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Akiboye, Funke; Sihre, Harpreet; Al Mulhem, Munerah; Rayman, G; Nirantharakumar, Krishnarajah; Adderley, Nicola

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DIABETIC Medicine

SYSTEMATIC REVIEW OR META-ANALYSIS

Impact of diabetes specialist nurses on inpatient care: A systematic review

Funke Akiboye[1] | **Harpreet K. Sihre**[1] | **Munerah Al Mulhem**[1] | **Gerry Rayman**[2] | **Krishnarajah Nirantharakumar**[1] | **Nicola J. Adderley**[1]

[1]Institute of Applied Health Sciences, University of Birmingham, Birmingham, UK

[2]Diabetes Centre and Diabetes Research Unit, Ipswich Hospital, Ipswich, UK

Correspondence
Funke Akiboye, Universtiy of Birmingham, Birmingham B15 2TT, UK.
Email: akiboyef@doctors.org.uk

Abstract

Background: People with diabetes have longer hospital stays and poorer clinical outcomes. Diabetes inpatient specialist nurses have been introduced to improve care.

Aims: To assess the evidence for the benefit of diabetes specialist nurses in the inpatient setting.

Methods: A systematic search of MEDLINE (ovid), Embase (ovid), CINAHL (EBSCO) and Web of Science core collection from January 1998 to September 2019 was performed using key terms for diabetes specialist nurses and hospital setting. Studies measuring patient care using any standardised or validated outcome measures after introduction of a dedicated diabetes specialist nurse or nursing team were eligible for inclusion and findings reported by narrative synthesis.

Results: There were 10 studies which met the inclusion criteria. One was a randomised controlled study and the remaining nine studies were before and after studies with three of them using a time series analysis methodology. The majority reported length of stay (LOS) and showed a reduction in median LOS by between 0.5 and 3 days. Reductions in bed occupancy ranged from 39% to 47%. There was a paucity of evidence for outcomes related to patient care with some measures limited to single studies. These included a 52% reduction in total drug errors, improved patient knowledge, higher patient satisfaction and improved glycaemic control post-discharge. There was no reduction of mortality observed.

Conclusions: These studies suggest a reduction in LOS and improved clinical care for patients with diabetes after the introduction of diabetes inpatient specialist nurses. Future research should examine a range of benefits associated with diabetes inpatient specialist nurse delivered services, including reduction of inpatient complications such as infections and cardiovascular events.

1 | INTRODUCTION

The incidence of diabetes continues to rise with the International Diabetes Federation predicting its prevalence will reach 9.9% globally by 2030.[1] People with diabetes tend to have longer length of stay (LOS) and are at greater risk of complications, often associated with hyperglycaemia.[2] The National Diabetes Inpatient

Audit (NaDIA) in 2019 showed that patients with diabetes account for 18% of bed occupancy, an increase from 14% in 2010.[3] For the majority of patients diabetes is a secondary diagnosis rather than the primary cause for admission, therefore patients are more commonly under the care of non-diabetes specialists. The training doctors on these teams report lack of further education in diabetes after qualifying with only 28% feeling fully confident in managing diabetes.[4] The delivery of care to patients with diabetes, as with a number of other specialities, has moved towards specialist nurses and nursing teams. They provide support and education for staff and patients across specialities and often provide phone or clinic contact to avoid hospital admission or facilitate discharge of patients in a timely fashion. The need for diabetes inpatient specialist nurses (DISNs) has been stated repeatedly and the economic case for their presence has been published by NHS diabetes in 2012 in a report titled "Specialist diabetes inpatient nurses cost-effectively improve care".[5-7] Despite strong endorsements, including a 2003 statement from the Department of Health (DH) highlighting the importance of effective care for inpatients with diabetes and a 2011 National Institute of Clinical Excellence (NICE) quality measure, advising at least one diabetes specialist nurse with an inpatient focus per 300 beds, DISNs are not ubiquitous.[8,9] NaDIA 2018 showed that 22% of hospitals still do not have a dedicated DISN.[10]

