Evaluating the effect of inpatient diabetes education on length of stay, readmission rates and mortality rates: a systematic review

ZEESHAN HUSSAIN, MOHAMMED ALKHARAJI, ISKANDAR IDRIS

Abstract
Background: Hospitalised patients with diabetes experience a longer duration of inpatient stay, increased readmission rates and excess mortality compared with patients without diabetes.

Objectives: To determine whether inpatient diabetes education (IDE), provided to hospitalised patients with diabetes, is an effective intervention in improving one or all of the following clinical outcomes: length of stay (LOS), readmission rate and mortality rate.

Methods: A free-text search on MEDLINE, PubMed, CINAHL, BNI and EMBASE was conducted on literature published from the date of each database's inception to March 2019. In addition, grey literature was used to support the search with the following key terms: 'IDE', 'LOS', 'readmission' and 'mortality', along with their possible substitutes and alternatives combined.

Results: In total, eight studies met the inclusion criteria with a total number of 3,828 participants. Seven studies investigated LOS outcome for which accumulated mean LOS and median LOS were both lower (16.5% and 26.67%, respectively) in the IDE group compared with the non-IDE group. Six studies investigated readmittance rates, for which accumulated readmission rate (up to 12 months) was 15.9% lower in the IDE group than in the non-IDE group. Finally, the mortality rate was 36.6% lower in the IDE group compared with the non-IDE group, but this was non-significant and only one study reported this outcome.

Conclusion: The findings of this review support the efficacy of an IDE programme in a hospital setting by reducing LOS and readmission rates in patients with diabetes. In addition, a possible trend towards a decreased mortality rate was observed. IDE is therefore recommended to improve clinical outcomes of hospitalised patients with diabetes.

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Key words: inpatient diabetes, education, length of stay, readmission rate, mortality, systematic review

Introduction
The prevalence of diabetes in the UK has increased by about 20% between 2012 and 2018, which has translated to an increased number of hospital admissions with patients with diabetes being three times more likely to be hospitalised than similar patients without diabetes. Admitted patients with diabetes experience a longer length of inpatient stay (LOS) and have higher rates of readmission and mortality than patients without diabetes. Collectively, over the past decade this has resulted in an increased utilisation of healthcare resources to manage inpatient diabetes as well as increased occupancy of hospital beds (approximately 1 in 6) by patients with diabetes. According to Diabetes UK (2019), in 2012 the National Health Service (NHS) had spent in excess of £13 billion of its healthcare budget on diabetes management and inpatient expenses comprised the majority of this budget (~£9 billion). Therefore, it is evident that increased LOS and higher rates of readmission and mortality are contributing to the medical expenditures related to inpatient diabetes care.

Inpatient diabetes education (IDE) is considered to be a cornerstone of diabetes care as hospitalisation provides a real opportunity for healthcare staff to address educational deficiencies in patients living with diabetes. The aim of IDE is to reinforce the patients' knowledge and understanding of managing their diabetes outside the secondary care settings. IDE equips patients with the understanding of the following core elements: correct administration of insulin, including dose and technique of injection; and recognising classic symptoms of dysglycaemia and their appropriate treatment. IDE is often delivered by a multidisciplinary team which includes diabetologists, diabetes specialist nurses as well as other allied healthcare professionals (diabetes pharmacists, nutritionists and dietitians). However, currently, there is no structured or formal definition of what
constitutes an IDE, which may present some heterogeneity in IDE contents but also outcomes.

Certain interventions, such as improving diabetes knowledge of the healthcare team and smooth care transition from hospital to outpatient settings, have yielded a positive impact on clinical outcomes. However, the overall effectiveness of providing diabetes education to hospitalised patients with diabetes and its impact on clinical outcomes has not been evaluated to date. Therefore, the overarching aim of this systematic review is to ascertain whether IDE improves the following clinical outcomes: (1) inpatient LOS; (2) readmission rate; and (3) mortality rate.

