BITTERSWEET FINDINGS OF BLOOD GLUCOSE LEVELS IN 467,955 PATIENTS IN PRIMARY CARE

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# ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVD</td>
<td>Cardiovascular Disease</td>
</tr>
<tr>
<td>eGFR</td>
<td>Estimated glomerular filtration rate</td>
</tr>
<tr>
<td>DPP4</td>
<td>Dipeptidyl peptidase 4</td>
</tr>
<tr>
<td>GP</td>
<td>General practitioner</td>
</tr>
<tr>
<td>GLP1</td>
<td>Glucagon like peptide 1</td>
</tr>
<tr>
<td>GPRN</td>
<td>General Practice Research Network</td>
</tr>
<tr>
<td>HbA1c</td>
<td>Glycated haemoglobin</td>
</tr>
<tr>
<td>HCN</td>
<td>Health Communication Network</td>
</tr>
</tbody>
</table>
This report is a retrospective analysis of patient-based electronic medical records in primary care in Australia between 2005 and 2013. The main objective was to examine trends in blood glucose levels and the prescription of hypoglycaemic treatment. It provides current data on the pattern of surveillance of blood glucose monitoring and management of diabetes over 9 years, in turn offering important clinical and public health messages for health professionals and the general public.

The importance of undertaking large scale analyses to examine blood glucose levels in the primary care setting, whereby the majority of management for diabetes occurs, cannot be overstated. In the context of escalations in blood glucose levels in Australia over the past 20 years, associated with increases in modifiable risk factors such as body fatness, clinical practice needs to be reviewed against standards of diabetes prevention and care. This is essential to reduce the prevalence of diabetes, minimise diabetic complications and prolong survival in those already affected by this condition.

We analysed de-identified data for this report from a representative sample of primary care clinics using Medical Director patient management software, supplied by the Health Communication Network© (HCN). A blood glucose measurement (either fasting glucose or HbA1c test result) was documented for 467,955 patients (55% women, aged 55.4 ± 19.7 years) by 945 GPs from 320 primary care clinics across Australia in the study period from 2005 to 2013.
KEY FINDINGS

• Women were more likely to have a blood sugar result recorded than men, particularly in the 25 to 34 year age group, perhaps reflecting surveillance for gestational diabetes.

• The frequency of blood glucose testing increased after 45 years of age for both men and women.

• Average blood sugar levels (both HbA1c and fasting glucose) showed no change between 2005 and 2013 and were consistently higher in men than women.

• The proportion of patients with elevated HbA1c levels above 7%, irrespective of treatment, was around 40% in 2013 and decreased by approximately 10% since 2005.

• Fasting glucose results identified individuals as low risk (< 5.5 mmol/L), increased risk (pre-diabetes; 5.6 to 6.9 mmol/L) or at very high risk of diabetes (> 7.0 mmol/L) for 71%, 21% and 8% of all measurements, respectively.

• In the 5% of patients with evidence of hypoglycaemic prescription information:
  › Biguanides and sulphonylureas were the most commonly prescribed non-insulin hypoglycaemic treatments in 74% and 43% of individuals, respectively, whilst insulin was prescribed for 20%.
  › Prescriptions for biguanides and insulin increased by 14% and 5%, respectively, and sulphonylureas decreased by 20% from 2005 to 2013.
  › The advent of DPP4 inhibitors saw 15% of patients on hypoglycaemic agents prescribed this treatment in 2013.

• Average blood sugar levels (both HbA1c and fasting glucose) were consistently higher in patients prescribed insulin than non-insulin hypoglycaemic treatment or those not prescribed any treatment.

• Any form of hypoglycaemic treatment (non-insulin or insulin) was associated with increased weight and reduced total cholesterol and eGFR levels with marginally higher blood pressure levels. The weight of those prescribed treatment and the eGFR levels of all individuals increased from 2005 to 2013.

• The HbA1c glycaemic goal of 7.0% was:
  › Achieved for 43% of patients without hypoglycaemic treatment and for 15% prescribed pharmacological therapy.
  › Not achieved for 22% of patients pharmacologically managed and 20% who were not prescribed hypoglycaemic medication yet who could benefit from treatment.
  › From the pool of HbA1c measurements, more patients who achieved the HbA1c glycaemic target of 7.0% over the study period (regardless of treatment) was offset by less patients above this target and not pharmacologically managed, rather than not being treated to target.

• Inability to achieve the HbA1c glycaemic recommendation of 7.0% was associated with increased weight but no differences in total cholesterol, eGFR or blood pressure levels from 2005 to 2013.

• There were no changes over time in HbA1c levels [range 7.0% to 7.5%] with more frequent medical evaluation, albeit average values were higher in patients with more regular evaluation.

• Between 10% and 36% of patients who were never prescribed hypoglycaemic treatment were above the recommended HbA1c level of 7.0% in at least half of all visits.

• Average time to hypoglycaemic treatment initiation was 18 ± 10 months [range 12 to 96 months] at a HbA1c level of 7.4 ± 1.4 % overall, but higher in men than women (7.4 ± 1.4 % vs 7.3 ± 1.3 %). Initiation of treatment was not influenced by more ongoing contact with a GP.

• Biguanides and sulphonylureas were the most commonly prescribed non-insulin hypoglycaemic treatments in 73% and 27.0% of newly treated individuals, respectively, whilst insulin was first recorded for 16% of patients.

