CLINICAL REPORT

Patient satisfaction and costs associated with insulin administered by pen device or syringe during hospitalization

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Purpose. Patient satisfaction, safety and efficacy outcomes, and cost savings with insulin pens versus conventional insulin delivery via vials and syringes in hospitalized patients with diabetes were compared.

Methods. Patients were recruited from two general medical–surgical units from July 2005 to May 2006. Patients completed a survey regarding satisfaction with the method in which insulin was administered before discharge. Patients completed a telephone survey approximately four weeks after discharge to determine home insulin use. Cost savings were determined using the average wholesale price of insulin vials and syringes, pens, and pen needles.

Results. A total of 94 patients were randomized to receive insulin administered via pen devices (n = 49) or using conventional vials and syringes (n = 45). Significantly more subjects in the pen group prepared or self-injected at least one dose of insulin during hospitalization, wanted to continue taking insulin at home using the method used during hospitalization, and would recommend their method of insulin administration used during hospitalization to other patients with diabetes compared with the vial and syringe group ($p < 0.05$). A cost saving of $36 per patient was projected if only insulin pens were dispensed during the entire hospital stay compared to insulin vials and syringes ($p < 0.05$).

Conclusion. Increased patient satisfaction and continuation of the method of insulin administration used in the hospital at home were reported by patients who received insulin pens compared with patients who received conventional vials and syringes during hospitalization. A substantial cost saving was projected for patients in the insulin pen group if insulin pens had been dispensed during their entire hospital stay.

Index terms: Data collection; Devices; Diabetes mellitus; Drug administration; Hospitals; Injections; Insulin; Insulins; Patients; Pharmacoeconomics; Toxicity

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Improvements in glycemic control have been shown to greatly reduce the progression of microvascular complications in patients with diabetes.[1,2] Adherence to insulin therapy is a major factor in achieving glycemic control. Insulin has conventionally been administered via the subcutaneous route with vials and syringes. Insulin pen devices were developed and introduced in the 1980s by combining the insulin reservoir and syringe into a single component in an effort to overcome barriers to adherence with insulin self-administration and to improve convenience and ease of use for patients.[3]

Despite the availability of insulin pens, hospitals continued to use vials and syringes for subcutaneous injections. One reason that insulin pens were not used in many hospitals was that there was no automatic safety feature that would prevent accidental

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needle sticks in health care workers. The use of insulin pens in the hospital setting became a more viable option with the introduction of an insulin pen product with a safety needle that provides a passive safety feature that automatically engages after an injection is administered (NovoFine Autocover 30G disposable safety needle, Novo Nordisk, Princeton, NJ). The safety feature prevents accidental needle sticks and needle reuse and is locked into place throughout needle disposal. The safety needle complys with U.S. Department of Labor Occupational Safety and Health Administration (OSHA) guidelines and appears on OSHA's list of approved safety-engineered sharps devices.[4]

Administration of insulin through pen devices in the ambulatory care setting has been shown to improve insulin regimen adherence and patient satisfaction.[5-9] Authors of a survey evaluating insulin pen use in patients who previously used vials and syringes found that more patients who used pens reported not missing any injections and felt it was easier to comply with their insulin regimen than when they used conventional vials and syringes.[8] Patients also reported a strong desire to continue using the pens and stated that they would recommend the method to other patients.

Studies in ambulatory care patients have also found that insulin pens have similar effects or improve glycemic control compared with insulin administered using vials and syringes. In a multicenter, randomized, crossover study in 121 patients with type 1 or type 2 diabetes mellitus using conventional insulin administration using vials and syringes or prefilled, disposable insulin pens, a significant improvement in glycosylated hemoglobin (HbA_{1c}) was observed in both treatment groups after a four-week treatment period, with an average reduction in mean HbA_{1c} values of 0.3% in the total population ($p < 0.05$).[10] Another randomized crossover study assessed the efficacy and safety of and patient compliance with insulin administered from vials and syringes versus prefilled, disposable pens for an eight-week treatment period in patients over age 60 years.[11] The authors found a reduction of 1.1% ± 1.2% in mean ± S.D. HbA_{1c} values for those using insulin pens compared with a 0.6% ± 1.2% reduction with vials and syringes (mean HbA_{1c} value of 8.4% at baseline for both groups) ($p < 0.02$). An additional study that evaluated the efficacy and safety of and satisfaction with insulin pens among elderly patients with type 2 diabetes found that HbA_{1c} values decreased significantly from 7.8% at baseline to 7.6% at three months after insulin pen use ($p < 0.05$).[12]

One long-term study followed patients who were newly initiated on insulin pen treatment or insulin treatment administered from a vial with a syringe for a minimum of two years to evaluate outcomes retrievable through an integrated medical and pharmacy claims database containing information for patients enrolled in managed care health plans in the United States ($n = 1156$).[13] They conducted a preanalysis and postanalysis to evaluate the effect of converting patients from conventionally administered insulin to insulin pens on adherence, hypoglycemic events, resource utilization, and the associated health care costs. Although the authors did not report findings related to HbA_{1c} values, they found that the likelihood of patients having a hypoglycemic event was significantly reduced after switching to insulin pens (odds ratio [OR], 0.50; 95% confidence interval [CI], 0.37–0.68; $p < 0.05$), and the rate of hypoglycemia in patients who were considered adherent to insulin decreased by nearly two thirds (incident rate ratio, 0.35; 95% CI, 0.11–0.81; $p < 0.05$). There were significant decreases in hypoglycemia-attributable emergency department visits (OR, 0.44; 95% CI, 0.21–0.92; $p < 0.05$) and physician visits (OR, 0.39; 95% CI, 0.24–0.64; $p < 0.05$) in patients receiving insulin pens, whereas the number of hypoglycemia-related hospitalizations and outpatient visits remained similar after switching from conventionally administered insulin to insulin pens.