Methods

Literature search

The medical literature was electronically searched on the National Institute for Health and Care Excellence (NICE) platform with access to the following five bibliographical databases: CINAHL, MEDLINE, EMBASE, PubMed and BNI. Terms used were related to ‘inpatient’ and ‘diabetes education’ in conjunction with ‘LOS’, ‘readmission’ and ‘mortality’ (see Appendix 1 online www.bjd-abcd.com for full search strategy). All types of published articles, with no language restrictions, were searched from the time period between the inception of the databases to March 2019. Furthermore, additional sources such as reference lists of all included studies, Google Scholar and individual journals were hand searched to identify any potential eligible studies that were not detected through the electronic searches.

Selection of studies

After obtaining the search results, the titles and abstracts of all studies were independently screened to retrieve relevant studies by removing duplicates and irrelevant abstracts. These relevant studies were individually assessed by the author (ZH) and selected to be included in the review if they fulfilled the following criteria: (a) recruited participants in the study had diabetes and were aged 18 years or older; (b) main focus of study is on patient education; (c) intervention takes place in inpatient setting; and (d) results report at least one of the clinical outcomes of interest (ie, LOS, readmission rate or mortality rate). There is currently no formal definition of what constitutes an IDE, and hence there are variations in IDEs for different studies being considered. In summary, the ultimate decision of including or excluding the study was made based on the article title, then the abstract followed by reviewing the full-text article.

Data extraction and synthesis

Important findings from the eligible studies were independently extracted and subsequently presented in a table format. The use of a table format was preferred since it is well conceived with ease of use and clarity in presenting important findings.

In this review, the findings are presented in a table with two main categories: study characteristics and study results. Study characteristics include demographic and descriptive profiles (such as age, gender, sample size, study design and duration of intervention). Study results include the assessed clinical outcomes (ie, LOS, readmission rate and mortality rate). Outcome results, in the form of mean and median for LOS and percent-ages for readmission and mortality rate, from different studies were extracted (or accumulated using average calculations). Unless otherwise stated, the statistical significance is referred to p<0.05 in this review. Due to the marked heterogeneity (mainly clinical) in study results, meta-analysis was not applicable, thus narrative synthesis was selected to discuss the findings. Lastly, Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) were followed to structure this review.

Risk of bias assessment

The methodological quality of all eligible studies was independently assessed by the author (ZH) using the Cochrane Handbook for Systematic Reviews of Intervention tool. This tool allowed an evaluation of studies for the possibility of the following bias elements: allocation sequence, allocation concealment, blinding (of participants, personnel and outcome assessors), incomplete outcome data and selective outcome for reporting or publication of data. Moreover, the risk of bias figure was created by using Cochrane Review Manager software (Version 5.3, Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014).

Results

Prisma flow chart summary

Initially, 1,609 articles (BNI=23, CINAHL=179, EMBASE=1,015, MEDLINE=257 and PubMed=135) were identified via an electronic database search. After removing duplicates (N=430) and irrelevant abstracts (N=971), 208 full-text articles were identified as potentially relevant. These were then subsequently assessed and only four articles met the inclusion criteria. The reasons for excluding 204 articles were as follows: (a) education intervention taking place in outpatient setting; (b) study analysing the data based on patients without the diabetes condition; (c) education not directed towards patients (ie, focus of education is geared towards healthcare staff); and (d) no clinical outcomes of interest were reported. However, grey literature search and reference list checks were also conducted which yielded an additional four study articles. Therefore, a total of eight studies became eligible for this review (see PRISMA flow chart in Figure 1).

Study characteristics

Table 1 shows the study characteristics of the participants (N=3,828) and summarises the results reported in the eight studies. All studies were published within the last 24 years in six different journals and were carried out in three different countries: USA (n=5), UK (n=2) and Spain (n=1). The study design consisted of seven retrospective observational studies and one randomised controlled trial (RCT).

