

## An evaluation of a Diabetes Specialist Nurse prescriber on the system of delivering medicines to patients with diabetes

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### An evaluation of a Diabetes Specialist Nurse prescriber on the system of delivering medicines to patients with diabetes

**Aim.** To evaluate the impact of a Diabetes Specialist Nurse prescriber on insulin and oral hypoglycaemic agent medication errors and length of stay.

**Background.** The National Health Service has committed to a 40% reduction in the number of drug errors in the use of prescribed medicines. Drug errors in diabetes care are a common cause of significant morbidity and complications. Nurse prescribing creates an opportunity for nurses to improve care for these patients.

**Design.** A quasi-experiment using six wards in a single hospital trust.

**Methods.** Inpatient care of a convenience sample of patients with diabetes was evaluated before ( $n = 27$ ) and after ( $n = 29$ ) the intervention of a Diabetes Specialist Nurse prescriber. Prospective data were collected to measure insulin and oral hypoglycaemic medication errors and length of stay.

**Results.** There was a significant reduction in the total number of errors between the pre-intervention and intervention group (mean reduction 21 errors) ( $p = 0.016$ ). The median length of stay was reduced by three days. The total number of errors and length of stay were affected by admission category ( $p = 0.0004$ ).

**Conclusions.** A medicines management intervention, provided by a Diabetes Specialist Nurse prescriber, had a positive effect on the system of delivering medicines to patients with diabetes and significantly reduced the number of errors. This

reduction had some effect on length of stay. The cost saving was sufficient to finance a Diabetes Specialist Nurse prescriber post.

**Relevance to clinical practice.** (i) Errors frequently occur in the prescription and administration of medicines to patients with diabetes. (ii) The education of healthcare professionals is a factor contributing to these errors. (iii) Nurse prescribing provides a new system by which to educate patients and staff about their medicines. (iv) A Diabetes Specialist Nurse prescriber can reduce insulin and OHA MEs. This reduction had some effect on LOS.

**Key words:** length of stay, medication error, medication system, nurse prescribing, nurses, nursing

## Introduction

Since 1997, a large number of radical reforms have been introduced within the National Health Service (NHS) in an attempt to control cost and improve quality (DoH 1998, DoH 2000). Such reforms have increasingly become an essential requirement of service delivery. In NHS organisations in the UK, the incidence of medication error (ME) is one specific indicator of quality that has been adopted to demonstrate medication safety (DoH 2004). Although the majority of MEs do not result in harm to the patient, it is suggested that the direct costs of MEs in the NHS hospitals are £200–400 million per year (DoH 2004). It is evident from the literature that patients who suffer adverse events and/or MEs also experience an increased length of stay (LOS) of between 2–8 days (Wilson *et al.* 1995, Classen *et al.* 1997, Vincent *et al.* 2001).

The National Patient Safety Agency recently adopted the following definition of ME (DoH 2004 P20): ME is any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of health professional, patient or consumer.

Patients with diabetes occupy approximately 10% of hospital inpatient beds and are likely to be admitted to hospital twice as often and stay twice as long as people without diabetes (Currie *et al.* 1997). Errors in diabetes care, which patients experience during admission to hospital, are also a common cause of significant morbidity and complications (Hellman 2001). A lack of information, inappropriate amounts and timings of meals, unnecessary side effects from medicines, delayed hospital discharge and prolonged admission as a result of errors in the medication process are all identified shortfalls at a national level in the diabetes service (Hiscock *et al.* 2001, van der Bijl & Shortridge-Baggett 2001, Fan *et al.* 2005).