There are no previous systematic reviews assessing the impact of diabetes specialist nurses in the inpatient setting. A Cochrane review in 2003 by Loveman et al. examines the role of diabetes specialist nurses focused predominantly on the community setting and did not find their introduction to be superior to standard care for improving care overall.[11] The impact of specialist nurses for all specialities has been assessed in the context of the changing work force and nurses work patterns in a Cochrane review by Butler et al in 2011.[12] This review of randomised controlled trials (RCTs) looked at any objective measure of patient or staff outcome and found that the introduction of specialist nurses reduced LOS and the development of pressure ulcers in hospital. While this review selected from a range of specialist areas, there was only one study included that was specific to diabetes.[13] On introducing diabetes nurse specialists, many trusts encouraged their teams to document their activity and their effectiveness. Consequently, there are a number of before and after studies looking at the effectiveness of diabetes specialist nurses that have not been assessed systematically. A recent hermeneutic review conducted by Lawler et al[14] explores the scope of diabetes specialist nurses' role, both in the community and hospital, but was not conducted systematically and did not include an appraisal of the quality of the evidence. While this phenomenological approach provides a broad and rich view of the range and impact of specialist nurses, it is subject to reviewer bias in study selection.

Therefore, we conducted a systematic review with the aim to examine the existing evidence on the impact of diabetes inpatient nurses on patient and staff outcomes and highlight areas for further research.

1.1 | Objectives

This review aims to look at the measured impact of introducing a DISN or dedicated diabetes inpatient nursing team on hospitalised adult inpatients with diabetes. For this assessment of impact, a measured comparison of the service, patient outcomes, knowledge or ability of patients with diabetes before and after the introduction of the DISN(s) could be included.

2 | METHODS

The review was conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) guidelines.

2.1 | Registration

A protocol for this systematic review is registered on PROSPERO 11/10/2017 (registration: CRD42017076478).

2.2 | Study design

All relevant published studies from 1 January 1998 to 1 September 2019 were sought for inclusion in this study as recent decades have seen a movement towards promoting DISNs in the literature and national guidance.[13,15] There was no restriction on the study design selected for inclusion, therefore RCTs, quasi-experimental studies and observational studies, including before and after studies and interrupted time series analysis studies were included. There was no language restriction applied during the search.

2.3 | Participants

The study participants were hospital inpatients with type 1 or type 2 diabetes mellitus. The hospitals include acute and non-acute hospitals ranging from small to large in size. Both public and private and teaching and non-teaching organisations were included.

2.4 | Interventions

Studies that involved the introduction or addition of one or more dedicated DISN, nurse prescriber, nurse educator or other equivalent terms used internationally were included. In focusing on reviewing the impact of new or additional DISNs, this review does not examine the specific tasks undertaken by nurses in their role. Studies extending the scope of an existing outpatient nurse to inpatient work or an inpatient team to provide an outpatient service or outreach service of in-post DISNs to the emergency department were excluded. These were deemed more of an evaluation service delivery, which is beyond the scope of this review. In a similar manner those studies upskilling an existing inpatient specialist nurse in post, for example, with prescribing training, were not included. Studies substituting physician for a specialist nurse were also excluded.

2.5 | Outcomes measures

This review examined any objective measures of patient outcomes including mortality, in-hospital death, LOS, and readmission. Also of interest were objectively measured 'nursing sensitive patient outcomes', defined by Doran (2003) as those that are 'relevant, based on nurses' scope and domain of practice, and for which there is empirical evidence linking nursing inputs and interventions to the outcomes'.[16] Examples include infections, falls, pressure ulcers, cardiovascular events, hypoglycaemia rates or medication errors. Objective measures of patient satisfaction, quality of life and disease impact were only included in this review if they used a validated tool, such as the Diabetes Treatment Satisfaction Questionnaire for inpatients (DTSQ-IP).[17]

2.6 | Search method for identification of studies

A search was conducted in MEDLINE (ovid), Embase (ovid), CINAHL (EBSCO) and Web of Science core collection from 1 January 1998 to 30 September 2019. The search strategy used exploded MeSH terms for variants of combinations of relevant keywords, including study population: 'inpatients' OR 'hospital' AND 'diabetes mellitus', AND intervention: 'specialist nurse'. The MEDLINE search strategy is shown in Table S1 and was adapted to the syntax of the aforementioned databases.

In addition, reference lists of all included papers and relevant literature such as position statements were screened to identify any further publications.

2.7 | Data collection and analysis

Titles and abstracts were screened by the primary reviewer (FA) for relevance to the population and intervention. The full articles for potentially relevant papers were then obtained. Full texts of obtained articles were read independently by two reviewers, FA and HS or MAM, and included if they fulfilled all of the following five pre-established criteria:

1. an original study published in full;
2. participants were patients with diabetes (type 1 or 2);
3. it was hospital-based;
4. the intervention involved a new or additional DISN;
5. the outcomes were formal extraction or collection of any objective or standardised data from or relating to participating patients.

