

Does a hospital diabetes inpatient service reduce blood glucose and HbA1c levels? A prospective cohort study

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ABSTRACT

Background: Diabetes education is believed to bring about sustained benefits in diabetes mellitus (DM) patient outcomes. These benefits have not been widely studied in an inpatient hospital setting, and as such the aim was to determine whether a hospital diabetes in-service, and specifically diabetes education, results in reduced blood glucose and HbA1c levels after hospital discharge.

Methods and materials: A cohort review was performed at a large teaching hospital, in Canberra, Australia. Sixty seven patients comprising 35 males and 32 females who were referred upon discharge to the Diabetes Services as having a history of uncontrolled DM from February 1st 2015 until January 31st 2016 were evaluated. The retrospective discharge blood glucose level (BGL) was compared to prospective BGL 3 months after hospital discharge. HbA1c was prospectively taken before and 3 months after Diabetes Service education. A between subjects *t*-Test was used to compare patients' glucose and HbA1c averages.

Results: The average discharge BGL result was 13.3 mmol/L, compared to the post-discharge result of 11.2 mmol/L, indicating a significant decrease ($p = < 0.01$). The average pre-HbA1c result was 10.45%, and decreased to the post-HbA1c result of 8.96%, which was significant ($p = < 0.05$).

Conclusion: This study is the first to measure the direct glucose adherence benefits associated DM education within Australia and provides evidence on the effectiveness of a Diabetes Service in reducing patient BGLs. Utilisation of Diabetes Services to control glycaemia encourages ongoing efforts and translates to reduced micro and macro cardiovascular risk factors associated with DM.

1. Introduction

Medical testing for the diagnosis and management of diabetes mellitus (DM) includes measurement of patients' glucose levels and glycated haemoglobin (HbA1c) levels. The criteria for diagnosing DM is: A hemoglobin A1c (HbA1c) level of 6.5% or higher; or a fasting plasma glucose (FPG) level of 7 mmol/L (126 mg/dL) or higher; or a 2-h plasma glucose level of 11.1 mmol/L (200 mg/dL) or higher during a 75-g oral glucose tolerance test (OGTT); or a random plasma glucose of 11.1 mmol/L (200 mg/dL) or higher in a patient with classic symptoms of hyperglycemia (i.e., polyuria, polydipsia, polyphagia, weight loss) or hyperglycemic crisis. Ideally, management of DM should target to have glycaemia below these levels. HbA1c reflects the average glycaemia over several months [1] and should be measured every 3 months. Ideally HbA1c targets to maintain levels as close as possible to non-diabetic levels $< 6.5\%$ (48 mmol/mol), but goals must be

individualised by age and by the presence of chronic diabetic complications [2]. The HbA1c test is an alternative to traditional glucose-based methods, but should not replace glucose testing [3].

DM education is defined as a collaboration process through which patients with or at risk of DM gain knowledge and skills needed to modify behaviour and self-manage the disease and its related commodities [4] and DM educators are healthcare professionals who focus on helping patients with DM [4,5]. DM education is effective in helping patients with DM in controlling their illness, and maximising their health [6–9].

DM education programs bring about sustained benefits in DM patient outcomes, including reduced hospital treatment, reduced mortality [10], adherence to therapeutic targets [11], and medical measures, such as improved heart rate (HR), blood pressure (BP), and blood pathology [12] but these benefits have not been widely studied in an inpatient hospital setting. One exception is an Australian study [13] on

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the prevalence of DM in inpatients within 11 hospitals in Melbourne who recruited 2308 adult inpatients in all wards apart from intensive care, emergency, obstetrics, and psychiatry and concluded that DM prevalence ranged from 15.7% to 35.1%. The study noted that the high burden of DM inpatients had major implications for patient health and health care expenditure and suggested that optimising care had the potential to decrease inpatient morbidity and length of stay.

There are significant research gaps in DM inpatient education, and hospital admission provides an opportunity to fill this DM education gap [13]. Appropriate management of DM early in hospital admission may shorten length of stay and decrease readmissions rates and optimising management can also reduce the risk of morbidity due to long-term complications.

Educating patients about self-management of DM has become a focus among health care professionals, and is advocated for patients e.g. with Type 2 Diabetes Mellitus (T2DM) to acquire skills necessary for active self-management [7,14,15]. Thus education in self-management is recognised as an important component in management of T2DM [16,17].