A quarter of people living with this disease also experience three or more other long-term conditions (DoH 2003a). The

number of co-morbidities is also linked to the number of medication-related problems a patient is likely to experience (Manley *et al.* 2003). Furthermore, patients with diabetes (who are more likely to have complex medicine regimens) do experience more medication-related problems. The DoH has estimated that £5 million a day is spent by the NHS on treatment for diabetes and its related complications (DoH 2003a). Additionally, the NHS has committed to reducing by 40% the number of serious drug errors in the use of prescribed drugs (DoH 2004). Therefore, reducing MEs in diabetes care for patients admitted to hospital is one way that significant improvement to care and sustainable savings to the NHS can be achieved.

## Background

There is substantial evidence to suggest that most MEs involve a chain of problems, and a wide variety of contributing factors that need to be considered (Reason 1990, Leape 1999, Hellman 2001, Dean *et al.* 2002, Vincent 2003). Reason (1990), Vincent *et al.* (1998) and Dean *et al.* (2002) describe two types of error: slips and lapses and mistakes. Slips and lapses are errors of action and occur when there is a break in routine and attention is diverted. In comparison, mistakes, which are more difficult to detect, are rule and knowledge-based errors and are errors of conscious thought. They commonly occur from a lack of knowledge or misperception of the situation with the subsequent application of the wrong rule to the situation.

The process of providing medications to patients is complex involving multiple sub-processes (Clancy 2004). Many specific factors have been associated with prescribing and MEs including calculations of drug dose, errors in decimal points, medications with similar names, medication dosage forms, use of abbreviations, unusual routes of drug administration, uncommon dosage regimens, complicated dosage regimens, poor history taking, lack of knowledge of

the drug and patient, work load, and failure to follow policy and procedure (Leape *et al.* 1995, Lesar *et al.* 1997, O'Shea 1999, DoH 2004). In an evaluation of MEs, Leape *et al.* (1995) discovered that 39% of errors occurred during physician ordering, 38% during administration by nurses, and the remainder were equally divided between pharmacy and transcription.

Insulin has been identified as one of the top five medications associated with MEs that cause harm to patients (Kowiatek *et al.* 2001). In a recent initiative to reduce insulin MEs, Kowiatek *et al.* (2001) conducted a one year evaluation and review of MEs. The majority of errors was classed as wrong dose/rate, omission and incorrect drug. A more detailed analysis identified that prescribing and transcribing errors were also related to inappropriate use of abbreviations (use of word 'unit' vs. 'u' and no zeros after whole numbers), and a lack of instruction and training on how to write insulin orders.

Interventions from hospital Diabetes Specialists Nurses (DSNs) include a strong emphasis on patient education, support, advice and medicines management (Cavan *et al.* 2001, Young *et al.* 2002, Barr-Taylor *et al.* 2003, Chan *et al.* 2006). These interventions have been shown to improve glycaemic control and decrease LOS (Koproski *et al.* 1997, Thompson *et al.* 1999, Grey *et al.* 2002, Wong *et al.* 2005, Sampson *et al.* 2006).

However, only minimal research has examined nurse prescribing in diabetes (James 2004, Courtenay *et al.* 2007). Qualified Nurse Independent/Nurse Supplementary Prescribers (DoH 2003b, 2006a) are able to prescribe any licensed medicine (and some controlled drugs) independently or, any medicine as a supplementary prescriber (provided that these medicines are within the prescribers area of competence). Supplementary prescribing takes place after an assessment and diagnosis of a patient's condition has been made by a doctor, and a clinical management plan (which includes a list of medicines from which the supplementary prescriber is able to prescribe) has been agreed among the nurse prescriber, doctor and patient.

Although errors are an intrinsic part of mental functioning and cannot be totally eliminated (Reason 1990), there is considerable evidence to suggest the fundamental cause usually lies in a variety of systemic features operating at the level of the task, the work environment and wider organisational context (Reason 1990, Leape 1999, Hellman 2001, Vincent 2003, DeLisa 2004). The primary objective of a system design for safety is to make it difficult for individuals to err (Leape 1994). Ideally a system, as Leape suggests, will automatically correct errors or has mecha-

nisms in place to at least detect errors in time for corrective action.