• Average time from non-insulin hypoglycaemic therapy to insulin therapy was 26 ± 17 months at a HbA1c level of 8.6% ± 1.6%.
INTRODUCTION

WHAT IS DIABETES?

Diabetes is a chronic disorder characterised by high blood sugar (hyperglycaemia)\(^1\). Sugar or glucose is a nutrient that cells in our body use to produce energy. Glucose is found in many foods including bread, cereals, fruit, starchy vegetables, milk, yoghurt and sweets. To absorb glucose from the blood stream into cells, a hormone named insulin is needed. Insulin is produced in the pancreas and when released, attaches to glucose. This combination then moves into our cells.

Individuals with diabetes do not produce insulin in sufficient amounts leading to excess blood glucose. When this condition is not treated accordingly by diet and lifestyle modification or pharmacological medication (injections or non-insulin agents), the result can be life threatening.

There are three main types of diabetes; type 1, type 2 and gestational. The signs and symptoms include:

- Excessive thirst
- Excessive and unexplained weight loss (specific to type 1)
- Blurry vision
- Slow healing cuts
- Mood swings, headaches and dizziness
- Leg cramps
- Feeling tired and lethargic
- Always feeling hungry
- Increased urination

Type 1 diabetes

In type 1 diabetes, the pancreas stops insulin production. As insulin is required for glucose uptake into the body’s cells, low amounts of insulin (or none at all) lead to hyperglycaemia. In order to maintain adequate blood sugar levels, regular monitoring and insulin injections are required numerous times per day.

Type 1 diabetes is an autoimmune disease; cells in the immune system (that usually protect the body from disease and illness) begin to attack the pancreas, destroying cells that produce insulin, hence decreasing insulin production and resulting in hyperglycaemia. There is no definitive cause of type 1 diabetes yet genetics, viral or bacterial infection, autoimmune reactions and toxic chemicals have been proposed as potential possibilities.

Type 2 diabetes

In type 2 diabetes, the pancreas may be able to produce insulin but in insufficient amounts and hyperglycaemia occurs. Type 2 diabetes is regularly treated without medication and can be managed by altering lifestyle via increasing physical activity and adopting a healthy diet. However some individuals with type 2 diabetes, particularly those with longer duration diabetes, require medication.

Type 2 diabetes occurs when the cells in the body become resistant to insulin, this is called insulin resistance. Initially, the pancreas reacts by over-producing insulin, but over time cannot sustain this, leading to a loss of insulin producing cells and insulin deficiency. This means that the pancreas works at a decreased rate and is not able to make an adequate supply of insulin for glucose uptake.

An individual is at higher risk of developing type 2 diabetes under the following conditions\(^1\):

- Family history of diabetes in a first degree relative (genetic predisposition)
- Aged above 55 years
- Aged above 45 years and are overweight or have hypertension
- Aged above 35 years and have Aboriginal and/or Torres Strait Islander ethnicity
- Personal history of gestational diabetes
- Delivered a baby weighing over 4.5 kgs (9 lbs)
- Personal history of polycystic ovarian syndrome

Gestational diabetes

Gestational diabetes is diagnosed during pregnancy (week 24 to 28) and often disappears after childbirth. It can recur in future pregnancies. In gestational diabetes, the placenta produces hormones to aid in pregnancy but which can make cells insulin resistant. Most of the time, the pancreas accounts for this and makes more insulin, however in some cases the pancreas cannot keep up and glucose remains in the blood stream resulting in hyperglycaemia\(^1\).

Gestational diabetes is more frequent in woman with the following characteristics:

- Aged above 30 years
- Family history of diabetes in a first degree relative
- Overweight or obese
- Aboriginal or Torres Strait Islander, Indian, Vietnamese, Chinese, Middle Eastern or Polynesian ethnic background

Gestational diabetes is managed by adopting a healthy eating plan and increasing physical activity with frequent monitoring of blood glucose levels. In some cases medication is necessary.
Presently, there are around 1.1 million people living with diabetes in Australia. This is double the number of Australians with diabetes since 1990, and the amount is enduring with about 100,000 new cases of diabetes diagnosed each year\(^1\).

**HOW IS DIABETES DIAGNOSED?**

Diabetes is diagnosed (and monitored) via a simple blood test to measure glucose levels. This can be done in a number of ways and the results compared to reference levels (refer Table 1)\(^2\).

- **Fasting blood glucose levels:** Measured after an overnight fast, a simple blood sample is taken to determine the amount of glucose in the blood.

- **HbA1c concentration:** A blood sample is collected (does not require overnight fasting) to measure HbA1c - a protein that is reflective of the average blood glucose concentration over an 8-12 week period.

- **Glucose tolerance test:** After consuming a drink loaded with glucose, blood samples are measured over a period of time (2 hours) to determine the rate at which the glucose is taken into the cells.

In addition to blood glucose monitoring, symptom assessment is recommended to identify typical symptoms such as increased thirst or hunger, frequent urination or slow healing wounds.

**Pre-diabetes**

Pre-diabetes is characterised by impaired fasting glucose or impaired glucose tolerance. Blood glucose levels are higher than normal in pre-diabetes but are not high enough for a diagnosis of diabetes. To prevent the development of type 2 diabetes, treatment involves lifestyle modification, predominantly to reduce body weight.