Despite such benefits, there is no extant literature on the benefits of a DM education service within the Australian hospital healthcare system. With this in mind, this study sought to investigate if:

- 1) diabetes education within hospital leads to reduced blood glucose level after discharge within three months;
- 2) diabetes education within hospital leads to reduced HbA1c level after discharge within three months.

It is therefore hypothesised that:

- blood glucose decreases within three months following diabetes education and hospital discharge;
- blood HbA1c decreases within three months following diabetes education and hospital discharge.

2. Methods

This cohort review was performed at a large teaching hospital, in Canberra, Australia. Calvary hospital has a small Diabetes Service, with one inpatient nurse practitioner-diabetes (NPD), and a diabetes educator (part-time). The NPD and the diabetes educator's emphasis upon patient referral includes instilling self-empowerment by focusing on an individual's needs, and providing knowledge, motivation and support to aid the prevention of DM related health complications [18]. This service focuses on education, and is limited by the ability of the patient in understanding, and their willingness to apply recommendations.

Data was accessed, from February 1st 2015 until January 31st 2016 (12 months), on all patients (100.0%) referred to the Diabetes Service, upon hospital discharge with a documented history of poorly controlled T1DM or T2DM in their medical notes; including the admission and/or emergency department presentation triage documentation. The reason for only including those patients with a 'history of poorly controlled T1DM or T2DM' was to attempt to limit confounding factors once discharged. Confounding factors, such as general practitioner involvement following discharge, is acknowledged, as part of the intervention is to provide recommendation to seek other clinical supports once discharged.

Retrospective data was calculated on the patient's average admission BGL before Diabetes Service referral and education, and then prospectively repeated and collected over the 3 months following discharge. In addition, patients' HbA1c was taken before Diabetes Service education and then prospectively repeated 3 months after education.

To be included in the study, patients needed to have their BGL taken on at least five separate occasions inclusive of within 3 months following discharge (Fig. 1).

Data analysis was conducted using SPSS Version 22.0. A between

subjects *t*-Test was used to compare patient averages, with significance determined at $p = < 0.05$. This statistical analysis was selected due to participant means being tested at discharge and then repeated after 3 months after the intervention was conducted to determine effect. Similar analyses have also been conducted in other hospital services [19].

The project was approved by the Calvary Public Hospital Bruce Research Ethics Committee (reference number: 33-2016), and the Charles Sturt University (CSU) Human Research Ethics Committee (reference number: H17009). This study has been reported in line with the STROCSS criteria: Strengthening the Reporting of Cohort Studies in Surgery [20], and has been reported in the Research Registry (UIN: researchregistry3153).

3. Results

The Diabetes Service received 224 patient referrals for poorly controlled DM, including 40 (18.0%) T1DM and 184 (82.0%) T2DM patients. Ninety two patients had at least 5 BGL results in the period of hospital discharge and of these, 67 received follow-up BGL testing following Diabetes Service referral. As such 67 patients were included in the pre and post comparison, equalling 30.0% of the referred patients. Of the 67 patients, 31 had HbA1c results before Diabetes Service education, with 30 having the HbA1c test repeated 3 months following discharge.

The average age of the participants ($n = 67$) was 67 years, ranging from 32 to 87 years old, with 35 males and 32 females. The average pre-BGL result was 13.3 mmol/L, compared to the post-glucose result of 11.2 mmol/L, indicating a significant reduction $t(2.6904) = 0.0081$, $p = < 0.05$. To determine the impact of education on glycaemia, the study compared HbA1c data at hospital discharge to that recorded 3 months post-discharge. The average pre-HbA1c result was 10.45%, compared to the post-HbA1c result of 8.96%, which again was a significant decrease $t(2.1276) = 0.0379$, $p = < 0.05$.

4. Discussion

HbA1c measurement is used to monitor DM, and a result of $> 6.5\%$ (> 48 mmol/mol) can be a diagnosis of DM, whereas HbA1c $< 8.0\%$ in DM indicates good control [21]. The results from this study show reductions in blood glucose levels (13.3 vs 11.2 mmol/L) as well as HbA1c (10.45 vs 8.96%) post-diabetes education by comparison with levels prior to education. Although education results in reductions, these were still higher than the diagnostic criteria and recommendations associated with controlling diagnosed DM.