It is evident that errors frequently occur in the prescription of insulin, and the education of healthcare professionals is a factor contributing to these errors (Kowiatek *et al.* 2001). Therefore, nurse prescribing (which provides a mechanism to educate and support patients and staff [National Prescribing Centre 2005] (NPC)) creates a new opportunity for nurses to provide care designed to have a positive effect on the system for prescribing and administering insulin and or insulin and oral hypoglycaemic agent (OHA) medicines to patients with diabetes.

## The study

### Aim

The aim of the study was to compare insulin and OHA MEs, and LOS between a comparison group receiving standard inpatient care and an intervention group who had their medicines managed by a DSN prescriber. The specific research questions were:

- Do patients treated by a DSN prescriber experience a reduction in the number of insulin and OHA MEs?
- Do patients treated by a DSN prescriber experience a reduction in LOS?

### Design

The study was a quasi-experiment carried out using six medical (including renal) and surgical (including orthopaedics, vascular surgery no amputation and vascular surgery) wards in a District General Hospital in the UK between May and December 2005.

### Sample

Subjects were a convenience sample of 56 patients with diabetes admitted into one of the six wards during a three month pre-intervention phase, and three month intervention period with a predicted LOS at least three days. Agreement from wards to participate in the study was obtained from ward managers. Seven patients in the pre-intervention group were readmitted twice. In the intervention group, three patients were readmitted twice and one three times. These patients were readmitted for reasons other than their diabetes, e.g. heart failure, renal disease and chemotherapy. All participants were part of a larger study, the results of which have been reported elsewhere (Courtenay *et al.* 2007).

## Intervention

Within the Hospital, Trust nursing and administrative staff identified several factors that appeared to affect the level of care patients in hospital with diabetes received (James 2003). The main areas of concern related to delays in diabetes treatment, inaccuracies in prescriptions for insulin or OHA, access to information about systems of delivery, gaps in knowledge about diabetes and its treatment, access to diabetes health professionals and lack of continuity of diabetes care. It is evident that these areas of concern were rooted across all parts of the medication system for patients with diabetes who are prescribed insulin and/or OHA. The medicines management intervention was therefore designed to address these factors.

During the first three months (pre-intervention phase), patients received standard care, i.e. their medicines were prescribed and managed by medical, i.e. house officers, senior house officers and non-diabetes specialist registrars and nursing staff other than a DSN prescriber. Following a one month period designed to enable ward staff to adjust to a nurse-led service, data were collected for a further three months (intervention period). During this period, in addition to standard care, patients received care and advice from a DSN prescriber. This included an initial patients' assessment by the DSN prescriber (including review of medicines regime), 1–3 individual patient's education sessions appropriate to need (information was provided on the patients' condition, management of medicines, any medication changes) and on-going review of patients' medicines regime. The need for frequency and content of education sessions was based on the initial patient's assessment.

During the intervention period, the DSN prescriber also provided medical and nursing staff with 1–2 individual education sessions appropriate to need. These sessions comprised information on the treatment regimes of each patient including drug action and dose, drug interactions and adverse effects. Nurse supplementary prescribing was instigated in the absence of medical staff in an emergency, or if a delay in prescribing would adversely affect the patient.

## Outcome measures and data collection

The two main outcome measures were insulin and oral hypoglycaemic MEs, and LOS.

### Medication errors

The findings from a preliminary audit (James 2003) undertaken within the hospital trust had identified a number of errors with regard to the prescribing of insulin and

**Table 1** Insulin and oral hypoglycaemic agent medication errors

Insulin doses not signed as given
Name of insulin incorrect
Insulin/oral medication dose not adjusted when persistent BG > 14 mmols
Insulin/oral medication dose not adjusted with persistent BG < 4 mmol
Insulin chart not signed by prescriber
Inappropriate dose of short acting insulin administered in response to hyperglycaemia
Unit abbreviated to 'u' and unclear
Insulin not written up
Oral hypoglycaemic agents not signed as given
Number of units of dose unclear
Sliding scale doses not signed as given. State number of doses
Omission of insulin after hypoglycaemia
Prescription chart not signed by prescriber
Chart incomplete

oral therapy. These errors were classifiable into 14 different categories. As part of the larger study (and reported elsewhere), an error chart (see Table 1), which described and categorised the range of possible insulin errors, was developed and piloted from this information (Courtenay *et al.* 2007).