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**Table 1. Reference blood glucose and HbA1c levels for the detection and control of type 2 diabetes**

<table>
<thead>
<tr>
<th>Diagnostic criteria for diabetes</th>
<th>Fasting</th>
<th>Pre-diabetes</th>
<th>Post-pandial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood glucose (spot sample)</td>
<td>Fasting</td>
<td>Pre-diabetes</td>
<td>Post-pandial</td>
</tr>
<tr>
<td>Ideal</td>
<td>Below 5.5 mmol/L</td>
<td>5.6 to 6.9 mmol/L</td>
<td>7.0 mmol/L and higher</td>
</tr>
<tr>
<td>Pre-diabetes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HbA1c (8-12 week period)</td>
<td>Below 5.7% (39 mmol/mol)</td>
<td>5.7 to 6.4% (39 to 46 mmol/mol)</td>
<td>6.5% (48 mmol/mol) and higher</td>
</tr>
<tr>
<td>Ideal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-diabetes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For individuals with diabetes</td>
<td>Pre-prandial</td>
<td>Post-prandial</td>
<td></td>
</tr>
<tr>
<td>Blood glucose (spot sample)</td>
<td>3.9 to 7.2 mmol/L</td>
<td>Less than 10 mmol/L</td>
<td></td>
</tr>
<tr>
<td>Target HbA1c</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More stringent</td>
<td>Below 6.5% (48 mmol/mol), if achievable without adverse effects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reasonable</td>
<td>Below 7.0% (53 mmol/mol)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less stringent</td>
<td>Below 8.0% (64 mmol/mol), if lower targets cause difficulty to achieve</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: American Diabetes Association\(^2\)
In 2010, approximately 7,750 Australians died from diabetes or a diabetes-related cause, accounting for 5.4% of all deaths, 55% of whom were men. By 2033, it is predicted that more than 3.4 million Australians will have diabetes at a cost of $8 billion, greatly increasing the burden imposed by diabetes, with a profound impact on our health care system.

**DIABETES PREVALENCE IN AUSTRALIA**

*Figure 1* shows the increasing prevalence in diabetes from 1988 to 2013 which has almost quadrupled within this 20 year span. More recently however, there is a plateau in prevalence rates of diabetes from 2008 to 2013. Approximately 1.1 million Australians already have diabetes consisting of 120,000 individuals with type 1, 956,000 with type 2 and 23,600 with gestational diabetes. This may be a significant underestimate however because a large number of individuals are living with diabetes but are unaware of it due to the progressively slow onset and the fact that it is largely asymptomatic; there is 1 undiagnosed diabetes case for every three diagnosed cases. Hence, the total number of Australians with diabetes, including those with pre-diabetes, is approximately 3.2 million. Lifestyle measures have been shown to prevent the progression to diabetes in people with pre-diabetes by up to 58.0%

**THE EFFECTS OF DIABETES**

Diabetes can predispose individuals to a number of dangerous and life threatening conditions. Diabetes shares a range of risk factors with cardiovascular disease (CVD) such as obesity, high blood pressure and raised lipids (e.g. cholesterol and triglyceride) due to poor diet and physical inactivity. Over half of sufferers of diabetes (58.0%) are diagnosed with CVD. Diabetes can directly damage vital organs; damage to the kidney (nephropathy), nerves (neuropathy) and eyes (retinopathy) can be affected, particularly if diabetes is left untreated. In 2007/2008, over 95,000 Australians experienced loss of vision due to diabetes and approximately 5,700 adults with diabetes received treatment for end stage kidney disease.

![Per cent](chart)

Source: Australian Institute of Health and Welfare

*Figure 1. The prevalence of diagnosed diabetes in Australia from 1988 to 2013*
THE ECONOMIC IMPACT OF DIABETES IN AUSTRALIA

In 2008/2009, 2.3% (estimated at $1,507 million) of the total allocated health expenditure was utilised to treat and manage diabetes. The majority of costs were spent in primary care, 24% on out of hospital medical services, 33% on hypoglycaemic medication and 43% on hospital admitted patients. General Practitioners (GP), endocrinologists, psychologists, exercise physiologists, diabetes nurses and diabetes educators are the first step in seeking diabetes treatment and management, and do not come cheaply.

TREATMENT FOR DIABETES

1. Lifestyle behaviours

- Increasing physical activity: At least 30 minutes of moderate physical activity should be performed on most, if not all days of the week. A total of at least 150 minutes per week is recommended.

- Making healthy nutrition choices: Diet should follow a normal and healthy eating plan. The Australian Dietary Guidelines provide information on healthy eating for adults. To ensure a healthy lifestyle, adults need to achieve and maintain a healthy weight by being active and choosing nutritious food and drink to meet energy needs.

A wide variety of food from the following 5 groups should be consumed:

I. Vegetables
II. Fruit
III. Grains, mostly wholegrain and high fibre
IV. Lean meats, poultry, fish, eggs, tofu, nuts, seed and legumes
V. Reduced fat milk, cheese and yoghurt

Foods with high salt content, added sugar and high saturated fat content should be avoided and alcohol intake restricted.

2. Medication

There are different types of medication used to treat diabetes that differ in respect to their action.

