.014, $p < 0.000001$) by week for pre-diabetes and diabetes respectively. Over the course of the year, this appears to be generating a 1% absolute increase in the rate of diabetes in ED.

Analysis of the records of admitted individuals revealed a similarly high rate of diabetes amongst all admissions. 20% of all individuals admitted during the 2015 financial year had a code for diabetes, which increased by 1% each year to 22% in the 2017 financial year.

As data for GP clinics only allowed for a cross-sectional view of diabetes rates, similar analyses to the ED cohort were not possible. However, analysis of the GP data from BMVP, which undertook testing on active patients for 12 months, indicated that there were more individuals testing positive for diabetes at the end of the testing period (10.8% or 710 of 6604 individuals) when compared to the start (8.9% or 601 of 6799 individuals). Active patients were defined as individuals who visited the practice at least 3 times in 24 months. This represents a 22% increase in the rate of diagnosed diabetes from prior to the testing regimen.

Fig. 3 provides an overview of the glycaemic categories by age bracket. There is worsening glucose tolerance with increasing age in both the ED and general practice cohorts. There is a notable decline in the diabetes category of the hospital cohort by the age of 80. By the age of 55, the number of individuals with pre-diabetes and diabetes outnumber those with normal glucose tolerance.

The mean cost of hospital admission (NWAU calculation) for a patient with diabetes was higher than a patient with a normal HbA1c, and that increasing categories of glucose intolerance– from normal range (\$5498), to pre-diabetes (\$6307) and then diabetes (\$7849) - was associated with higher costs. (Fig. 4, $F = 61.55$, $p < 0.00001$).

4. Discussion

Based on registration data sourced by the National Diabetes Services Scheme, the prevalence of diabetes in Western Sydney is 6.3%, which compares to the national prevalence of 5.2% [15]. NSW Health estimates that diabetes prevalence has risen in the general population from 7.9% in 2014 to 11.5% at the most recent estimate in 2017 [16]. This study reports rates of diabetes that are much higher and there also appears to be a year-on-year increase in the proportion of individuals presenting to ED with diabetes. The data from primary care (BVMP) also suggests increased rates of diabetes over 12 months.

Table 1 – Rates of pre-diabetes and diabetes by sampling location.

Location of detection	Number of people tested	Time period	Normal % $HbA_{1C} \leq 5.6\%$ (38 mmol/mol)	Pre-diabetes % HbA_{1c} 5.7–6.4% (39–46 mmol/mol)	Pre-diabetes % HbA_{1C} 6.0–6.4% (42–46 mmol/mol)	Diabetes % $HbA_{1C} \geq 6.5\%$ (48 mmol/mol)
Blacktown & Mt Druitt Hospital	**55,568**	**24 months**	**52%**	**30%**	**13%**	**18%**
General practice	**5911**	**Variable (see below)**	**56%**	**27%**	**11%**	**17%**
Toongabbie (BVMP)	2855	12 months	59%	23%	10%	18%
Blacktown	2630	1 month	54%	31%	12%	15%
Mt Druitt	211	1 month	38%	33%	12%	29%
Hills District	118	1 month	50%	28%	14%	21%
Westmead	97	1 month	66%	17%	9%	16%

Bold values are totals for all suburbs, as opposed to the unbolded suburb values below.

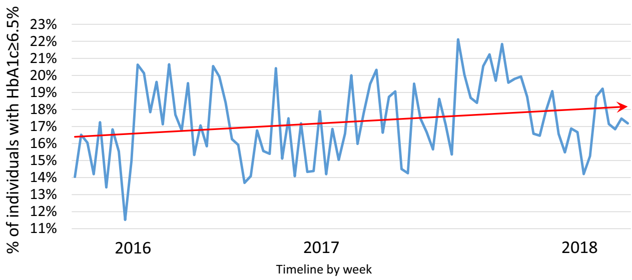

Fig. 2 – Increase in the rate of diabetes, by week of the year.

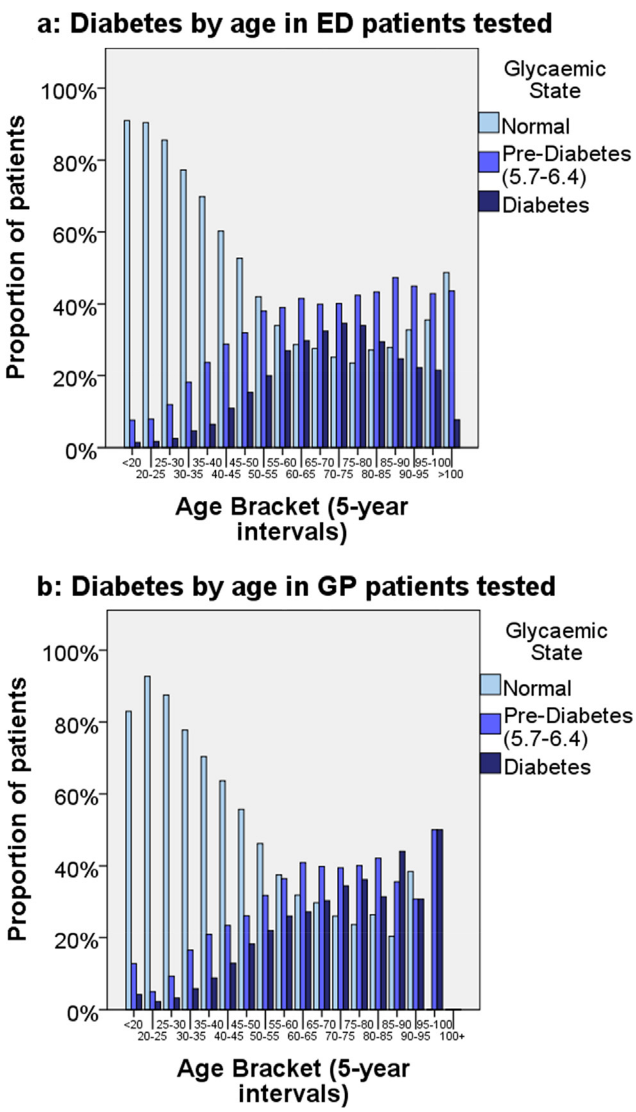

Fig. 3 – Distribution of glycaemic tolerance by age group.