Studies that could not be accessed in full (such as conference abstracts) were excluded, as there was insufficient detail to determine whether they met the inclusion and exclusion criteria. Where the full article was available, but insufficient information was available to determine whether the study was eligible for inclusion, the authors were contacted to clarify whether the study fulfilled the inclusion criteria. We included studies that provided any widely accepted measures, quantitative data and standardised or validated questionnaires. Any disagreement was discussed and where necessary resolved in collaboration with a third independent reviewer (KN).

Data extraction was carried out independently by the primary reviewer (FA) and a second reviewer (MAM) using forms developed for the study (after piloting the forms in two contrasting, included studies.[18,19] The data collected included the study design, setting, study baseline and follow-up period, sample size, patient population studied and whether the changes in the background patient population (without diabetes) were also measured. For each study, any objective variable was recorded as a primary outcome with the validated or modified assessments recorded as secondary outcomes. An example data collection sheet is shown in Appendix 1.

2.8 | Quality assessment

All studies were assessed for risk of bias using the relevant tool according to study design. The Cochrane RCT risk of bias tool was used for RCTs and the NIH National Heart Lung and Blood Institute Quality Assessment Tool for Before-After (Pre-Post) Studies, including interrupted time series analysis.[20,21]

2.9 | Data analysis

The extracted data comprising measured changes and effect sizes from included studies was analysed in the broader context of the field, with exploration of the relationships between the data. A preliminary tabulated analysis is presented as well as a more detailed narrative synthesis. A meta-analysis was not conducted as the number of studies with overlapping outcomes was limited.

3 | RESULTS

3.1 | Results of the search

The initial search extracted on 1 May 2017 identified 8464 unique studies and a further 1209 in the second search. The full articles for 47 potentially relevant studies were obtained and assessed independently by the two reviewers. Of the total 47 articles, 10 met the inclusion criteria for final inclusion in the study. Study selection is summarised in the flow diagram in Figure 1.

3.2 | Description of included studies

Of the 10 studies included, there was one prospective RCT by Davies et al[18] and two controlled cohort studies by Cavan et al. and Gardiner et al.[22,23] The remaining seven studies were before and after cohort studies.[19,24,25,26,27,28,29] The Pledger, Sampson and Akiboye studies[19,24,29] incorporated time series design in the methodology with sequential measurements over the study duration.