The reductions observed in this study are positive, and can contribute to a reduced cardiovascular risk. Eeg-Olofsson et al. [20] reported that patients who reduced HbA1c levels by nearly one percentage point e.g. from 7.8 to 7.0%, had a significant 45% decreased risk of cardiovascular death (HR 0.55, 95% CI 0.49 to 0.63, $p < .001$). That study also noted that the absolute risk of a first fatal or nonfatal event caused by coronary disease was 10.3 per 1000 person-years for those who had better glycaemic control versus 17.9 per 1000 for those without better control. Such observations are consistent with Stratton et al. [21] who in the observational United Kingdom Prospective Diabetes Study (UKPDS) demonstrated a 14–16% increased risk of MI and stroke per 1% unit increase in HbA1c during their study.

Educational services, such as the Diabetes Service and other services detailed in our prior publications involving cardiac rehabilitation services [19], are also important for related diseases, such as cardiovascular disease (CVD) and chronic kidney disease. Given the projected increase in obesity, DM, hypertension, and CVD, the need for effective interventions such as the Diabetes Service and cardiac rehabilitation that are shown to reduce CVD mortality remain vitally important.

The current study focuses on inpatients and future studies will determine whether an Australian Diabetes Service reduces hospital

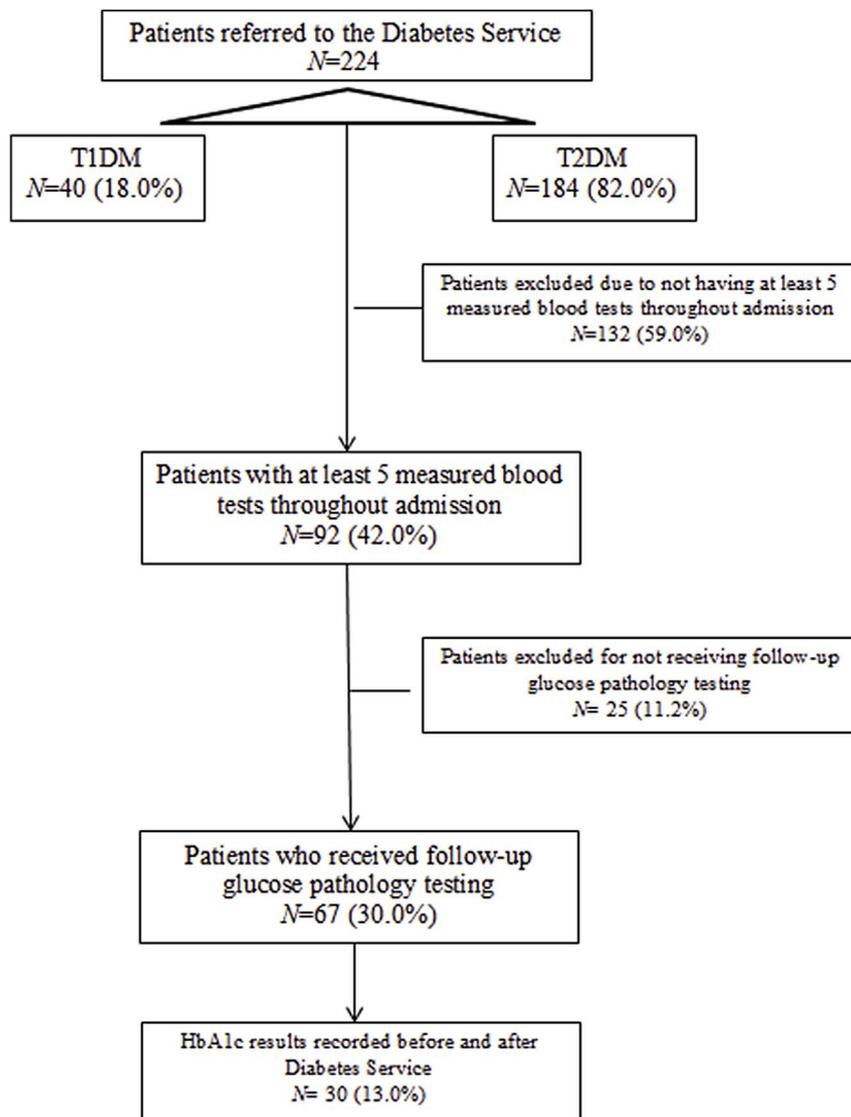


Fig. 1. Study inclusion flowchart.

patient length of stay (LOS). The relative stay index (RSI) summarizes the LOS for admitted patients, with adjustments for Casemix (the types of patients treated and the types of treatments provided). A RSI greater than 1.0 indicates that patient's LOS is higher than expected and that less than 1.0 indicates that the length of stay was less than expected. The RSI is an indicator of the efficiency of the hospital as it relates to patient outcomes and while this was not a direct focus of this study, the study established that the *Hospital in the Home* (HITH) RSI was 0.98, indicating efficiency. This possibly indicates that the Diabetes Service has a positive impact on diabetic RSI.