One survey of 33 physicians found that 97% of physicians ($n = 32$) whose patients switched to insulin pens for six weeks in an outpatient setting felt the insulin pen was a better method for insulin delivery overall, 85% felt more confident in their patients' ability to accurately deliver a dose, and 91% felt it was easier to initiate insulin therapy with the insulin pen than with insulin vials to be administered with syringes.[9] Another study evaluated home care nurse resource utilization in 79 ambulatory elderly patients with visual disabilities, motor disabilities, or both who required assistance for insulin preparation and administration using insulin pens or vials and syringes.[14] More patients were able to independently give themselves injections using insulin pens compared with vials and syringes (53% versus 20%, respectively). The mean ± S.D. time spent by nurses to assist with injections for those who used pens (4.2 ± 8.1 minutes) was shorter compared with administration via vials and syringes (5.8 ± 8.9 minutes). The saving in time spent assisting with injections significantly reduced the mean daily nursing cost (calculated from nursing visits to assist patients with insulin injections) for those who used pens versus vials and syringes ($114 versus $196, respectively; $p < 0.001$).[14]

Direct and indirect costs attributed to diabetes in the United States were $132 billion in 2002.[15] The development of novel insulin technologies that can increase patient adherence, improve patient and health care worker safety, and decrease potential institutional and health care costs

has driven organizations to consider using insulin pen devices for hospitalized patients. To the best of our knowledge, there are no published articles that evaluate insulin pen use in hospitalized patients and cost savings or patient satisfaction associated with insulin pen use in the hospital setting. Further, it is not known whether patients who are exposed to insulin pen devices in a hospital setting would continue to use them after hospital discharge or if insurance and reimbursement issues would be barriers to their use. The goals of the current study were to evaluate patient satisfaction, glycemic control, economic effect, and postdischarge insulin administration method by comparing the use of insulin administered through a pen device with the administration of insulin from vials using a syringe in hospitalized patients.

Methods

Study design. This prospective, randomized, controlled, parallel-group study compared the use of pen devices with conventional vials and syringes for the administration of insulin in hospitalized patients with diabetes mellitus requiring subcutaneous injections. A noninferiority study design was used to evaluate patient satisfaction and cost savings with insulin pens versus vials and syringes. Patients were randomly assigned (1:1) to receive their insulin using pen devices or vials and syringes.

The study was conducted in accordance with the Declaration of Helsinki.[16] The procedures for the study were followed in accordance with the ethical standards of the investigational review board at Creighton University and Alegent Health System. Written informed consent was obtained from all patients prior to any trial-related activities. Patients were recruited from two general medical–surgical units from July 2005 to May 2006.

Two prefilled, disposable insulin pen devices were used: InnoLet and FlexPen (Novo Nordisk). Because the hospital has one preferred formulary manufacturer for insulin analogues, orders from prescribers for comparable insulin analogues were therapeutically substituted with an analogue of the hospital's preferred manufacturer whenever possible. Patients received InnoLet if they were randomized to the insulin pen group and prescribed insulin human regular, isophane insulin human (NPH insulin), or the combination of 70% NPH insulin and 30% regular insulin. Patients received the FlexPen if they were randomized to the insulin pen group and prescribed any rapid-acting insulin (insulin lispro or insulin aspart) or the combination of 70% insulin aspart protamine with 30% insulin aspart or 75% insulin lispro protamine with 25% insulin lispro. NovoFine Autocover 30G disposable safety needles were dispensed for patients enrolled in the pen group. If insulin glargine was prescribed, a vial was dispensed regardless of the treatment group because it was not available in a pen device at the start of the study.

To prevent the delay of insulin delivery to patients on the study floors, potential study patients who met inclusion criteria were initially given insulin vials to cover immediate insulin needs. If patients were ultimately randomized to the insulin pen group, the insulin vials were discontinued and the appropriate insulin pens and pen safety needles were used. Patients randomized to the vial and syringe group continued this method during their hospital stay.

Insulin pen training. Before study initiation, registered nurses on the study floors received instruction by study investigators on both pen devices and proper use of the safety needles. Successful completion of a competency-based insulin pen administration checklist and successful demonstration of a mock insulin injection were required by the investigator before a nurse could administer insulin to a patient using the insulin pen devices. During this training period, all pharmacists and pharmacy technicians were trained how to use, label, dispense, and store the insulin pens.