During the pre-intervention and intervention phases of the study, patient's medication charts (including the insulin and/or insulin infusion chart) were collected upon patients' discharge. These charts were photocopied and made anonymous and reviewed blind by a researcher with a background in diabetes research. Any errors identified within the 14 categories were then recorded on the insulin and OHA error chart (one chart per person). To increase the robustness of this process, and as part of the larger study, the first 20 error charts and medication charts from which these errors were extracted were reviewed by a Consultant Diabetologist (J. R.) (Courtenay *et al.* 2007). There was an agreement between the two reviewers with regard to the insulin errors extracted from the medication charts and recorded on the error charts.

### Length of stay

Admission and discharge dates were collected manually on all participants. Additional demographic information including admission category, type and management of diabetes, the age and sex of patient, ethnicity, employment status, accommodation and history of another chronic disease or illness was also collected. LOS was calculated for all admissions (excluding readmissions). This information was collected by the DSN prescriber.

## Data collection

Data were collected on admission and at discharge. Admission data included demographic information. Discharge data include MEs and LOS.

## Data analysis

SPSS was used for data entry and analysis. Descriptive statistics were used to describe the demographic nature of the sample. Chi-squared tests were used for categorical data when testing for association. To ensure that cell size reached the recommended minimum of five and achieve a reasonable degree of statistical power to detect effect (Pallant 2005), the 14 insulin and OHA MEs were reduced into four categories (Table 2). Continuously distributed data were analysed with independent sample *t*-tests, and the Pearson-moment correlation coefficient.

A general linear modelling procedure was used to explore which, if any factors, contributed significantly to explaining the variation in the total number of errors and LOS. These factors included age, sex, type of diabetes, time since diagnosis, admission category, management of diabetes, employment, accommodation and having another chronic disease or illness. The model was then checked using residual analysis.

## Ethical considerations

Approval for the study was granted by the research ethics committee of the study hospital and the university with which

the principal investigator was affiliated. Agreement from wards to participate in the study was obtained from ward managers. A series of staff meetings were held prior to the pre-intervention phase at which details (including information sheets) about the research were disseminated.

## Results

Fifty-six patients were recruited across both the pre-intervention ( $n = 27$ ) and intervention ( $n = 29$ ) groups between May 2005 and December 2005. Patients' demographic data in the two study groups were generally similar (Table 3), although there is an evidence that a greater proportion of patients in the pre-intervention group were treated with insulin and/or OHA medication, had been diagnosed with diabetes >15 years and reported another chronic disease. In comparison, a greater proportion of patients in the intervention group were admitted under medicine, and were aged <70 years. However, results of chi-squared analysis showed that although there was a significant difference in the type of admission between the two groups, there were no significant differences in the other demographic characteristics, i.e. sex, age, Type 1/Type 2 diabetes, management of diabetes, ethnicity, employment status, marital status or accommodation.

## Main outcome measures

### Medication errors

In total, MEs were recorded for 42 patients across both the intervention and pre-intervention groups (see Table 2).