- Biguanides: Reduce the amount of glucose that is released from the liver and slows glucose absorption in the small intestine, preventing blood glucose from rising.
- Sulphonylureas: Stimulate the release of insulin from the pancreas. This leads to an increased amount of glucose taken into the cells, lowering blood glucose.
- Thiazolidineodiones: Reduce the amount of glucose released from the liver and improves the action of insulin on our cells, resulting in lower blood glucose.
- Dipeptidyl Peptidase 4 (DPP-4) inhibitors: Elevate the release of a hormone within the gut that stimulates the pancreas to release insulin.
- Alpha Glucosidase Inhibitor: Decrease the rate of carbohydrate digestion in the intestine, reducing the rate at which glucose enters the blood stream.
- Glucagon Like Peptide 1 (GLP1) agonists: Stimulates the pancreas to release insulin and restricts the release of glucose into the blood stream by the liver. Additionally, this medication group can delay the stomach from emptying, reducing appetite and preventing blood glucose from rising after meals.
- Metiglinide: Increases the release of insulin from the pancreas resulting in greater uptake of glucose into our cells.
- Insulin: Aids in glucose absorption from the blood stream into cells. Insulin attachment to insulin receptors is required to bring glucose into the cell.
OBJECTIVES

Given the escalation in blood glucose levels in Australia over the past 20 years, the main objective of this Report was to examine trends in blood glucose and HbA1c levels and treatment in patients attending primary care, whereby the majority of management for the condition occurs. It provides current data on the pattern of surveillance of blood glucose monitoring and management of diabetes for the nine years beginning from January 2005 to December 2013. Many clinical and public health messages for health professionals and the broader community can be gleaned from these analyses.
There are two main sections to the report that vary based on the data selected for analyses, with relevant sub-analyses contained within each section:

**SECTION 1: Blood sugar levels of first patient encounters**

This section uses only one measurement (the first) for any individual patient in the data set. For patients who had more than one recorded blood glucose result, only the initial result was used and their remaining data were set aside for analyses to be undertaken as part of Section 2.

The key elements of Section 1 are:

- **Part 1** – General trends in blood glucose/HbA1c levels and associated anthropometric and biomedical risk factors according to gender and treatment; diagnostic criteria and hypoglycaemic treatment prescriptions

- **Part 2** – Glycaemic control and treatment and associated risk factor control

**SECTION 2: Blood sugar levels of repeat patient visits**

This section uses all measurements for an individual patient whereby there are at least two HbA1c results separated by 6 months. Results are shown in 6 monthly epochs for the longest available sequence length, up to a maximum of 9 years (i.e. 18 sets of 6 monthly blocks).

The key elements of Section 2 are:

- **Part 1** – Patients never prescribed hypoglycaemic treatment

- **Part 2** – Patients who are initiated on hypoglycaemic treatment or insulin therapy
GENERAL PRACTITIONERS
Over the 9 years commencing in 2005, a blood glucose measurement (either fasting glucose or HbA1c test result) was recorded for a total of 467,955 patients (55% women, aged 55.4 ± 19.7 years) by 945 GPs from 320 primary care clinics across Australia. Figure 2 shows the distribution of results and the number of clinics who provided the measurements for each State and Territory in Australia.

**Figure 2.** Total primary care clinics and patients with fasting glucose or HbA1c monitoring per State and Territory between 2005 and 2013
PATIENTS

Raw data of 1,516,347 blood sugar readings (HbA1c or fasting glucose) from 487,638 patients between 2005 and 2013 were received. Following the exclusion of patients with missing age and sex information and removal of outliers or extreme HbA1c and/or fasting glucose measurements, there were a total of 1,296,396 blood sugar readings from 467,955 unique individuals during the study period.

Table 2 shows the number of men and women who had either HbA1c or glucose measured according to year of visit. Within the entire dataset, there was a predominance of fasting glucose (n=448,362) compared to HbA1c (n=50,721) measurements. A total of 31,128 had both a fasting glucose and HbA1c result recorded on the same date of visit; both of these values were used in Section 1 of this report. Another 417,234 individuals had only a fasting glucose result and 19,593 had only a HbA1c measurement the first time they appeared in the dataset.

Of the total sample, 55% (n=256,038) were women. Figure 3 shows the number of men and women who had any blood sugar assessment between 2005 and 2013 according to age. As shown, there was a progressively greater number of blood sugar results with increasing age, with more frequent testing (approximately 80,000 tests per age decade) occurring after 45 years of age. In nearly all age groups, excluding 55 to 74 year olds, there were more women than men who had a blood sugar result recorded.