Gender information was reported in four studies, which showed the percentage of women was lower than men (overall female proportion 46.93%). Moreover, the mean age from three studies was 60.72±8.7 years and the median age from four studies was 60.43 years, with one study.
not documenting the age profile. Sample size ranged from 65 to 2,265 participants, with the duration of the study varying from three to 72 months.

Study results and quality assessment of studies

Length of stay

Of the eight studies included in this review, seven investigated the impact of IDE on LOS.\textsuperscript{9,15,17,19,21} Of these studies, four used mean values\textsuperscript{15,17,19,21} and three used median values\textsuperscript{9,16,20} to present LOS (see Figure 2A and 2B, respectively). An accumulated mean LOS was calculated to be 16.45\% lower in the IDE group compared with the non-IDE group (5.35±1.09 vs 6.40±2.45 days, respectively). The calculated greatest mean effect in LOS reduction due to the IDE intervention was 56.1\%, which was observed in a study by Levetan \textit{et al.}\textsuperscript{19} An accumulated median LOS was calculated to be 26.67\% lower in the IDE group compared with the non-IDE group (5.5 vs 7.5 days, respectively). The calculated greatest effect in median LOS reduction due to the IDE intervention was 37.5\%, which was observed in a study by Murphy \textit{et al.}\textsuperscript{20}

Readmission rate

Of the eight studies included in this review, six investigated the impact of IDE on readmission rates.\textsuperscript{9,15,16,18,20,21} Readmission rates assessed in the included studies varied from 7 days up to 12 months (7 days, 14 days, 30 days, 6 months and 12 months) (see Figure 3). Seven-day readmission was recorded by one study only,\textsuperscript{15} which showed a reduction of almost 60\% (p<0.01) in the readmission rates of the IDE group compared with the non-IDE group (see Figure 3). Fourteen-day readmission was also recorded by one study only,\textsuperscript{15} which demonstrated a non-significant reduction of 38\% in the readmission rates of the IDE group compared with the non-IDE group. Thirty-day readmission was the most popular time period which was observed in five studies.\textsuperscript{9,15,18,20,21} The 30-day readmission rate was over 15\% lower in the IDE group compared with the non-IDE group (accumulated readmittance rate 11.75\% vs 13.85\%). In addition, two studies\textsuperscript{18,20} showed a statistically significant (p<0.01) reduction in 30-day readmission rates. The 6-month readmission rate was recorded by one study only,\textsuperscript{18} which showed a statistical
### Table 1: Eligible studies presented in chronological order that summarise study characteristics and clinical outcome results

| Author (year) | Country | Study design | Intervention | Sample size (N) | Female (%) | Length of stay† | Readmission | Mortality |
|--------------|---------|--------------|--------------|----------------|------------|----------------|-------------|-----------|
| Hardee (2015) | USA   | Retrospective observational study | ‘Interdisciplinary diabetes care’ model for inpatient diabetes education | NR | NR | 3.5 vs 3.5 | 30 days readmittance (16.3 vs 15.7) | NR |
| Corl (2015) | USA | Retrospective observational study | Bedside diabetes education | 254 | 38.75 | 4.9±0.2 vs 3.9±0.3** | 7-day readmittance (2.5 vs 6.2)** | NR |
| Davies (2001) | UK | Randomised controlled trial | Diabetes specialist nursing service | 300 | 46.65 | 8 vs 11** | 12-month readmittance (25 vs 25) | NR |
| Flanagan (2007) | UK | Retrospective observational study | Inpatient care team | NR | NR | 7.98±0.2 vs 8±0.2 | NR | NR |
| Healy (2013) | USA | Retrospective observational study | Inpatient diabetes education | 2265 | NR | NR | 30-day readmittance (10.88 vs 15.44)** | NR |
| Levetan (1995) | USA | Retrospective observational study | Specialist multidisciplinary diabetes team consultation | 61 | NR | 3.6±1.7 vs 8.2±6.2** | NR | NR |
| Murphy (2019) | USA | Retrospective observational study | Inpatient diabetes patient education | 513 | NR | 5 vs 8** | 30-day readmittance (13.2 vs 21.5)** | NR |
| Puig (2007) | Spain | Retrospective observational study | Specialised endocrinology team consultation | 435 | 55.3 | 4.90±2.27 vs 5.49±3.11* | 30-day readmittance (4.48 vs 4.72) | 0.90 vs 1.42 |