**Table 2** Insulin and oral hypoglycaemic agent (OHA) medication errors

Error category	Pre-intervention	Intervention	Difference
Incorrect/unclear prescribing including: name of insulin incorrect, number of units of dose unclear, unit abbreviated to 'u' and unclear, insulin not written up	126	63	-63
Medicines not signed as given including: OHA not signed as given, insulin doses not signed as given, sliding scale not signed as given	271	69	-202
Charts not signed/incomplete including: insulin chart not signed by prescriber, prescription chart not signed by prescriber, charts incomplete	74	8	-66
Dose adjustment incorrect/omitted including insulin/oral medication dose not adjusted with BG < 4 mmol, or BG > 14 mmol inappropriate dose of short acting insulin in response to hypoglycaemia	49	6	-43
Sum of total errors	520	146	-374 (-72%)

**Table 3** Comparison of patients' characteristics in the two study groups

Chi-squared test	Pre-intervention ( <i>n</i> = 27)		Intervention ( <i>n</i> = 29)		<i>p</i> -value
	<i>n</i>	%	<i>n</i>	%	
Type of diabetes					
Type 1	5	18.5	5	17.2	1.00
Type 2	19	70.4	23	79.2	
Sex					
Male	16	59.3%	19	65.5	0.836
Female	11	40.7	10	34.5	
Management of diabetes					
Oral hypoglycaemic agents	10	37	10	34.5	0.206
Insulin with oral hypoglycaemic agent and insulin only	14	51.9	15	51.7	
Diet only	0	0	3	10.3	
Type of admission					
Medicine (including renal)	9	33.3	19	65.5	0.02
Surgery (including orthopaedics, vascular surgery and vascular amputation)	17	63.7	8	27.6	
Age					
< 50 years	3	11.1	6	20.7	0.254
51–69 years	11	40.7	15	51.7	
>70 years	13	48	8	27.6	
Marital status					
Married/living together	12	44.4	13	44.8	1.00
Divorced/separate/single/widowed	15	55.6	16	55.2	
Employment					
Not employed	20	74.1	23	79	0.883
Employed	7	25.9	6	20.7	
Ethnicity					
White	25	92.6	28	96.6	0.587
Asian/Black/British-Asian/British-Black	2	7.4	1	3.4	
How long since diagnosed?					
0–15 years	15	55.6	21	72.4	0.300
>15 years	12	44.4	8	27.6	
Other chronic disease/illness					
No	10	37	5	17.2	0.589
Accommodation					
Detached or semi detached house	23	85.2	20	71.4	0.217
Terrace or flat	4	14.8	8	28.6	

An independent sample *t*-test was conducted to compare the total number of errors between groups. There was a significant difference and reduction in the total number of errors between the pre-intervention group ( $M = 26$ ,  $SD = 35.04$ ) and intervention group [ $M = 5.03$ ,  $SD = 7.79$ ;  $t(47) = 2.632$   $p = 0.016$ ]. The magnitude of the differences in the means was large (a mean reduction of 21 errors was identified in the intervention group).

Some patients experienced multiple errors. The maximum number of errors recorded for one patient in the pre-intervention group was 130, and in the intervention group the maximum number of errors recorded for one patient was 33. Nurse supplementary prescribing was used in seven patients.

Using a general linear model, it was evident that admission type contributed, although not to a significant level ( $p = 0.06$ ), to the total number of errors. A greater number of errors were identified in patients who had been admitted to the surgical wards in both the pre-intervention and intervention group compared with those patients admitted to medicine (see Table 4).

#### *Incorrect/unclear prescribing*

An independent sample *t*-test was conducted to compare the total number of incorrect/unclear prescribing errors between groups. There was no significant difference in the number of incorrect/unclear prescribing errors between the pre-intervention group ( $M = 6.3$ ,  $SD = 9.5$ ) and intervention group

**Table 4** Effect of admission category and group on insulin and oral hypoglycaemic agent (OHA) medication errors and length of stay

	Pre-intervention	Intervention
Adjusted mean number of total errors		
Surgery	35	8
Medicine	9	4
	Significance probability = 0.06	
Adjusted mean length of stay		
Surgery	41	22
Medicine	15	21
	Significance probability = 0.41	

The means are adjusted to take account of the other factors included in the model.