### Table 2. Number of men and women with HbA1c and/or fasting glucose measurements recorded per year between 2005 and 2013

<table>
<thead>
<tr>
<th>Year</th>
<th>HbA1c (n=50,721)</th>
<th>Glucose (n=448,362)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>2005</td>
<td>5,798</td>
<td>4,742</td>
</tr>
<tr>
<td>2006</td>
<td>3,352</td>
<td>3,053</td>
</tr>
<tr>
<td>2007</td>
<td>3,340</td>
<td>3,013</td>
</tr>
<tr>
<td>2008</td>
<td>3,271</td>
<td>3,064</td>
</tr>
<tr>
<td>2009</td>
<td>3,086</td>
<td>2,762</td>
</tr>
<tr>
<td>2010</td>
<td>2,544</td>
<td>2,325</td>
</tr>
<tr>
<td>2011</td>
<td>2,173</td>
<td>1,895</td>
</tr>
<tr>
<td>2012</td>
<td>1,963</td>
<td>1,820</td>
</tr>
<tr>
<td>2013</td>
<td>1,286</td>
<td>1,234</td>
</tr>
</tbody>
</table>

*Figure 3. Total number of men and women with HbA1c or fasting glucose measurements recorded between 2005 and 2013 according to age.*
BLOOD SUGAR LEVELS OF FIRST PATIENT ENCOUNTERS

In this first set of analyses, only the earliest HbA1c and fasting glucose result(s) that was recorded for an individual patient was used. In instances where patients had repeat blood sugar measurements taken between 2005 and 2013, the initial recorded result was included for analyses and any additional measurements were set aside for analyses to be undertaken in Section 2 of this Report.

GENERAL TRENDS
TRENDS OVER TIME

HbA1c

Based on 50,721 HbA1c measurements, Figure 4 shows that average yearly HbA1c levels remained unchanged at around 7.0% between 2005 and 2013.

Figure 4. Average annual HbA1c levels between 2005 and 2013

Figure 5 shows, for three different glycaemic control targets, a general trend for a reduction in the proportion of individuals with elevated HbA1c levels between 2005 to 2013, becoming evident after 2011.

Over 60% of patients had a HbA1c level greater than 6.5% in 2005 compared to approximately 50% in 2013. Likewise, just under half of patients had a HbA1c value above 7.0% in 2005 compared to under 40% in 2013. The percentage of patients with elevated HbA1c above 8.0% remained unchanged at approximately 20% between 2005 and 2013.

Figure 5. Percentage of patients with elevated HbA1c levels between 2005 and 2013
Fasting glucose

Based on 448,362 fasting blood glucose records, Figure 6 shows no change in yearly glucose measurements between 2005 and 2013, which remained at an average level of 5.5 mmol/L.

Figure 6. Average annual fasting glucose levels between 2005 and 2013

According to diagnostic thresholds\(^2\), Figure 7 shows a consistent trend over time in the proportion of patients (71%) with a fasting glucose measurement who were low risk for diabetes (< 5.5 mmol/L). Exactly 21% of patients were identified at increased risk in the pre-diabetes range (5.6 to 6.9 mmol/L) and for 8.0%, diabetes may be considered by a fasting blood glucose of over 7.0 mmol/L.

Figure 7. Percentage of patients in each diabetes risk category according to fasting glucose levels between 2005 and 2013

Note: Medical histories are not captured in the clinical management software used by GPs. Therefore it is unknown from the available data who, with a fasting glucose result, has a diagnosis of diabetes to be able to distinguish between diagnostic testing and glycaemic control.
TIME TRENDS ACCORDING TO GENDER

**HbA1c**

Figure 8 shows that average yearly HbA1c levels were relatively unchanged between 2005 and 2013 for both men and women; they remained at around 7.0% but were consistently higher for men than women.

![HbA1c levels graph](image)

**Fasting glucose**

Consistent with observed trends in HbA1c levels according to gender, Figure 9 illustrates that there was no change over time in fasting blood glucose results between 2005 and 2013 for men or women. Men had higher levels than women (5.7 mmol/L vs. 5.3 mmol/L) for all years.

![Fasting glucose levels graph](image)

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**Figure 8.** Average annual HbA1c levels according to gender between 2005 and 2013

**Figure 9.** Average annual fasting glucose levels according to gender between 2005 and 2013
HYPOGLYCAEMIC TREATMENT
HYPOGLYCAEMIC TREATMENTS PRESCRIBED ACCORDING TO CLASS

Any hypoglycaemic treatment was prescribed for 24,534 individuals upon initial presentation (5.2% of total cohort). However it is likely that only people with a HbA1c measurement (i.e. 50,721), that is used to assess the effectiveness of management on glycaemic control, had been diagnosed with diabetes so the percentage would be 48.4%.

Figure 10 shows that non-insulin hypoglycaemic medication was prescribed more frequently than insulin. The most common class used to treat diabetes were biguanides (74%) followed by sulphonylureas (43%). Less commonly prescribed non-insulin hypoglycaemic treatments were thiazolidinediones and DPP4 inhibitors prescribed for 8.0% and 3% of patients, respectively. Insulin was prescribed for 20% of all patients being treated.

Figure 10. Percentage of patients prescribed hypoglycaemic treatments according to class
TIME TRENDS IN CLASS OF HYPOGLYCAEMIC TREATMENTS PRESCRIBED

Figure 11 highlights the change over time in the proportion of patients prescribed hypoglycaemic treatments. There was an increase from 66% to 80% in the number of patients prescribed biguanides. Conversely there was a 20% reduction in sulfonylurea prescriptions from 49% to 29%. The number of patients prescribed thiazolidinediones doubled from 5% to 10% in 2005 to 2010, before dropping to 4% in 2013. The advent of DPP4 inhibitors in 2009 saw a rise to 15% by 2013 of patients prescribed this class of treatment. Insulin showed a slight increase of 5% to 21% from 2005 to 2013. All other forms of treatment were rarely prescribed at any time over the study period.