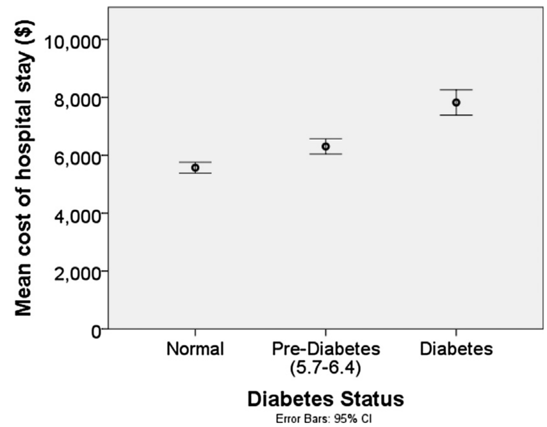

Fig. 4 – Costs of hospital stay (calculated by NWAU) by glycaemic category.

At an individual level, HbA1c measurements are used to monitor treatment and diagnose diabetes in individuals at risk. In our centre, HbA1c testing is part of routine care in individuals presenting to the ED. To the best of our knowledge, there are no other centres in Australia undertaking HbA1c testing at this scale. It is important to emphasize that the HbA1c data needs to be viewed from an epidemiological perspective as the allocation of individuals to the categories (normal, pre-diabetes and diabetes) is undertaken based on the absolute HbA1c result and ADA criteria. No clinical information has been taken into account in this process and it is possible that imprecise allocation may occur in some individuals (e.g. HbA1c < 6.5% may indicate pre-diabetes or alternatively well controlled diabetes).

The GP testing would not have been possible without the close relationship fostered in this and other work with the Primary Health Network. A surprising finding was the similar rates of pre-diabetes and diabetes detected between the ED and general practice cohorts, which conflicts with the literature that has previously indicated that diabetes severity is higher in hospital [17]. This suggests that diabetes may be more pervasive in the community than previously thought. This has implications for healthcare policy and resource allocation for both State and Federal governments. Given the cost-benefit of diagnosing and treating diabetes early [18], these results suggest that routine testing in GP and ED settings may be a reasonable approach.

Whilst the data presented captures information about the rates of diabetes, it also provides important information about those at-risk of developing diabetes. Regardless of how pre-diabetes is defined (ADA vs IEC criteria), it is clear that there are at least equal or double the number of individuals at risk. Fig. 3a suggest approximately 13% of women in the childbearing age (20–40 years) who were tested have pre-diabetes. It is likely that most will also have diabetes in pregnancy and a subsequent high rate of conversion to diabetes post-partum [19].

This study has also demonstrated the utility of routine HbA_{1c} testing in both ED and GP settings in Western Sydney. While population screening is considered unfeasible and not useful clinically, opportunistic testing as conducted in this study is comparatively cheap, easy to implement, and fits within existing hospital and GP frameworks. Widespread testing is likely to reduce the cost per test and better prevention and management strategies could reduce health care costs in Australia. Such testing should be accompanied by adequate resources to manage the increased detection rate, particularly in the hospital setting. In addition, it is clear that the costs of inpatient care increase with worsening glycaemic tolerance which has implications for the hospital budget.

There are a number of limitations to our study design. This population tested was opportunistic with high acuity, which implies that our observed figures are likely to be higher than the true rate of diabetes. However, the fact that the proportions have remained similar across several suburbs within the district and across large numbers of individuals indicate that data is a robust. These findings are specific in our high risk area and may might not be generalizable to more affluent or less culturally diverse regions elsewhere in the state or country. Our analysis was limited to the data available through the hospital and GP systems which leaves residual confounding as an issue. While we did control for age, further research is needed to identify whether the increased rates of diabetes are due to obesity, socio-economic factors, or other unidentified reasons. The small sample size at several collection locations also means that the geographically-specific estimates have wide margins of error. Individuals presenting to the ED on multiple occasions (n = 8968) may have influenced the results; the data collection process in GP did not allow for duplicate patient testing due to the limitations of the PEN clinical software used. Moreover, a sensitivity analysis excluding representations from the ED did not significantly affect any results. The use of HbA_{1c} alone to delineate diabetes can be flawed due to allocation bias as discussed above and a range of clinical scenarios returning an incorrect result [20]. Apart from extreme haemoglobin levels, the other factors were not controlled in this analysis.

5. Conclusion

This study demonstrated that HbA1c testing in ED and GP reveal a similarly high burden of diabetes and pre-diabetes across different areas of the healthcare system. The rates themselves are alarming, as well as the similarity between what are traditionally considered very different areas of the healthcare system. This has important policy implications, as early intervention for diabetes and pre-diabetes through lifestyle modification programs can have large benefits both to individual individuals and the health system.

Conflict of interest

The authors declare no conflict of interest.

Funding

The authors received no funding from an external source.

Acknowledgements

Bridgeview Medical Practice, Kildare Road Medical Centre, Richmond Road Medical Centre, Mt Druitt Medical Centre, Myhealth Castle Towers, Advance Medical Practice Westmead, Healthway Medical Practice, S & P Family Practice, The Practice, Walter's Road Medical Centre, Westmead Doctors, Dr Josh Ryan and Sayed Hamdam from Pathology West.

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