[ $M = 2.2$ ,  $SD = 3.8$   $t(47) = 1.838$ ,  $p = 0.08$ ]. A mean reduction of four errors was identified in the intervention group.

#### Charts not signed/incomplete

An independent sample *t*-test was conducted to compare the total number charts not signed/incomplete errors between groups. There was no significant difference in the number of charts not signed/incomplete errors between the pre-intervention group ( $M = 3.7$ ,  $SD = 9.0$ ) and intervention group [ $M = 0.28$ ,  $SD = 0.7$   $t(47) = 1.689$ ,  $p = 0.1$ ]. A mean reduction of 3.4 errors was identified in the intervention group.

#### Dose adjustment incorrect/omitted

An independent sample *t*-test was conducted to compare the total number of dose adjustment incorrect/omitted errors between groups. There was a significant difference in the total number of dose adjustment incorrect/omitted errors between the pre-intervention group ( $M = 2.5$ ,  $SD = 4.2$ ) and intervention group [ $M = 0.21$ ,  $SD = 0.68$   $t(47) = 2.348$ ,  $p = 0.03$ ]. A mean reduction of 2.3 errors was identified in the intervention group.

**Table 5** Significant correlations and relationships

Measures	Pre-intervention			Intervention		
	<i>r</i>	<i>n</i>	<i>p</i>	<i>r</i>	<i>n</i>	<i>p</i>
Length of stay						
Medicines not signed as given	0.53	18	0.024	0.4	26	0.045
Total errors	0.5	18	0.036			
Charts not signed/incomplete	0.49	18	0.040			
Total errors						
Medicines not signed as given	0.96	20	0.00	0.87	29	0.00
Charts not signed/incomplete	0.88	20	0.00	0.4	29	0.033
Incorrect/unclear prescribing	0.47	20	0.036			
Medicines not signed as given						
Charts not signed/incomplete	0.92	20	0.000			
Incorrect/unclear prescribing				0.44	29	0.017

#### Medicines not signed as given

An independent sample *t*-test was conducted to compare the total number of medicines not signed as given errors between groups. There was a significant difference and large reduction in the total number of medicines not signed as given errors between the pre-intervention group ( $M = 13.55$ ,  $SD = 22.7$ ) and intervention group [ $M = 2.38$ ,  $SD = 4.92$ ;  $t(47) = 2.166$ ,  $p = 0.042$ ]. A mean reduction of 11 errors was identified in the intervention group.

A large positive correlation was found between the number of medicines not signed as given and charts not signed/incomplete errors in the pre-intervention group [ $r = 0.92$ ,  $n = 20$ ,  $p < 0.001$ ]. This effect was not present in the intervention group. A medium positive correlation was found between the number of medicines not signed as given and incorrect/unclear errors in the intervention group [ $r = 0.44$ ,  $n = 29$ ,  $p < 0.05$ ]. This effect was not present in the pre-intervention group (see Table 5).

There was no correlation between the total number of errors, the four error categories and LOS, age, admission type, type and management of diabetes, ethnicity, employment status, accommodation and history of another chronic disease or illness.

#### Length of stay

In the pre-intervention group, the minimum LOS was three days and the maximum 113 days, compared to a minimum of six and maximum of 52 days in the intervention group. Over half (54%) the patients in the pre-intervention group were in hospital for more than 15 days compared with 42% in the intervention group.

In the pre-intervention group, the median LOS was 17.5 days (interquartile range 10.25–46.75), compared to median of 14.5 days (interquartile range 9.75–32.25) in the intervention group ( $p < 0.05$ ). Despite this reduction in LOS,

it was evident from the independent *t*-test that the difference in LOS between the pre-intervention group ( $M = 31.05$ ,  $SD = 31.8$ ) and intervention group [ $M = 21$ ,  $SD = 15.1$ ,  $t(48) = 1.46$ ] was not significant ( $p = 0.15$ ).