*Figure 11. Percentage of patients prescribed hypoglycaemic treatments according to class between 2005 and 2013*
TRENDS ACCORDING TO HYPOGLYCAEMIC TREATMENT
BLOOD GLUCOSE LEVELS OVER TIME ACCORDING TO HYPOGLYCAEMIC TREATMENT

Figure 12 shows that the average HbA1c levels of those prescribed insulin (8.4%) was significantly higher than those prescribed non-insulin hypoglycaemic treatment (7.5%) or not taking any hypoglycaemic therapy (6.8%). There was some variation in HbA1c levels over time as a function of treatment; average HbA1c levels were higher in 2011 in people prescribed insulin and in 2008 for people not on any treatment for diabetes. Otherwise, there was no change in HbA1c levels within groups between 2005 and 2013.

Figure 13 shows that the fasting glucose levels of those prescribed insulin (10.1 mmol/L) was significantly higher than those prescribed non-insulin hypoglycaemic treatment (8.7 mmol/L) or not taking hypoglycaemic therapy (5.3 mmol/L). Aside from an increase in fasting glucose levels in 2010 in people prescribed insulin, there was no change in blood sugar levels within groups from 2005 to 2013.

Figure 12. Average annual HbA1c levels according to hypoglycaemic treatment between 2005 and 2013

Figure 13. Average annual fasting glucose levels according to hypoglycaemic treatment between 2005 and 2013
ASSOCIATED RISK FACTORS ACCORDING TO HYPOGLYCAEMIC TREATMENT

Weight
As shown in Figure 14, weight was significantly lower in untreated individuals (81 kg) compared to those prescribed either non-insulin or insulin hypoglycaemic medication (average 90 kg). Hypoglycaemic therapy was also associated with a heavier weight over time, ranging from approximately 87 kg in 2005 to 90 kg in 2013.

Blood pressure
Figure 15 shows that systolic blood pressure levels were slightly lower in non-treated individuals (131 mmHg) over the period 2005 to 2013 but was similar for people prescribed either non-insulin on insulin hypoglycaemic therapy (approximately 135 mmHg). Diastolic blood pressure was similar in all three groups, ranging between 76 and 79 mmHg for insulin and non-treated patients, respectively.

Figure 14. Average annual weight levels according to hypoglycaemic treatment between 2005 and 2013

Figure 15. Average annual systolic (upper trends) and diastolic (lower trends) blood pressure levels according to hypoglycaemic treatment between 2005 and 2013
Cholesterol
As shown in Figure 16, total cholesterol levels were higher in untreated individuals (5.1 mmol/L) compared to those prescribed either non-insulin or insulin hypoglycaemic medication (average 4.5 mmol/L) for the duration of the time period. There was no change in cholesterol levels over time or within treatment groups.

![Figure 16. Average annual total cholesterol levels according to hypoglycaemic treatment between 2005 and 2013](image)

eGFR
As shown in Figure 17, eGFR levels were higher in untreated individuals compared to individuals prescribed non-insulin or insulin hypoglycaemic medication which each showed similar levels over the study duration. In all groups, there was an increasing trend in eGFR levels from 2005 to 2013 which was a greater difference (16 ml/min per 1.73 m2) in those not taking hypoglycaemic treatment compared to those prescribed non-insulin agents (11 ml/min per 1.73 m2) or insulin (8 ml/min per 1.73 m2) agents.

![Figure 17. Average annual eGFR levels according to hypoglycaemic treatment between 2005 and 2013](image)
RESULTS
SECTION 1
PART 2

GLYCAEMIC CONTROL
HbA1c LEVELS ACCORDING TO HYPOGLYCAEMIC TREATMENT

Figure 18 shows the proportion of patients who achieve HbA1c glycaemic targets according to hypoglycaemic treatment\(^2\). More stringent targets prove more difficult to achieve as evidenced by 56.6%, 42.3% and 22.5% of patients above the glycaemic goals of ≥ 6.5%, ≥ 7.0% and ≥ 8.0%, respectively. To illustrate using a reasonable HbA1c goal of 7.0%, 2 in every 5 patients achieved this goal without pharmacological treatment (white segment) and a further 15% were effectively managed with hypoglycaemic medication (red segment). Approximately 1 in 5 patients who were prescribed treatment did not attain the recommended level of 7.0% (light blue segment). Another 1 in 5 individuals with a HbA1c level ≥ 7.0% were not pharmacologically managed and could benefit from treatment.

HYPOGLYCAEMIC TREATMENT ACCORDING TO HbA1c CONTROL

Figure 19 shows a small increase from 2005 to 2013, albeit with some year-to-year variability in the proportion of people below the HbA1c glycaemic target of 7.0% who are not prescribed hypoglycaemic therapy (41% to 46%; white stack) and who achieve this target with medication (12% to 17%; red stack). Therefore, there was approximately 10% improvement over time in the percentage of patients who achieved the HbA1c glycaemic target of 7.0%. More people who achieve the recommendations means less people who are above target; there was a reduction in the proportion of patients above the HbA1c goal of 7.0% who were not pharmacologically managed (28% in 2005 to 17% in 2013, dark blue stack) with no change in the percentage of individuals treated but not at target (19% to 20%; light blue stack).
Figure 19. Percentage of patients who achieve the glycaemic target HbA1c of 7.0% according to treatment between 2005 and 2013

Figure 20 identifies that individuals above the glycaemic goal of 7.0% were almost 3 times more likely to be prescribed insulin (28.0% vs. 10%). Around 10% more patients who were effectively managed were prescribed biguanides (79% vs 71%). More patients above the recommended level of 7.0% were prescribed sulphonylureas (47.0% vs. 39%), thiazolidinediones (10% vs. 5%) and DPP4 inhibitors (4% vs. 2%).