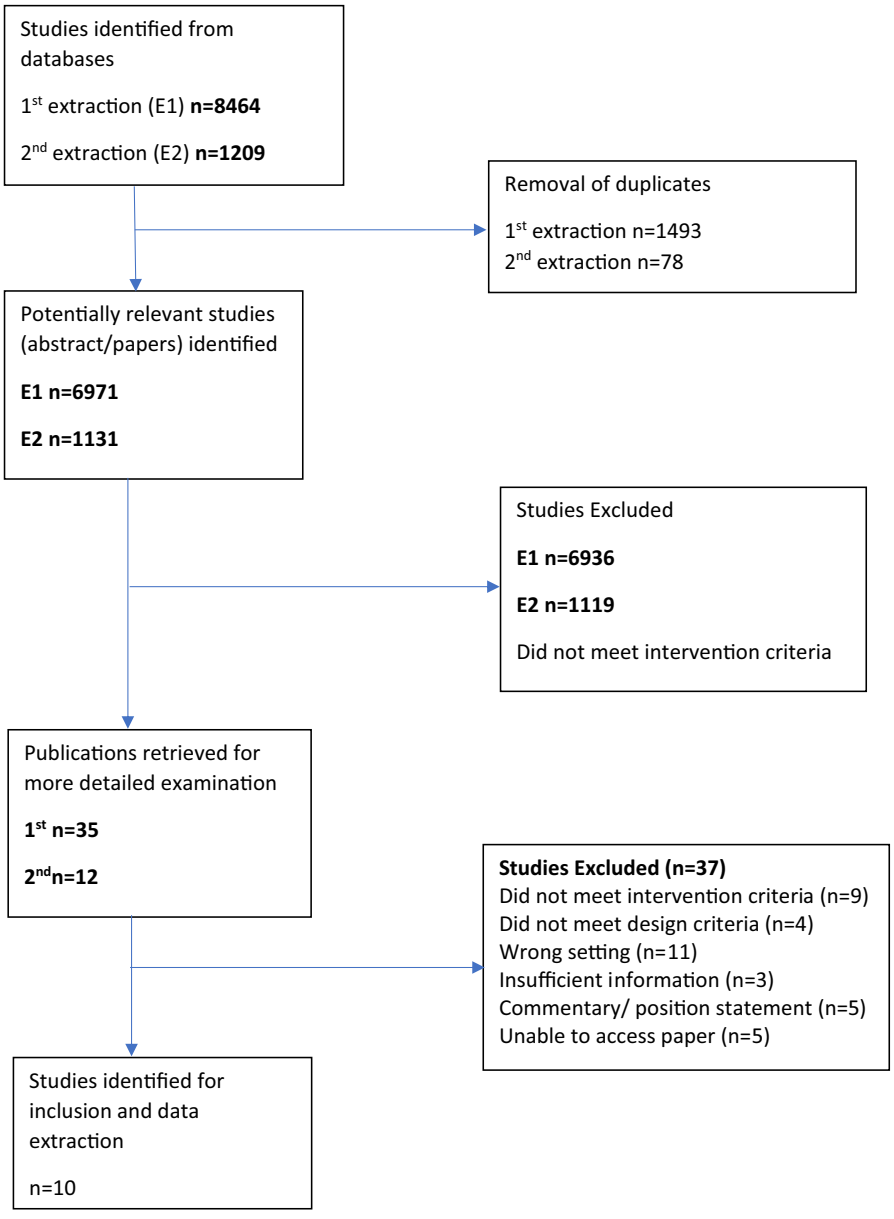

FIGURE 1 Flow diagram for study selection

TABLE 1 Baseline characteristics of included studies

Study	Design	Hospital type	Number of additional DISNs (WTE)	Sample size	Patient population	Follow- up duration	Background population assessed
Davies (2001)[18]	Prospective RCT	University hospital	1	152 148	Medical and surgical referrals	1-year post-discharge	NA
Cavan (2001)[22]	Controlled cohort study	District general	1	24 323 24 365	Medical and surgical	1 year 1 year	Yes
Pledger (2005)[19]	Before and after/ time series analysis	District general	0.85 WTE	Not disclosed Not disclosed	Unselected referrals	7/12 6/12…	Yes
Sampson (2006)[24]	Before and after/time series analysis	University hospital	1	14 722	Medical and surgical	4 years 2 years	Yes
Courtenay (2007)[25]	Before and after	District general	1	187 265	Med and surgical patients with DM on treatment	3/12 3/12	No
Carey (2008)[26]	Before and after	District general	1	27 29	Med and surgical patients with DM on treatment	3/12 3/12	N/A
Flanagan (2008)[27]	Before and after	Large teaching 1200 bed	5	3903 24 031	Medical and surgical patients	1 year 5 years	Yes
Gardiner (2018)[23]	Prospective cohort study	Large teaching hospital	2 (1 DISN and 1 educator)	35 32	Patients referred to DM service with poor glycaemic control	Baseline and 3/12 post discharge 12/12 study	N/A
Mandel (2019)[28]	Before and after	Medical and surgical	2 (1 practitioner, 1 educator)	850	Medical and surgical patients	1/12 1/12	Yes
Akiboye (2019)[29]	Before and after/ time series analysis	District general	2.5 (increase of 1.5 WTE)	2337 2433	Medical and surgical patients	6/12 B&A 6 years 2.5 years	Yes

Abbreviation: DISN, diabetes inpatient specialist nurse; WTE, whole time equivalents.

Sample size varied from under 30 patients in each arm, in the Carey study,[26] to around 25,000 in the Cavan study.[22] The follow-up period ranged from 3 months in the Carey and Courtenay[25,26] studies to 5 years in the Flanagan study[27] and is summarised for included studies in Table 1.

All of the studies looked at patients over a range of disciplines specifying either inclusion of patients from medicine and surgery or that participant inclusion was 'unselected'. While all nine before and after studies were looking at patients with diabetes, six of them additionally examined the background population without diabetes to account for trends of confounders in the hospital population.[19,22,24,27,28,29]

Notably, the Courtenay[25] and Carey[26] papers were conducted in the same trust over the same time period and the Carey paper appears to be a subgroup analysis using the same data; the results of the small Carey study are therefore only considered where the authors reported additional outcomes to the Courtenay study.[25,26]

The study aims for all included studies was to determine the impact of one or more DISNs on a range of patient outcomes within a service. As any objectively measured or standardised outcome could be included, all are reported. The primary stated outcome for each study is indicated in Table 2.