*Statistical significance p<0.05.
**Statistical significance p<0.01.
†Outcome results reported as either mean±SD or median.
IDE, inpatient diabetes education; NR, not reported.
reduction of over 15% in the readmission rates of the IDE group versus the non-IDE group. Finally, 12-month readmission was recorded by one study only, where no change in readmission rates was observed (25% reduction across both groups). Overall, for periods up to 12 months, the combined calculated readmission rate was 15.92% lower in the IDE group than in the non-IDE group (13.32% vs 15.84%, respectively) (Figure 4).

**Mortality rate**

Of the eight studies included in this review, only one study investigated the impact of IDE on mortality outcome. In this study, in-hospital mortality was noted to be 36.6% lower in the IDE group than in the non-IDE group (0.90% vs 1.42%), although the difference was not statistically significant (95% confidence interval −5.56 to +4.52) (Figure 5).

**Quality assessment of studies**

The studies included in the review had different types of bias present (see Appendix 2 online www.bjd-abcd.com). There was a high risk of selection and performance bias in all studies. This was because all the selected studies, except for one RCT, were designed to retrospectively evaluate the intervention (pre- and post-periods), and therefore randomising participants into separate groups was not feasible. However, the risk of detection bias was low because the outcomes were assessed from historical medical data and therefore the assessor had no influence on
outcomes. Moreover, the attrition and reporting bias was determined to be between low and unclear risk of bias category, which may add to the overall reliability of findings in this review.

Discussion
The purpose of this review was to determine the impact of IDE on patients’ LOS, readmission rate and mortality rate. From the available evidence, the findings indicate that IDE can support reduction in the patients’ length of hospital stay and short- to medium-term (7 days up to 6 months) readmission rates. In addition, evidence from only one available study has shown a non-significant reduction in the mortality rate following IDE intervention.

Length of stay
Providing education to inpatients with diabetes has shown a positive influence on reducing the patients’ length of hospital stay. This could be partly explained by the fact that patients receiving the education had improved knowledge and understanding of self-managing their diabetes care. Therefore, this could make the attending physician more confident in expediting the discharge of these patients. Furthermore, IDE would facilitate discharge of these patients. Furthermore, IDE would facilitate the attending physician more confident in expediting the discharge of these patients.

Readmission rate
Patients who experience shorter LOS have higher rates of early readmissions. However, our findings in this review are not consistent with this. Our findings indicate that, following IDE, there is a successful reduction in both LOS and short- to medium-term readmission rates (up to 6 months). However, it is evident that the effect of IDE on reducing readmission rates was not sustained at 12 months and suggests that IDE could be supplemented with outpatient educational programmes. The successful reduction in readmission rates following IDE could be attributed to better self-efficacy skills that patients acquire as part of their education. According to a study by Mohebi et al., patients with improved self-efficacy skills had better management of their diabetes care at home. Improved self-efficacy is thought to induce motivation and play a vital role in changing the self-care behaviour process, which may lead to improved compliance to diabetes care at home. This could further promote improvement in glycaemic and metabolic control that subsequently delays the progression of long-term complications.

Mortality rate
In this review only one study was eligible for investigating the impact of IDE on mortality, which showed that inpatients with IDE had a lower mortality rate than those who did not receive IDE (0.9% vs 1.42%). The literature on the effect of diabetes education on mortality is scarce, but the available information indicates that the predictor of high mortality is attributed to poor inpatient glycaemic and metabolic control. Furthermore, our study findings on mortality rate are in agreement with those of McHugh et al., who observed a significantly lower mortality rate in patients with good glycaemic control compared with poor glycaemic control (9% vs 16%, p=0.01). Moreover, frequent hyperglycaemic episodes in hospital have been shown to be associated with increased complications, morbidity and in-hospital mortality.