Patient selection. Patients were eligible for study inclusion if they had documentation of type 1 or 2 diabetes mellitus in their medical record, required subcutaneous insulin for glucose control during hospitalization, and were above the age of consent (19 years) in Nebraska, where the study was conducted. Patients were excluded if they were prescribed a sole insulin analogue that could not be substituted with Innolet or FlexPen.

Outcomes measures. *Patient satisfaction.* All patients completed a self-administered, eight-question survey about their insulin administration experience during their hospital stay. The first two questions addressed the number of times that the patient withdrew the insulin dose from the insulin vial or used the pen to dial the dose of insulin and the number of times the patient self-administered the insulin dose during the hospital stay. For the remaining questions, patients were provided statements and asked to rate their level of agreement with the statement (i.e., strongly disagree, disagree, unsure, agree, or strongly agree). Any patients who had used both insulin pens and conventional insulin vials and syringes before study enrollment were asked to rate their level of agreement with three additional statements to compare the two methods of insulin administration.

The satisfaction survey tools were developed from surveys used in previous studies assessing patient and health care provider satisfaction with existing insulin delivery methods, satisfaction with comparative types of insulin delivery methods, and satisfaction with novel insulin pen

devices in the self-care outpatient environment.[6,9,17-21] Two validated surveys—the Patient Satisfaction with Insulin Therapy questionnaire and the Diabetes Treatment Satisfaction Questionnaire—were used to help develop survey items for the study. Nine questions were identified for inclusion in the survey. The surveys were pilot tested and modified to finalize the survey items.

Clinical outcomes and safety. All patients were followed to evaluate glycemic control during hospitalization. The primary clinical outcome was to compare the initial blood glucose level at admission and the final blood glucose level at discharge. Secondary clinical outcomes included the number of hypoglycemic and hyperglycemic events and the mean rates of hypoglycemic and hyperglycemic events.

The mean rates of hypoglycemic and hyperglycemic events for patients in the vial and syringe group were calculated using the number of events per length of stay in days. Hypoglycemic and hyperglycemic event rates for patients in the insulin pen group were calculated using the number of events per length of stay in days and the number of events while receiving insulin pens per number of days using insulin pens. These events were analyzed in two ways for the pen group because patients could have been receiving insulin pens for a shorter duration than their length of stay due to the consent process. Hypoglycemic events were defined per hospital policy as any blood glucose concentration of <70 mg/dL. Hyperglycemic events were defined as events requiring administration of a rapid- or fast-acting insulin for coverage of high blood glucose concentrations (typically >200 mg/dL) via a one-time dose or sliding-scale insulin coverage. Severe hyperglycemia was defined as blood glucose concentrations of >400 mg/dL. During the time of this study, the hospital did not have a universal sliding-scale order set that was automatically initiated for high blood glucose levels.

Health care staff were encouraged by investigators to report any insulin-related medication errors using the hospital's standard voluntary reporting method. Insulin-related needlestick or sharps injury data were collected by the hospital's department of infection control. Insulin-related adverse events, with the exception of hyperglycemic or hypoglycemic events, were recorded on the hospital's forms for reporting adverse reactions.

Postdischarge insulin use. Patients were also asked to complete a follow-up telephone survey approximately four weeks after they were discharged from the hospital. Patients were asked about the type of setting they went to after discharge; about the type of insulin they were currently taking, if any; whether their insulin and associated supplies were covered by insurance; and what their estimated out-of-pocket costs per month were for their insulin and associated supplies.

Economic outcomes. A cost-saving analysis was conducted during the study period to compare the two insulin administration methods. The cost-saving analysis evaluated the direct insulin medication and needle costs using the average wholesale price (AWP) for the corresponding insulin vials, insulin syringes (Safety Glide, Becton-Dickinson, Franklin Lakes, NJ), insulin pens, and pen safety needles used by each patient (Table 1).

A conversion factor was used to more accurately estimate the number of insulin vials and pens used by each patient based on the total number of insulin units documented as administered on the medication administration record during hospitalization for both groups. For the vial and syringe group, if the number of units of insulin administered per patient was 1000 or less, this was equivalent to one vial. For the vial and syringe group, the total number of subcutaneous injections was converted to the total number of syringes used. In the insulin pen group, if the number of units of insulin consumed per patient was 300 or less, this was equivalent to one insulin pen used after consent was obtained to convert insulin analogues to FlexPen or InnoLet. Before consent was obtained from patients assigned to the insulin pen group or for patients whose order for an insulin analogue was not converted

Table 1.
Average Wholesale Price (AWP) Used to Calculate Direct Insulin Costs

Insulin Type	AWP ($)	
	Vial[a]	Insulin Pen[b]
Insulin human regular	34.59	14.73
Isophane insulin human (NPH)	34.59	14.73
70% NPH insulin with 30% insulin human regular	34.59	14.73
Insulin aspart	83.70	32.34
70% insulin aspart protamine with 30% insulin aspart	83.70	32.34
Insulin glargine	77.85	31.73[c]
75% insulin lispro protamine with 25% insulin lispro	80.35	32.34[c,d]
Insulin lispro	80.35	32.34[c,d]