3.3 | Quality of the evidence and risk of bias in included studies

All of the studies included, other than the one randomised controlled study,[18] were observational studies using either administrative data or data collected by the DISNs. The quality of the evidence in the identified studies was therefore mixed.

The single RCT (Davies 2001) was assessed using the Cochrane risk of bias tool for RCTs and was assessed to be of fair quality with unclear bias due to insufficient information in the categories of random sequence generation and allocation concealment.

Using the NIIR quality assessment tool, the Sampson 2006, Courtenay 2007, Carey 2008, Flanagan 2008, and Akiboye 2019 studies were assessed as having a low risk of bias.[24,25,26,27,29] The studies by Cavan 2001, Pledger 2005, Gardiner 2018 and Mandel 2019[19,22,23,28] were assessed to be of moderate risk of bias, as detailed in Table 3. The studies are arranged by year of publication, and the quality is generally higher in the more recent studies. Pledger is the weakest study with the number of participants not disclosed and a lack of clarity around several other categories which were not reported particularly around the selection and eligibility of participants,[19] but on further discussion, it was included in the review as a visual representation of the outcome is presented, which was taken into account in this report. However, unlike all other studies, the objectives are not clearly stated. Selection bias was reduced in most studies by including all patients with diabetes in certain clinical areas. The review design for reporting on objective and validated criteria was corroborated by all studies fulfilling this component of the quality assessment tool. It was difficult to tell in all except the Akiboye 2019 study,[29] whether the researchers were blind to the intervention.

3.4 | Outcomes

The range of outcomes reported was narrow and generally focused on LOS, measured as mean or median, or bed occupancy as this would translate into savings for the trust employing the DISN. A summary of the outcomes is displayed in Table 2.

A measure of LOS was reported in all studies except Gardiner 2018, with the Sampson paper reporting this as excess LOS above the population without diabetes.[23,24] The studies varied in their methods for calculating LOS with some reporting LOS as a mean while others reported a median LOS. Bed occupancy as a percentage of patients in hospital beds with diabetes was expressed with differing timeframes and was evaluated in the studies by Cavan, Pledger and

TABLE 2 Primary outcomes across the reported studies

Study	Length of stay	Excess length of stay	Bed occupancy	Readmission	Insulin errors	Oral hypoglycaemic agent errors	Mortality	Mean blood glucose
Davies 2001	↓			↔				
Cavan 2001	↓		↓					
Pledger 2005	↓		↓					
Sampson 2006		↓						
Courtenay 2007	↓				↓	↓		
Carey 2008	↔				↓	↓		
Flanagan 2008	↓		↓					
Gardiner 2017								↓
Mandel 2017	↓			↓				
Akiboye 2019	↓			↔			↔	

TABLE 3 Risk of bias assessment using NIH quality assessment tool for before and after (pre–post) studies with no control group

	Was the study question or objective clearly stated	Were eligibility/selection criteria for the study population prespecified and clearly described?	Were the participants in the study representative of those who would be eligible for intervention in the general or clinical population of interest?	Were all eligible participant that met the pre-specified entry criteria enrolled?	Was the sample size sufficiently large to provide confidence in the findings?	Was the intervention clearly described and delivered consistently across the study population?	Were the outcome measures prespecified, clearly defined, valid and reliable assessed consistently across all study participants?	Were the people assessing the outcomes blinded to the participants' interventions?	Was the loss to follow-up after baseline 20% or less? were those lost to follow-up accounted for in the analysis?	Did the statistical methods examine changes in outcome measures from before to after the intervention? Were statistical tests done that provided p values for the pre-to-post changes?	Were outcome measures of interest taken multiple times before the intervention and multiple times after the intervention (i.e. did they use an interrupted time-series design?)	If the intervention was conducted at a group level (e.g. a whole hospital) did the statistical analysis take into account the issue of individual level data to determine effects at the group level?	Overall quality of study
Cavan 2001	●	○	●	●	●	●	●	●	○	●	●	●	fair
Pledger 2005	●	●	●	●	○	●	●	●	○	○	●	●	fair
Sampson 2006	●	●	●	●	●	●	●	●	●	●	●	●	good
Courtenay 2007	●	●	●	●	●	●	●	●	●	●	●	●	good
Carey 2008	●	●	●	●	●	●	●	●	●	●	●	●	good
Flanagan 2008	●	●	●	●	●	●	●	●	○	●	●	●	good
Gardiner 2017	●	●	●	●	●	●	●	●	●	●	●	●	fair
Mandel 2017	●	●	●	●	●	●	●	○	●	●	●	●	fair
Akiboye 2019	●	●	●	●	●	●	●	●	●	●	●	●	good

NR = not recorded, CD = can't decide, NA = not applicable.