Using a general linear model, it was evident that admission type contributed, although not to a significant level ( $p = 0.42$ ), to LOS. Patients admitted to the surgical wards in the pre-intervention group experienced a mean LOS, which was more than double than those patients admitted under medicine (see Table 4). To explore the extremely large difference between LOS and admission type in the pre-intervention group, a further independent sample *t*-test was conducted. It was evident from this that admission type had a highly significant effect on LOS for this group of patients ( $p = 0.0004$ ).

A large, positive correlation was found to exist between the LOS and the total number of errors in the pre-intervention group [ $r = 0.5$ ,  $n = 18$ ,  $p < 0.05$ ]. This effect was not present in the intervention group (see Table 5).

A large positive correlation was found between medicines not signed as given errors and LOS in the pre-intervention group [ $r = 0.53$ ,  $n = 18$ ,  $p < 0.05$ ]. This effect was also present in the intervention group but was less marked [ $r = 0.4$ ,  $n = 26$ ,  $p < 0.05$ ] (see Table 5).

A medium, positive correlation was found to exist between the LOS and charts not signed/incomplete errors in the pre-intervention group [ $r = 0.49$ ,  $n = 18$ ,  $p < 0.05$ ]. This effect was not present in the intervention group (see Table 5).

There was no correlation between LOS and age, admission type, type and management of diabetes, ethnicity, employment status, accommodation, history of another chronic disease or illness and side effects from medicines for diabetes.

## Discussion

Several potential limitations of our methodology need to be taken into account. Firstly, only patients admitted on to one of the six wards during the three month pre-intervention phase, and three month intervention period, were included in the study, i.e. it was not a random sample. A second potential limitation is that only one DSN prescriber participated in the study. Although this helped with regard to standardising the patient and staff individual education sessions, there is the possibility of character bias.

It is evident from our findings that insulin and OHA errors were recorded for nearly 75% of patients in both the pre-intervention and intervention groups and some patients experienced multiple errors. The 'medicines not signed as given' and 'incorrect/unclear prescribing' categories were the most frequent type of MEs present on the medicines charts of

patients in both the pre-intervention and intervention groups. Our findings suggest that when the medication system failed multiple insulin and OHA MEs occurred. Specifically, patients who experienced large numbers of 'medicines not signed as given' errors also experienced large numbers of 'charts not signed/incomplete' and 'incorrect unclear' errors.

The median number of total errors in the intervention group was 1, i.e. 10 less than in the pre-intervention group. In addition to having a longer LOS, this could have been as a result of this group of patients having a longer duration of diabetes requiring more complex drug regimens, and being more likely to be treated with insulin therapy (see Table 3). A similar percentage of patients in each group experienced insulin and OHA MEs. However, it is evident from our findings and the substantial (72%) reduction in errors that the medicines' management intervention provides a system, such as that described by Leape (1994), i.e. it automatically corrects errors and provides a mechanism which detects errors in time for corrective action.

It is evident from our findings that the total number of insulin and OHA MEs and LOS were affected by admission category. Patients admitted under surgery in both groups experienced a much greater number (two to four times as many) of insulin and OHA MEs than those admitted under medicine. In the pre-intervention group, the LOS for patients admitted under surgery was nearly three times that compared to those admitted under medicine.

These findings suggest that the substantially higher number of insulin and OHA errors identified on the medicines charts of surgical patients are more likely to have occurred from a lack of knowledge, or misperception of the situation, with the subsequent application of the wrong rule to the situation as described by Vincent *et al.* (1998) and Dean *et al.* (2002). Furthermore, the higher number of errors had a subsequent detrimental effect in the pre-intervention group with regard to the LOS of patients admitted to these wards. It is possible, therefore, that the nursing and medical staff working on the surgical wards may have had less experience and or confidence in managing the medicines of patients for their diabetes than those on medical wards, which ultimately affected the number of insulin and OHA MEs their patients experienced.