[a]The AWP for each insulin syringe was $0.41.
[b]The AWP for each safety needle used with the insulin pen device was $0.35.
[c]Not dispensed as an insulin pen during the study period.
[d]The AWP was not included in the projected costs because insulin lispro products were not on the hospital formulary; the AWP of comparable insulin pen devices was substituted, assuming that future patients would be converted to an insulin pen on the formulary.

to FlexPen or InnoLet, if the number of units of insulin administered per patient was 1000 or less, this was equivalent to one vial. For the insulin pen group, the number of subcutaneous injections given before consent for conversion was obtained or the number of injections given using an insulin analogue in patients whose insulin was not converted to a pen device after consent was converted to the number of syringes used. After consent was obtained from patients assigned to the pen group, the number of subcutaneous injections was converted to the total number of safety needles used. These conversion factors did not account for lost, misplaced, or extra vials or needles that may have been dispensed to the study floors.

The totals for the direct insulin costs for patients from both groups were determined by multiplying the AWP for insulin analogues, syringes, and pen needles by the number consumed during their hospitalization. The totals for the projected direct insulin costs for patients in the pen group were determined by evaluating the total number of insulin units given per analogue and converting that number to project how many insulin pens would have been dispensed if only insulin pen devices were available (i.e., no insulin vials would have been dispensed for initial insulin orders because consent would not be required). The projected total number of insulin injections for the pen group would remain the same, but this number would be multiplied by the cost of pen safety needles to determine costs, since insulin syringes would not be used. The average direct insulin costs were calculated by dividing the total direct insulin costs by the number of patients in each group. The average direct cost savings were calculated by subtracting the average direct costs of the group with lower average costs from the average direct insulin costs for the group with higher average costs.

Statistical analysis. Data were entered into a spreadsheet (Microsoft Excel 2000) and imported into the Statistical Package for Social Sciences (SPSS-PC, version 14.0). All statistical analyses were performed using this software. Specifically, survey satisfaction data, discrete demographic outcomes, and the number of hyperglycemic and hypoglycemic episodes were analyzed using Pearson's chi-square test. Continuous data (i.e., cost savings and demographic data) were analyzed using analysis of variance.

Results

A total of 94 patients were eligible for study inclusion and randomization from July 2005 through May 2006; 45 were randomized to the vial and syringe group and 49 were randomized to the insulin pen group. Five patients dropped out of the vial and syringe group (3 were started on an insulin drip, 1 withdrew consent, and 1 died of pneumonia during hospitalization), and 14 patients dropped out of the insulin pen group (7 were started on an insulin drip, 4 transferred to a nonparticipating study floor during enrollment, 2 withdrew consent, and 1 had an adverse event associated with a pen device and withdrew from the study). The patient satisfaction survey results were based on the responses of the patients who completed the study: 35 patients in the pen group and 40 patients in the vial and syringe group.

Demographic characteristics of the 75 patients completing the study are listed in Table 2. There was no significant difference between groups in reasons for admission. The number of concomitant diseases including hypertension, hyperlipidemia,

Table 2.
Demographic Characteristics of Study Patients[a]

Variable	Insulin Pen Group (n = 35)	Vial and Syringe Group (n = 40)
Age (yr), mean ± S.D.	57.5 ± 11.4	57.1 ± 11.6
Male, no. (%)	16 (46)	23 (58)
Race, no. (%)		
Caucasian	30 (86)	27 (68)
African American	4 (11)	8 (20)
Other	1 (3)	5 (12)
Type 1 diabetes, no. (%)	6 (17)	4 (10)
Type 2 diabetes, no. (%)	29 (83)	36 (90)
Duration of diabetes (yr), mean ± S.D.	14.9 ± 11.2	10.6 ± 9.3
Insulin use before admission, no. (%)		
Vials and syringes only	18 (51.4)	18 (45)
Insulin pens only	4 (11.4)	3 (7.5)
Both vials and syringes and pens	0	1 (2.5)
Currently using vials and syringes but used pens in the past	1 (2.9)	1 (2.5)
Currently using oral antidiabetic medication but used conventional insulin in the past	1 (2.9)	3 (7.5)
Currently using oral antidiabetic medication but used insulin pens in the past	0	1 (2.5)
Currently using oral and injectable pen medication for diabetes	1 (2.9)	1 (2.5)
Never treated with injectable insulin	10 (28.6)	12 (30)

[a] $p > 0.05$ for all comparisons.

kidney disease, pulmonary disease, and peripheral vascular disease, was similar between treatment groups. Interestingly, more patients in the insulin pen group had a history of liver disease than did patients in the vial and syringe group (11.4% versus 0%, respectively). At baseline, both groups had similar rates of vision problems, such as diabetic retinopathy, cataracts, glaucoma, nearsightedness, and farsightedness.

The mean ± S.D. length of stay was similar between treatment groups: 8.9 ± 7.5 days for the insulin pen group and 8.1 ± 7.7 days for the vial and syringe group. The mean number of days of treatment for the vial and syringe group was equal to the group's average length of stay. The mean ± S.D. number of days of treatment for the insulin pen group was 5.1 ± 5.7 days.