● = yes, ● = can't decide, ● = no, ● = not applicable, ○ = not recorded.

Note: ● = yes; ○ = can't decide; ● = no; ● = not applicable; ● = not recorded.

Abbreviations: CD, can't decide, NA, not applicable; NR, not recorded.

Flanagan,[19,22,27] while the effect on readmissions was assessed in the studies by Davies, Mandel and Akiboye.[18,28,29]

The Courtenay and Carey papers examined oral hypoglycaemic and insulin errors, with the Courtenay study providing detailed subgroup analysis of the drug errors noted in the Carey study.[25,26] The Gardiner study[23] reported change in mean blood glucose and HbA1c 3 months following discharge, and one study additionally reported inpatient mortality as an outcome measure (Akiboye).[29]

The majority of secondary outcomes were reported in the comprehensive Davies study,[18] which used validated and modified established questionnaires to measure diabetes related QOL, diabetes knowledge and patient satisfaction. The authors also sought to determine if the improvement in hospital care impacted negatively on use of community resources.[18]

3.5 | LOS and bed occupancy

The LOS measured at baseline, prior to introduction of the DSNs varied widely across studies from 7.5 (Akiboye 2019) to 9.8 (Pledger 2005) for mean measurements[19,29] and 3.5 (Akiboye 2019) to 17.5 days (Carey 2008) for median LOS.[26,29] There was a significant reduction seen in LOS in all except the Carey study which reported a median 3-day reduction that was not statistically significant. The median reduction in LOS reported ranged from a 0.5- to 3-day difference before and after the intervention. Those reporting a mean LOS (Pledger 2005, Flanagan 2008, Akiboye 2019) describe a smaller difference of 0.5–1.1 days.[19,27,29]

The three studies reporting bed occupancy (Cavan 2001, Pledger 2005, Flanagan 2008) had a larger number of participants and reported significant and sizable reductions of 36%–47%.[19,22,27]

3.6 | Readmissions

Three studies measured readmissions by various methods (Davies, Mandel, Akiboye).[18,28,29] Mandel and Akiboye reported 30-day readmission rate (Mandel, Akiboye).[28,29] The Davies study measured mean time to readmission in days

while the Akiboye study also conducted an interrupted time series analysis of 30-day readmission rates over an 8-year period. There was no statistically significant impact on hospital readmissions on introduction of a diabetes specialist nurse in any of the studies over the short term.

3.7 | Drug errors

Two published studies looked at drug errors; however, they were carried out in the same trust over the same period with Carey effectively a subgroup study of the Courtenay study providing more detailed drug error information. Drug errors were significantly reduced in the Courtenay 2007 and Carey 2008 studies.[25,26] Courtenay reported an overall 52.1% reduction in drug errors, while Carey specified a 50% reduction in insulin errors and 74.5% reduction in oral hypoglycaemic agent errors (74.5%).[25,26]

3.8 | Mean glucose

Gardiner reported statistically significant reductions in mean glucose from 13.3 to 11.2 mmol/L ($p \leq 0.05$) and HbA1c from 10.45% to 8.96% ($p \leq 0.05$) following inpatient nurse education.[23]

3.9 | Mortality

There was one study reporting mortality,[29] which measured mortality with both before and after study and interrupted time series.[29] The 6-month period before and after implementation of DISN showed lower mortality following the intervention in those with diabetes OR 0.63 (0.48, 0.82). In the interrupted time series analysis, this was found to be a secular trend that cannot be attributable to the intervention with the reduction being not statistically significant in those with diabetes ($p = 0.305$).[29]

3.10 | Miscellaneous outcomes

The findings of Davies' study relating to quality of patient care are reported below.

3.11 | Quality of life

The Audit of Diabetes Dependent Quality of Life (ADDQoL) was used to measure diabetes related quality of life and did not demonstrate any differences in quality of life between or within groups at baseline or post-discharge.