This belief is consistent with findings by Flanagan et al. [22], who found that dedicated diabetes specialist nurses dedicated to inpatient diabetic care, lead to significant impacts on the diabetic populations LOS and medical readmission rates. This finding is supported by Davies et al. [23], who aimed to determine the effectiveness and cost implications of a hospital diabetes specialist nursing service. They found that following referral and education, LOS was significantly lower, as compared to standard care (11.0 vs. 8.0 days, $P < .01$). Furthermore, although they found that the cost per patient decreased, the finding was non-significant. As such, our findings that indicated that the Diabetes Service had positive effects on glucose adherence, coupled with the reported literature on reduced LOS, is extremely encouraging.

Future studies need to consider other hospital services such as the hospital's Cardiac Rehabilitation Service and whether the service leads

to perceived patient benefits associated with: pathological risk factors, improvements to functional capacity, and improvements in mental health; and to what extent are the targets for BP control in patients with HT and DM achieved.

This study had the following limitations:

- Referral to the Diabetes Services was often as a result of the treating team determining the patient as having a history of poorly controlled DM (undefined). As such the intervention only provided education to potentially the most severe DM patients.
- The Diabetes Service, at time of publication was an in-patient service. This resulted in the educators not being able to follow patient treatment to the community, thus the only intervention was the education conducted within the hospital upon referral. It is unknown whether out-patient education over a longer time period would have resulted in enhanced pathology results.
- This study had confounding factors, such as other services or clinicians affecting the outcomes observed after discharge. These confounders were limited due to including only those with a documented history of poor control, and the service providing recommendations associated with seeking outpatient support services. Thus, the intervention may have assisted in patients seeking external outpatient supports. Information concerning subsequent outpatient support was not collected.

- Small sample size limited to one hospital service. This intervention only included one hospital located within the northern aspect of Canberra.

Further to the limitations highlighted above, we need to acknowledge that a comparative study would be beneficial, comparing patients who receive education (intervention) to those that do not (control), and measuring the differences in terms of glycaemic control.

This study is the first to measure the glycaemic control benefits associated with DM education. The study's results indicating improvements in glycaemia following education, coupled with prior studies possibly indicating reduction in CVA risk factors and the belief that the service leads to reductions in LOS and RSI, provides justification for broadening the service. This knowledge is important as it provides measurable data on effectiveness of a Diabetes Service in controlling glycaemia, which reduces micro and macro cardiovascular risk factors.

Ethical approval

The project was approved by the Calvary Public Hospital Bruce Research Ethics Committee (reference number: 33-2016), and the Charles Sturt University (CSU) Human Research Ethics Committee (reference number: H17009).

Sources of funding

Furthermore we declare that we do not have a financial conflict of interest associated with this article.

Author contribution

FG was the lead author and led study design, conducted data collection and analysis, conducted the literature review, and formulated and coordinated the article for publication. EUN was FG's primary supervisor during this study, and assisted in drafting and editing, design, and data collection and analysis. PTB and JC, contributed to the study design, data collection and analysis, and paper drafting and editing. LW contributed to the study design, helped in providing clinical support during patient data collection and analysis, and assisted in paper drafting and editing.

Conflicts of interest

We declare that the manuscript has not been published except as a brief abstract in the proceedings of a scientific meeting or symposium, the manuscript has not been submitted for publication elsewhere, all authors have contributed significantly, and that all authors are in agreement with the content of the manuscript.

We have no conflicts to declare.

Registration of research studies

N/A retrospective chart review.

Guarantor

Fergus W Gardiner.

Consent

N/A.

Data sharing statement

We are encouraging of having open data sources, and will seek

permission from the relevant hospital HREC committee to provide de-identified patient data upon request.

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