A total of 19 patients in the insulin pen group (54%) and 18 patients in the vial and syringe group (45%) received insulin glargine during hospitalization. Eighteen patients in the insulin pen group (51%) and 30 patients in the vial and syringe group (75%) had an order for at least one oral hypoglycemic medication during their hospitalization.

Patient satisfaction. More patients in the insulin pen group (77.1%) dialed at least one dose of insulin using the pen device, compared with 5% of patients who drew at least one dose using the vial and syringe method during hospitalization ($p = 0.002$). More patients in the insulin pen group (77.1%) used the pen to self-inject at least one dose, compared with only 12.5% of patients who self-injected at least one dose using the vial and syringe method during hospitalization ($p = 0.001$).

In both groups, the majority of patient responses regarding their satisfaction with insulin treatment during hospitalization were positive ("agree" or "strongly agree") (Table 3). Significantly more patients using the pen devices than those using the vials and syringes responded positively that they would like to continue administering insulin at home by the method used during the hospital stay (74% versus 45%, $p < 0.05$) and would recommend the insulin administration method used during the hospital stay to other patients with diabetes (94% versus 73%, respectively; $p < 0.05$).

Thirty-two patients (26 in the pen group and 6 in the vial and syringe group) indicated having used both insulin pens and vials and syringes before the study. The majority of responses to the satisfaction questions comparing insulin pens with vials and syringes were positive ("agree" and "strongly agree") in favor of insulin pens. All patients who had used insulin pens before the study and were assigned to insulin vials and syringes during randomization felt more confident they were receiving the correct dose of insulin using pens, felt more comfortable using insulin pens, thought it took less time to prepare and administer insulin using pens, and believed insulin pens were an improvement over administration using vials and syringes (Table 4). Further, a high percentage of the patients who had prior experience using vials and syringes and were randomized to receive insulin via pen devices during hospitalization indicated that they felt more confident they were receiving the correct dose of insulin using pens, felt more comfortable using pens, thought it took less time to prepare and administer insulin using pens, and believed that pens were an improvement over vials and syringes (Table 4). There was no significant difference between groups for each of these comparative satisfaction questions.

Clinical outcomes. The mean ± S.D. nonfasting blood glucose concentration at the time of admission was 227.3 ± 100.1 mg/dL for the insulin pen group and 233.7 ± 126.5 mg/dL for the vial and syringe group ($p > 0.05$). The mean ± S.D. nonfasting blood glucose concentration at the time of discharge was 182.9 ± 73.5 mg/dL for the insulin pen group and 181.3 ± 76.2 mg/dL

Table 3.
Summary of Positive Responses to Survey Items Regarding Patient Satisfaction Asked Before Discharge from Hospital[a]

Survey Item	No. (%) Respondents	
	Insulin Pen Group ($n = 35$)	Vial and Syringe Group ($n = 40$)
The method used to give me my insulin in the hospital was convenient.	33 (94)	39 (98)
The method used to give me my insulin in the hospital was simple and easy.	31 (89)	38 (95)
I would like to continue taking insulin at home by the method used during my hospital stay.	26 (74)[b]	18 (45)
I would recommend to other people with diabetes to use insulin by the method I used during my hospital stay.	33 (94)[b]	29 (73)
I was confident I was given the correct dose of insulin during my hospital stay.	34 (97)	37 (93)
Overall, I was satisfied with the method used to give me my insulin in the hospital.	34 (97)	38 (95)

[a]Positive responses include responses of "agree" or "strongly agree."
[b]$p < 0.05$, chi-square test.

for the vial and syringe group ($p > 0.05$). The mean ± S.D. number of hypoglycemic events during hospitalization was 1.2 ± 2.3 for the insulin pen group and 0.8 ± 1.5 for the vial and syringe group. The mean ± S.D. number of hyperglycemic events during hospitalization was 19.5 ± 18 for the insulin pen group and 13.2 ± 11.8 for the vial and syringe group. The mean ± S.D. rates of hypoglycemic and hyperglycemic events for the vial and syringe group were 0.7 ± 1.5 events daily and 7.97 ± 7.2 events daily, respectively. The mean ± S.D. rate of hypoglycemic events for the pen group for the entire length of stay was 1.1 ± 2 events daily, and the mean ± S.D. rate of hypoglycemic events while receiving insulin pens was 0.4 ± 0.9 event daily. The mean ± S.D. rate of hyperglycemic events for the pen group for the entire length of stay was 9.1 ± 7.2 events per day, and the average rate of hyperglycemic events while receiving insulin pens was 5.1 ± 5.7 events per day. There was no significant difference between the number or average rate of hypoglycemic and hyperglycemic event rates between groups. Severe hyperglycemia occurred in 10 patients in the vial and syringe group (25%) and 12 patients in the insulin pen group (34%). Specifically, 24 episodes of severe hyperglycemia occurred in the vial and syringe group, and 41 episodes of severe hyperglycemia were reported in the insulin pen group, with 16 episodes occurring before the patients were switched to insulin pens and 25 episodes occurring while the patients were receiving insulin from pen devices. One patient in the insulin pen group experienced 11 episodes of severe hyperglycemia and had a length of stay of 34 days.