3.12 | Diabetes knowledge

The diabetes knowledge questionnaire was assessed with a modified version of the Diabetes Knowledge Scale accounting for insulin users and non-users. There was a significant improvement in the knowledge score post-admission in the intervention group.

3.13 | Patient satisfaction

A modified version of the Diabetes Clinic Satisfaction Questionnaire (DCSQ) was administered one week post-discharge to assess patient satisfaction and demonstrated that 91% of patients in the intervention group were satisfied with their DISN delivered care compared with 59% in the control group ($p < 0.001$).

3.14 | Post-discharge outcomes

The Davies study showed a trend towards fewer post-discharge referrals to the community diabetes nurse; however, this was not statistically significant.[18]

3.15 | Gaps in the literature data

There were no studies looking at inpatient complications or standardised measures of staff satisfaction or knowledge after addition of DISNs.

4 | DISCUSSION

There is a body of evidence indicating that DISNs reduce LOS by a median of up to 3 days or mean of 1.14 days. Bed occupancy may be reduced by as much as 47%. It is worth noting that the earlier studies conducted between 2001 and 2006 showed the larger effect sizes when baseline LOS was longer. Fortunately, this bed day saving does not appear to have a negative impact on readmissions or community referrals.

There is some evidence that the introduction of DISNs reduces the number of drug errors both for insulin and oral hypoglycaemic agents.[25,26] There is also evidence from one study to suggest their input has had a positive effect on inpatient glycaemic control.[23] Although these benefits are encouraging, National Inpatient Diabetes Audit (NaDIA) does not clearly demonstrate that trusts with inpatient nurses consistently show lower drug errors and rates of dysglycaemia. The presence of DISNs does appear to improve patient knowledge and have a positive effect on patient satisfaction.[18]

However, the studies concluded that DISNs do not have an impact on quality of life following discharge or on inpatient mortality.[18,29]

4.1 | Completeness and applicability of evidence

This is a comprehensive review that systematically assesses the impact of DISNs taking into account recent publications. The specialist nurses' activities undertaken in each trust were not differentiated, and the majority of studies looked at nurses' impact in both medical and surgical ward settings. As such the findings reported are widely applicable to hospital trusts which still lack a dedicated DISN or where one could expand their existing team with additional DISNs.

The majority of studies looking at bed occupancy or LOS were published before 2008 when the baseline LOS was higher than it is currently.[17,18,19,22,25,27] With the drive to reduce bed occupancy in today's climate, the evidence for the recent LOS reduction is limited to one study, Akiboye et al.[29] While the two methodologies used in this study demonstrate a reduction in LOS, this reduction is smaller than previous studies. Further analysis on the cost implications at present was beyond the scope of this study and may warrant re-evaluation.

This review did not identify studies evaluating in-hospital complications aside from mortality.[29] Two studies in a single trust examined drug errors with significant reductions reported with DISN input in 2007.[25,26] Today, with an increasing prevalence of diabetes, it is not clear whether such a workload is feasible or sustainable for specialist nurses, and it may be that these benefits may be achieved in other ways for example with protocol development and electronic prescribing. The role of the specialist nurse in educating inpatients with diabetes appears to carry important and sustained benefits beyond discharge, which have previously been contested in the inpatient setting.[23] This suggests that although the benefits seen in earlier studies such as reduced LOS may have a smaller effect at present, there are likely other as yet unmeasured benefits to DISN input depending on their activity and assumed roles.

4.2 | Potential biases in the review process

This study is limited by the small number of studies fulfilling the inclusion criteria; however, the search strategy was set up to find all possible studies by limiting the search strategy to the population of interest and intervention of interest.

Four databases were used to locate studies, and Web of Science database in particular picked up studies submitted in abstract form to conferences which have less strict criteria than papers published in full. As there has generally been a drive to publish positive findings in peer reviewed journals, the use of this broader database helped reduce publication bias. The use of all objective outcome measures from the studies included enabled a more accurate representation of the impact by including the negative secondary outcomes from studies.

4.3 | Study limitations

The search criteria were broad in order to maximise the likelihood of searching and including all relevant studies. The search strategy was focused on the presence of DISN by using a range of terms; however, the list was not exhaustive and may have missed some of the job titles for nurses working in diabetes care, which was measured as 117 in the TREND 2019 audit.[30]

The databases searched provided a limited search of grey literature; however, Web of Science Core collection searches conference proceedings which were therefore included. In addition, the significant experience, knowledge and active involvement of the authors in this field provided potential papers for evaluation of inclusion.