The median LOS for patients in the intervention group was 14.5 days compared with 17.5 days for patients in the pre-intervention group. Based on a cost per patient per day of £250 (DoH 2006b), over one year this is a potential cost saving of £168 000. Although several factors may have affected LOS (e.g. severity of illness, availability of investigations and response to treatment), a correlation was found to exist, in the pre-intervention group, between LOS and the



total number of errors and also between LOS and the error category 'medicines not signed as given', i.e. as the total number of errors increased, so did LOS.

These findings are in-line with those reported by previous research (Wilson *et al.* 1995, Classen *et al.* 1997, Vincent *et al.* 2001). Wilson *et al.* (1995) in a retrospective review of 14,000 medical records of patients in Australia reported that adverse events accounted for an additional seven hospital bed days per admission, of which 51% were highly preventability. Additionally, cognitive error (including both slips and lapses and mistakes) was deemed to play a part in nearly 60% of these adverse events. More recently in the UK, Vincent *et al.* (2001) conducted a retrospective review of 1014 patients' records and similarly reported that 50% of adverse events are preventable. Similar findings were reported within the Hospital Trust by James (2003) in a review of hospital patients with poorly controlled diabetes. In this small-scale study, it was identified that over 50% of the MEs for the management of diabetes were preventable.

Although not looking at nurse prescribing, a reduction in LOS when care has been provided by DSN has been reported by a number of researchers (Koproski *et al.* 1997, Cavan *et al.* 2001, Davies *et al.* 2001, Sampson *et al.* 2006, Courtenay *et al.* 2007). Sampson *et al.* (2006), for example in a study of 14 722 patients with diabetes, reported the mean excess bed days were significantly lower in patients who received individual structured information and practical management of diabetes from a DSN compared with those patients who had not.

In line with these findings, and as part our larger study, a reduction in insulin and OHA MEs was identified in a sample of 452 patients whose medicines were managed by a DSN prescriber (Courtenay *et al.* 2007). Furthermore, the median LOS was significantly lower in patients who had received the medicines management intervention compared with those who had not.

Our findings are in line with policy and the literature (Leape 1994, Hellman 2001, DoH 2003a, Woloshynowych *et al.* 2005, Clinical Resource Efficiency Support Team (CREST) 2006). *The National Service Framework for Diabetes* emphasises the role of the nurse in the care of patients with diabetes (DoH 2003a). More recently, recommendations for the safe and effective use of insulin in secondary care (Clinical Resource Efficiency Support Team 2006) also emphasise the role of the DSN, the importance of education and training, and the use of audit in improving the standards of care for inpatients with diabetes. New methods and improved ways of working are therefore essential if the process of prescribing and administering of medicines to patients with diabetes is to be improved (Leape 1994,

Hellman 2001). However, more attention as Woloshynowych *et al.* (2005) suggest must be given to psychological and human factors that contribute to error, particularly the fact that liability to error is strongly affected by the context and conditions of work. It is evident that the medicines management intervention delivered by a DSN prescriber had a dramatic effect on both the medication system and the number of insulin and OHA MEs patients experienced.

## Conclusion

In most high-risk industries, learning from accidents or near misses is a long-established practice and a cornerstone of safety analysis and improvement. There is substantial evidence to suggest that most incidents involve a chain of problems, and a wide variety of contributing factors that need to be considered. We have shown that the medicines management intervention delivered by a DSN prescriber has a positive effect on the system of delivering medicines to patients with diabetes, and substantially reduced the number of insulin and OHA MEs. This reduction had some effect on LOS. The reduced LOS of patients in the intervention group produced a cost saving sufficient to fund at least the cost of a DSN prescriber post.

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## Contributions

Background: NC and MC; method: NC, MC, JJ, MH and JR; data collection: NC, MC, JJ, MH and JR; results: NC and MC; discussion: NC and MC; conclusion: NC and MC; and manuscript preparation: NC and MC.

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