Safety. No insulin-related medication errors or needle-stick injuries were reported in either group. One report of an adverse event of hyperglycemia was reported and thought to be related to the insulin pen device. The patient and nurse reported to the investigator that insulin was "coming out of the skin" after the appropriate injection technique was utilized. This patient chose to withdraw from the study and switched back to the conventional vial and syringe method.

Table 4.
Summary of Positive Responses to Survey Items for Patients with Experience Using Both Insulin Administration Methods[a]

Survey Item	No. (%) Respondents	
	Insulin Pen Group ($n = 26$)	Vial and Syringe Group ($n = 6$)
I felt more confident that I was receiving the correct dose of insulin using the FlexPen, InnoLet pen, or other insulin pens than with insulin vials and syringes.	21 (81)	6 (100)
I felt more comfortable using the FlexPen, InnoLet pen, or other insulin pens than with insulin vials and syringes.	21 (81)	6 (100)
It took less time to prepare and give insulin using the FlexPen, InnoLet pen, or other insulin pens than with insulin vials and syringes.	23 (88)	5 (83)
The FlexPen, InnoLet pen, or other insulin pens are an improvement over vials and syringes.	23 (88)	6 (100)

[a]Positive responses include responses of "agree" or "strongly agree"; $p > 0.05$ for all comparisons, chi-square test.

Postdischarge insulin use. One patient in the insulin pen group died, from a cause unrelated to the study, between hospital discharge and the follow-up telephone survey. Follow-up surveys were completed for 34 patients in the insulin pen group and 40 patients in the vial and syringe group. The majority of patients returned to their home after discharge in the insulin pen group (86%) and vial and syringe group (82%). In the insulin pen group, 12 patients (35%) continued to use insulin pens, 14 patients (41%) switched back to vials and syringes, 2 patients (6%) used both insulin vials and pens, and 6 patients (18%) discontinued insulin use. In the vial and syringe group, 23 patients (58%) continued to use vials and syringes, 4 (10%) switched to insulin pen use, and 13 (33%) discontinued insulin use. Patients from both groups who discontinued insulin use at home were switched to oral hypoglycemic agents or the injectable insulin incretin mimetic exanatide (Byetta, Amylin Pharmaceuticals). Forty-one percent of patients in the insulin pen group used insulin pens after discharge, while only 10% of patients in the vial and syringe group switched to insulin pens after discharge ($p = 0.016$).

More patients in the insulin pen group had insurance coverage for their insulin and related supplies compared with the vial and syringe group (79% versus 52%, respectively; $p = 0.070$). More patients in the insulin pen group paid for their insulin supplies via a copayment compared with the vial and syringe group (56% versus 30%, respectively; $p = 0.038$).

Economic outcomes. Table 5 provides the actual number of insulin vials, pens, syringes, and pen needles used by all patients in each group.

Table 6 provides the projected direct insulin costs for the pen group if no insulin vials were dispensed to the pen group and only insulin pens and pen needles were used for those patients. The total mean ± S.D. direct

Table 5.
Direct Insulin Costs During Hospitalization for Study Patients

Insulin Type	Insulin Pen Group[a] (*n* = 35)		Vial and Syringe Group[b] (*n* = 40)
	No. Vials Dispensed (Total Cost, in Dollars)	No. Pens Dispensed (Total Cost, in Dollars)	No. Vials Dispensed (Total Cost, in Dollars)
Insulin human regular	21 (726.39)	22 (324.06)	34 (1176.06)
Isophane insulin human (NPH)	5 (172.95)	9 (132.57)	3 (103.77)
70% NPH insulin with 30% insulin human regular	2 (69.18)	4 (58.92)	3 (103.77)
Insulin aspart	13 (1088.10)	21 (679.14)	11 (920.70)
70% insulin aspart protamine with 30% insulin aspart	2 (167.40)	2 (64.68)	0
Insulin glargine	19 (1479.15)	0	18 (1401.30)
75% insulin lispro protamine with 25% insulin lispro	1 (80.35)	0	3 (241.05)
Insulin lispro	0	0	1 (80.35)
Total direct costs	3783.52	1259.37	4027.00

[a]A total of 425 syringes at a cost of $174.25 were dispensed to patients in the insulin pen group before initiation of insulin pen therapy; 533 pen needles were dispensed to these patients at a cost of $186.55. The total cost of insulin, syringes, and needles for this group was $5403.69.
[b]A total of 719 syringes at a cost of $294.79 were dispensed. The total cost of insulin and syringes for this group was $4321.70.