Limitations and conclusion
The strength of this review lies in broad inclusion and limited exclusion criteria applied to capture studies that represented our well-defined research question. To minimise the potential of
missing any relevant articles, we conducted an additional search from sources other than the databases on the NICE platform. Despite this, only a few relevant studies were identified, which highlights the dearth of evidence that surrounds this important clinical issue. It is important to interpret this as a lack of evidence rather than evidence of no effect.

Although, a reduction in LOS and rates of readmission and mortality were observed following IDE, it is difficult to establish how much education per se corresponds to the reduction in these clinical outcomes. It is also unclear whether early introduction of IDE has a beneficial impact on these clinical outcomes because the stage at which education was delivered to inpatients has not been recorded in the included studies. To clarify this, robustly designed studies that record pre- and post-intervention knowledge of patients who receive IDE is required. This will identify any improvement in diabetes knowledge of patients from their admission to discharge. Furthermore, studies could also investigate factors responsible for the selection of patients and the level of patient satisfaction from IDE. For example, studies may be associated with a selection bias—that is, patients who are recruited may be less unwell, have better cognitive function and perhaps fewer co-morbidities—which may have an impact on their LOS and mortality risk. Furthermore, studies have not adjusted for patient age, diabetes duration or types of diabetes. Also, the cause of admission was not stated in all studies, which may have an impact on the likelihood of readmission if the problem is a recurrent problem (e.g., gastroparesis and diabetic ketoacidosis, infective foot ulcers, etc). The heterogeneity of outcomes in different studies may be due to differences in education and educators.

Following IDE, there was a reduction in LOS and short- to medium-term (up to 6 months) readmission rates. Only one study reported on the effect of IDE on mortality rate, which showed a reduction at discharge because certain barriers prevent the delivery of IDE (such as acute illness, cost of delivering education and a decrease in the number of staff with specialised knowledge of diabetes). Patients with acute illnesses have limited exposure to educators in hospitals, so these patients are less likely to have adequate time to receive comprehensive education prior to discharge.

Despite literature being scarce in the area of inpatient education, the reviewed evidence for the IDE suggests a positive effect on clinical outcomes. Following IDE, there was a reduction in LOS and short- to medium-term (up to 6 months) readmission rates. Only one study reported on the effect of IDE on mortality rate, which showed a reduction. To explore these clinical outcomes further, patient satisfaction as well as pre- and post-assessment scores of diabetes knowledge is encouraged, which will profoundly contribute to the current literature of IDE.

Conflict of interest None.

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Key messages
- Although, a reduction in LOS and rates of readmission and mortality were observed following IDE, it is difficult to establish how much education per se corresponds to the reduction in these clinical outcomes.
- The heterogeneity of outcomes in different studies may be due to differences in education and educators.
- Following IDE, there was a reduction in LOS and short- to medium-term (up to 6 months) readmission rates. Only one study reported on the effect of IDE on mortality rate, which showed a reduction.
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Appendix 1. Search strategy performed on National Institute for Health and Care Excellence (NICE) platform.

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(((educa* OR "diabetes educa*" OR "diabetes under*" OR "diabetes school*" OR "diabetes knowledge" OR "diabetes tutor") AND ("hospital* patient*" OR hospital* OR inpatient* OR "secondary care" OR admit* OR ward)) AND ("clinical outcomes" OR LOS OR "length of stay" OR "duration of stay" OR readmission OR readmit* OR rehospital* OR mortality OR death)) AND (diabetes OR T1DM OR T2DM)).ti,ab
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Appendix 2. Risk of bias graph: author (ZH) judgements about each risk of bias item presented as percentages across all included studies.