Due to the small number of studies and restricted range of reported measures, for the outcomes of mortality, mean glucose and drug errors a description of the outcome is taken from a single dataset, limiting its applicability.

4.4 | Agreements and disagreements with other studies or reviews

It is widely accepted that DISNs reduce LOS and this review adds that significant reductions in LOS can still be seen today despite shorter baseline hospital spells for patients throughout the health service.

Diabetes UK has published a literature review citing many of the included studies in a case for economic change advocating the use of DISNs. For this analysis, the bed occupancy cost of diabetes is a dominant part of the analysis. LOS/bed occupancy was therefore a primary outcome of many of the papers that contributed to the evidence. While their findings agree with those of this systematic review, the economic case does not examine the quality of the evidence prior to drawing conclusions, and with the addition of a more recent study, the current cost implications may benefit from further evaluation, given the additional benefit in terms of savings from reduced LOS may be limited.[29]

The hermeneutic review conducted by Lawler et al. draws on some of the same evidence to conclude that diabetes specialist nurses are cost effective and improve patient care by reducing patient LOS and reduced inpatient harms (drug

errors).[14] It also describes the diabetes specialist nurses roles as staff and patient educators as well as providing direct patient care. The efficiency and extent to which DISNs engage with these various roles will undoubtedly vary between hospitals and even areas within the same trust with differing outcomes. Such differentiation is beyond the scope of this and the Lawler review; however, we note that the roles undertaken and outcomes produced by the diabetes specialist nurse are linked and further examination of the most effective activities of the specialist nurse could be usefully examined as a focus in future studies to help guide their key activities. Lawler et al. did note that in the outpatient setting patient satisfaction was increased with the presence of diabetes specialist nurses and suggested it was due to time spent with the nurse and continuity of care.[14] With the national trend towards shorter inpatient LOS, it is not clear whether the rising trend in readmissions observed in one study along with pressures on the DISN workforce are now having a negative impact on patient satisfaction documented in the Davies study of 2001. The hermeneutic review also offers a note of caution that the stretched diabetes inpatient nursing workforce will not sustain current levels of care for the projected growth in prevalence of diabetes.[14] There is a concern that their presence has deskilled and reduced the confidence of non-specialist staff.

This systematic review, while drawing similar conclusions to existing reviews and statements, tempers the interpretation of the results that has informed these recommendations due to the small number of studies and mixed quality of evidence available when the previous reviews were written. The more common use of analytical methods such as interrupted time series analysis allows a more informed view than the shorter before and after studies most widely used to examine the introduction of DISNs.

5 | CONCLUSION

There appears to be ongoing benefit in employing DISNs within the NHS today; however, the bed saving implications in recent years are less than previously and depend on the background LOS within the trust. Future studies looking at the impact of diabetes specialist nurses on in hospital complications, up-to-date measures of patient satisfaction and staff outcomes are warranted. With the increase in demand for DISNs, we recommend effective education of non-specialist staff and evaluation of such initiatives to ensure inpatient diabetes care is sustainable for the future.

AUTHOR CONTRIBUTIONS

The review was conducted primarily by Dr. F. Akiboye with Dr. H. Sihre acting as a second reviewer independently selecting abstracts for inclusion against eligibility criteria, validating chosen papers and discussing the final critical appraisal. Miss M. Al Mulhem acted as a second reviewer to select papers and quality assess papers from the second data extraction and independently extract data from the selected papers. Dr. N. Adderley supported writing the paper. Dr. K. Nirantharakumar and Professor G. Rayman helped inform the scope of the review with Professor Rayman providing expert opinion in the field of inpatient diabetes. All authors reviewed and approved the final manuscript.

TRIAL REGISTRATION

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ORCID

Funke Akiboye https://orcid.org/0000-0002-7632-5587
Gerry Rayman https://orcid.org/0000-0003-3331-7015
Krishnarajah Nirantharakumar https://orcid.org/0000-0002-6816-1279
Nicola J. Adderley https://orcid.org/0000-0003-0543-3254

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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APPENDIX 1.

Example Data Collection Sheet

Design.

Hospital type.

Sample size (before and after intervention).

Patient population (medical/ surgical/ unselected).

Follow-up duration.

Background population assessed? (are the population without diabetes assessed as a negative control).

Primary outcomes (LOS, Excess LOS, Bed occupancy, readmission, insulin errors, OHA errors).

- Baseline, change and P-value/ CI

Secondary/ Other outcomes?