Table 6.
Projected Direct Insulin Costs for Patients in the Insulin Pen Group[a] (*n* = 35)

Insulin Type	No. Pens Dispensed (Cost, in Dollars)
Insulin human regular	24 (353.52)
Isophane insulin human (NPH)	10 (147.30)
70% NPH insulin with 30% insulin human regular	5 (73.65)
Insulin aspart	24 (776.16)
70% insulin aspart protamine with 30% insulin aspart	3 (97.02)
Insulin glargine	20 (634.60)
75% insulin lispro protamine with 25% insulin lispro	3 (97.02)
Insulin lispro	0
Total projected direct costs	2179.27

[a]Reflects costs if all insulin used by patients in the pen group were converted to costs of insulin administered through pen devices. A total of 958 pen needles would have been used by the patients at a total cost of $335.30; the total cost of insulin in pen devices and pen needles would have been $2514.57.

costs of the insulin vials and pens and syringes and safety needles per patient were significantly higher in the pen group ($154.39 ± $91.41) compared with those of the vial and syringe group ($108.04 ± $62.30) ($p$ = 0.012). However, once the insulin direct costs per patient were adjusted to project dispensing only the equivalent insulin pen products, the mean ± S.D. direct cost per patient for the pen group was projected to be $71.85 ± $46.21, yielding a cost saving of $36 per patient for the insulin pen group when compared with the actual mean total direct costs per patient in the vial and syringe group (p = 0.006).

Discussion

In this study, significantly more patients in the insulin pen group prepared and self-injected at least one dose of insulin compared with the vial and syringe group. Patients with newly diagnosed or existing diabetes admitted to our hospital have an educational care plan, with an interdisciplinary education record initiated and placed under the patient education section in their permanent medical chart. This document is intended to provide an educational checklist for various health care professionals to document a patient's readiness to learn about multiple aspects of diabetes, including an understanding of the disease, signs and symptoms and treatments for hyperglycemia and hypoglycemia, blood glucose monitoring, oral antidiabetic medications and injectable insulins, the effects of stress and exercise on diabetes, preventive care, and nutrition therapy. In addition, health care professionals may ask patients to demonstrate certain skills to assess the patient's self-care technique. One skill a patient may be asked to demonstrate is insulin preparation and injection. The patient may be asked to prepare an insulin injection three times before discharge, inject the insulin dose, rotate injection sites, dispose of the syringe, and mix two types of insulin, if necessary. During the study training sessions for the nurses, the investigators did not specifically instruct the

nurses to educate enrolled patients in either group on how to prepare or self-inject their insulin. Perhaps the difference found between groups could be attributed to the novelty of the insulin pen devices and the patients' desire to try using them, or the nurses may have felt more comfortable letting patients self-administer using the pens because they were simple and easy to use.

Significantly more patients in the insulin pen group indicated that they would like to continue using pens at home and would recommend this method of insulin delivery to other people with diabetes compared with patients in the vial and syringe group. Summers et al.[22] evaluated the preference for two insulin delivery methods (insulin pens and vials and syringes) when distributed to insulin users and nonusers. Regardless of whether the responder used insulin, there was a significant preference for insulin pens over administration using insulin vials and syringes. One of the significant predictors for preference of insulin pens for both groups was social acceptability of the method. The authors hypothesized that if responders viewed insulin pens as more socially acceptable, then this could lead to positive clinical outcomes.

A survey of outpatient insulin users found that fewer patients miss insulin injections when using pen devices versus vials and syringes.[8] Studies have also shown that the use of insulin pens compared to vials and syringes results in reduced HbA_{1c} values, lower mean fasting blood glucose levels, improved medication adherence, and improved health care resource utilization in outpatients.[7,11,13,23] The current study was not designed to measure long-term indicators of glucose control, such as HbA_{1c} values or morbidity, or measure adherence through prescription-refill history. We believe that improved compliance and health care resource utilization could be realized for patients who continue using insulin pen devices in the ambulatory care setting due to fewer missed injections, improved adherence, and increased satisfaction with the pen method. The hospital has since adopted the use of insulin pens for all subcutaneous doses.

In this study, more patients in the insulin pen group had insurance coverage and paid a copayment for their insulin supplies. Information regarding individual prescription drug coverage was not collected from each patient before discharge to actively investigate if insulin pens were included in the patient's prescription benefit provider's drug formulary. It could be that patients using the vial and syringe method for insulin administration who continued or switched back to this method may have done so because of unequal coverage through their managed care plan. During the time of study enrollment, insulin pens could have been on a higher tier, requiring higher out-of-pocket prescription expenses for patients or prior-authorization criteria to be met before pens would be covered by insurance. An attempt to locate publicly accessible prior-authorization criteria for insulin pens or medication formularies from private managed care companies proved difficult, as this information may be proprietary information and unavailable to the public. Medication formularies for state departments of Medicare and Medicaid are accessible online.[24,25] Currently, the majority of Medicare prescription drug plan formularies cover insulin pens,[24] and over 50 plans include the InnoLet and FlexPen devices on their formulary in Nebraska, usually classified as tier 2 or 3, which in most cases was the same tier as the same insulin analogue in vial form. However, insulin pen coverage for managed care plans could have been much different during the time of patient enrollment. Prior authorization is required for Medicaid patients or for beneficiaries of a few Medicare plans in Nebraska; however, specific authorization criteria were not publicly retrievable. One state's prior authorization criteria for Medicaid patients specified that insulin pens were considered convenience items unless medical necessity could be documented and that coverage was limited to patients with significant visual impairment or physical disability that prevented the use of conventional vials and syringes or to juvenile patients self-administering insulin in an educational setting.[26] Therefore, the desire to continue or switch to insulin pens can be greatly influenced by a patient's prescription benefit provider's drug formulary and the potential cost to the patient. Also, the patient must be willing to switch to a different insulin preparation and administration method.