Figure 20. Percentage of patients prescribed hypoglycaemic treatment according to class and achievement of the glycaemic HbA1c goal of 7.0%
ASSOCIATED RISK FACTORS ACCORDING TO HbA1c CONTROL

Weight

Figure 21 shows that weight was consistently lower in patients who achieved the glycaemic goal of 7.0% (86 kg) compared to above this level (90 kg). Similar to observed trends in weight according to hypoglycaemic treatment, there was a gradual incline in weight from 2005 to 2013.

Blood pressure

From 2005 to 2013, Figure 22 shows that blood pressure levels were similar for individuals above or below the glycaemic goal of 7.0% (approximately 136/79 mmHg) with no change over time.
**Cholesterol**

Figure 23 shows that from 2005 to 2013, total cholesterol levels did not change over time and were similar for individuals above or below the glycaemic goal of 7.0% (approximately 4.7 mmol/L).

**eGFR**

Figure 24 shows that eGFR levels were similar for individuals above or below the glycaemic goal of 7.0% (approximately 79 ml/min per 1.73 m²), with an approximate 10 ml/min per 1.73 m² increase overall from 2005 to 2013.
RESULTS

SECTION 2

BLOOD SUGAR LEVELS OF REPEAT PATIENT ENCOUNTERS

In this section, all available HbA1c measurements for an individual patient were averaged into 6 monthly epochs from the index date of visit. Patients who had two or more contiguous blocks with HbA1c measurements between 2005 and 2013 are included for analyses and their longest sequence selected for investigation. For example, if a patient had 2 visits 6 months apart in 2008 and 5 visits every 6 months from 2010, the second sequence of 5 visits would be chosen to analyse.

Figure 25 shows minimal incremental benefit in HbA1c levels with more ongoing medical evaluation in primary care. HbA1c levels were lowest in people with fewer contiguous visits and highest in people who had 8 years of visit data (shown as 16 epochs). The range of HbA1c results was confined to between 7.0% and 7.5%.

Figure 25. Average HbA1c levels of contiguous 6 monthly visit data
The flow chart in Figure 26 describes patients with contiguous 6 monthly visit data and their treatment plans according to the timing of prescriptions for non-insulin and insulin hypoglycaemic treatment. Of a total of 37,044 patients with contiguous data, half were initially prescribed such therapy (i.e. epoch 1 representing 0-6 months). Of the individuals not prescribed treatment at the start of their data series (n=18,479), approximately two thirds (n=11,517) never started hypoglycaemic medication (light grey text box, refer Part 1 analyses) and one third were initiated on treatment (red text boxes, refer Part 2 analyses). All individuals prescribed hypoglycaemic treatment, evident at either their first (n=18,565) or subsequent GP encounters (n=6,962), with continuing HbA1c evaluation were reviewed for medication type (light blue text boxes, also refer Part 2 analyses).

Figure 26. Flowchart of contiguous 6 monthly visit data according to hypoglycaemic treatment
PATIENTS NEVER PRESCRIBED HYPOGLYCAEMIC TREATMENT

For 11,517 individuals who are never prescribed hypoglycaemic medication, Table 3 identifies the number of epochs within contiguous visit sequence lengths that the glycaemic goal of 7.0% is not achieved. It can be seen that the majority of people consistently achieved this goal and were rarely above the recommended level. Only a small proportion of patients, ranging from 10% to 36%, were above the recommended HbA1c level of 7.0% in at least half of all visits (grey shaded area).

*Grey shading; indicative of approximately 50% of visits with elevated HbA1c levels ≥ 7.0%
### PATIENTS INITIATED ON HYPOGLYCAEMIC TREATMENT

Table 4 shows the proportion of individuals who start hypoglycaemic medication (n=6,962) and the timing of initiation within contiguous visit sequence lengths. To illustrate, 69% of individuals with 3 contiguous visits are initiated on hypoglycaemic medication after epoch 2 (i.e. 1 year).

The average time to hypoglycaemic treatment initiation was 18 ± 10 months [range 12 to 96 months], with no difference between men and women. This did not vary by the frequency of contact with GPs over the years; the majority of patients were prescribed hypoglycaemic medication within the first 18 months (epoch 3), with little evidence of slighter longer delays with more frequent visitation. Overall, 80% of all patients had begun therapy by this time.

#### Table 4. Percentage of patients who started hypoglycaemic treatment according to time therapy was initiated and sequence length

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<th>Time treatment initiated (6 month epoch)</th>
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<tbody>
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**RESULTS SECTION 2 PART 2**
Independent of ongoing management, the average HbA1c level when treatment was first prescribed was 7.4 ± 1.4 %. It was significantly higher in men than women (7.4 ± 1.4 % vs 7.3 ± 1.3 %, p<0.01) regardless of the delay to initiate treatment (see Figure 27).

Figure 27. Average HbA1c levels that treatment was initiated according to gender
Figure 28 shows that upon initiation, the most commonly prescribed hypoglycaemic medication was biguanide therapy in 73% of all patients. Sulphonylureas were prescribed for 27% of individuals and insulin for 16%.

**Figure 28. Class of hypoglycaemic treatments patients were initiated on**

As summarised in Figure 26 (light blue text boxes), a total of 2,018 patients (56% men) were initiated on insulin after ongoing management with non-insulin hypoglycaemic treatments. The average time from non-insulin to insulin hypoglycaemic therapy was 26 ± 17 months. One third of individuals begun insulin therapy after 12 months, two thirds by 24 months and 4 in 5 patients were prescribed this treatment after 36 months of being prescribed non-insulin treatment.

The average HbA1c level at the time insulin was first prescribed following management with non-insulin hypoglycaemic treatments was 8.6% ± 1.6% and was significantly higher in men than women (8.6% ± 1.7% vs 8.5% ± 1.6%).
CONCLUSIONS

This is the first report of its kind to evaluate patterns of blood glucose levels and pharmacological management of patients attending primary care in Australia. The data from almost half a million individuals managed by nearly 1000 GPs in the 9 years beginning from 2005 showed evidence of improvements in HbA1c results, with about a 10% reduction in individuals above the glycaemic goal of 7.0%. Hyperglycaemia remains to be a concern for clinicians, patients, scientists and the general public however, with 30-40% of people presenting to primary care with blood glucose assessment having values above recommended limits for reduced risk of diabetes (or complications thereof). There appears to be plenty of opportunity to improve glycaemic control with half of patients above target likely to benefit from starting treatment or up-titration of treatment.

For decades, the reported prevalence of diabetes and pre-diabetes has been on the rise. This has provided the impetus for increased surveillance of glucose levels in primary care, supported by government initiatives and primary care items to proactively detect and manage the condition. This undoubtedly explains our findings in relation to increasing surveillance with age, particularly from middle age and onwards.

As with our other reports focussing on blood pressure and lipid trends and management in primary care, we observed no improvements in average blood glucose levels over the period 2005 to 2013. These consistent findings are a reminder of the challenge to improve antecedent risk factor levels at the whole population level. Within this patient cohort, fasting glucose levels suggested that 8.0% were consistent with a diagnosis of diabetes and a further 21% with abnormal glucose levels had high risk of developing the condition.

The management of diabetes remains dynamic in terms of the observed trends in pharmacological management and in subsequent glycaemic control. For example, we observed an encouraging trend in achieving the HbA1c goal of 7.0% that coincided with the transition from older to newer therapeutics from 2011, with only nominal changes in insulin therapy.

Despite some encouraging trends, these data are a reminder of the clinical challenges health professionals face in preventing and managing diabetes. The proportion of individuals, either being actively treated for hyperglycaemia or not, remains stubbornly high at around 40%. Of these individuals, the rule of half applies; half were not on treatment and could benefit from therapy, whilst the other half were treated but did not achieve target HbA1c levels and could benefit from more proactive management.

More frequent patient/GP encounters did not appear to result in better glycaemic control. This may reflect the well described and common phenomenon of treatment inertia. It may also indicate the possibility that more complex patients attend more regularly and are harder to achieve glycaemic control. Therefore, as with the primary care management of elevated blood pressure, there appears to be clear potential to firstly initiate treatment earlier and apply more structured and intensive management to achieve control in those with persistently elevated blood glucose levels. Further investigation of the individual and physician factors influencing clinical management of diabetes in primary care need to be undertaken, including duration of diabetes, frequency and severity of hypoglycaemic events, weight gain and other side effects of medication. This would include exploring the application of reimbursement items (now a major government expenditure) to promote best practice in diabetes prevention and management.
In summary, this report provides bittersweet findings - pleasing in respect to improved HbA1c levels mixed with still unacceptably high blood glucose readings and room for improvement using new and potentially effective treatments in combination with more proactive management. Blood sugar levels remain at historically high values necessitating a more intensive approach to lower blood glucose to levels to prevent the progression of pre-diabetes to overt diabetes and to reduce risk of complications of this insidious condition.

LIMITATIONS

This report is a large and unique body of evidence however consideration must be given to limitations of data of this kind. As mentioned in our previous reports, the data were collected as part of routine clinical practice and not in a systematic and prospective manner. Specifically, diabetes status was unknown to be able to distinguish between measures of surveillance/screening and glycaemic control. Furthermore, due to the de-identified nature of data (both from a patient and GP perspective), we are unable to determine if individual patients consulted another GP and therefore included twice in the data-set. In addition to having to apply a series of conservative assumptions to standardise between individual comparisons (for example we only accepted records where the age and gender of individuals were clearly identifiable), we have no way of verifying the veracity of individual data. Moreover, these data describe a specific primary care patient cohort and caution should be applied when making extrapolations (i.e. beyond within cohort comparisons) to the wider patient population being managed within primary care in Australia and, indeed, the wider population.
REFERENCES

General Practice Research Network

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To do this we are collecting information from the medical records kept by your doctor. None of the information that we collect will identify you. HCN has applied rigorous measures to ensure that the collection, storage and use of all data received is compliant with the National Privacy Principles.

The GPRN is interested in how large groups of patients are treated, not individuals. Through this we can work towards better health and health care.

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