Two recent studies evaluated the impact of insulin pens on health care costs from a managed care perspective. One study examined medication adherence and total health care costs among patients with type 2 diabetes who were enrolled in a Medicaid program from 2001 to 2006.[23] The study evaluated patients initiated on or converted to insulin with a pen device compared with a vial and syringe as add-on therapy to oral antidiabetic drugs. Patients receiving insulin with a vial and syringe who converted to pen therapy were compared with those who continued to use the vial and syringe method in both unmatched comparisons (n = 560 and n = 9,988, respectively) and after pair matching using propensity scores (both groups, n = 560). The authors performed a second analysis comparing patients who initiated insulin with vials and syringes (n = 1,162) with a cohort that initiated insulin pen therapy (n = 168) after controlling for covariates in a multivariate regression model. All patients had complete enrollment in the program for at least 24 months of follow-up. The authors found that diabetes-related and overall medi-

cation adherence were comparable for patients initiating insulin with a pen versus a vial and syringe (53% versus 50% and 94% versus 94%, respectively). However, total annualized health care costs were significantly lower for patients using pen therapy than for those using a syringe ($14,857.42 versus $31,764.78, $p < 0.05$). Cost reductions with pen therapy were reflected in hospital costs ($1,195.93 versus $4,965.31, $p < 0.05$), diabetes-related costs ($7,324.37 versus $13,762.21, $p < 0.05$), and outpatient costs ($7,795.98 versus $13,103.51, $p < 0.05$). However, prescription costs of syringes were significantly lower ($535.70 versus $670.52, $p < 0.05$) and costs of pens were higher ($840.33 versus $0, $p < 0.05$) in patients who switched from syringes to pens versus those who continued to use syringes. The authors concluded that in a state Medicaid setting among patients with type 2 diabetes, initiating insulin therapy with a pen device was associated with comparable medication adherence and significant reductions in health care resource utilization and associated costs compared with insulin therapy with vials and syringes.[23] This study is important because it sheds some light on the financial impact of insulin pens from a Medicaid perspective on health care costs that affect hospital, outpatient, and prescription costs. Further, this study documents that in Medicaid patients, while health care costs were lower with insulin pens, prescription costs were significantly higher compared with vials and syringes. This clearly affects the potential for patients to continue using the insulin pen method after discharge since their out-of-pocket costs would be higher and would account for Medicaid patients switching back to vials and syringes, as pen devices would be cost prohibitive.

Another study evaluated patients enrolled in 1 of 57 managed care health plans in the United States (n = 1,156) and found that medication adherence was significantly improved, the likelihood of experiencing a hypoglycemic event was significantly reduced, and the frequency of hypoglycemia in adherent patients decreased by nearly two thirds after conversion to insulin pens.[13] There were significant reductions in emergency department visits and physician visits, whereas hypoglycemia-related hospitalizations and outpatient visits remained similar after conversion. Total mean all-cause annual treatment costs were reduced by $1,590 per patient (from $16,359 to $14,769, $p < 0.01$). Annual hypoglycemia-related costs were reduced by $788 per patient (from $1,415 to $627, $p < 0.01$), predominantly as a result of decreased hospitalization costs (from $857 to $288, $p < 0.01$), and annual diabetes-related costs were reduced by $600 per patient (from $8,827 to $8,227, $p < 0.01$). Similar to the previous study,[23] the authors found that among patients with type 2 diabetes treated in a managed care setting, a switch from administration of insulin therapy by vial and syringe to a prefilled pen device was associated with improved medication adherence, fewer claims for hypoglycemic events, reduced emergency department and physician visits, and lower annual treatment costs.[13] Unlike the previous study, these authors found that based on refill history, medication adherence was significantly improved with insulin pens in managed care patients.

A significant saving of $36 per patient was realized for patients in the pen group compared with the vial and syringe group. It is important to note that our hospital's infection control policy did not allow sharing of insulin vials for multiple patients on the floors. The cost savings may not be realized by other institutions if the hospital uses one vial of insulin analogue for multiple patients on a hospital unit. Similar cost savings may also not be realized if the average length of stay is considerably longer than found in this study, since more insulin may be used during longer stays. The cost savings could be underestimated if the number of insulin-related needle-stick injuries decreases and care needed for the treatment of a blood-borne pathogen is prevented. It is estimated that the follow-up for a high-risk exposure costs $500–$2500 per needle-stick injury, even when no infection occurs.[27]

There were some limitations to this study. Some patients in the insulin pen group received insulin administered from vials with a syringe during the study period because investigators did not want to delay the delivery of insulin before obtaining consent or if a patient received insulin glargine. This exposure to insulin vials could have confused the patient as to how he or she should respond to the survey questions. Patients in the insulin pen group who had experience with the vial and syringe method during hospitalization only may not have completed the subsequent comparative questions of the satisfaction survey.

Prescription benefit information was not obtained for each patient; therefore, it was difficult to clearly determine if insulin pens required prior authorization or were on a higher tier of coverage in 2005–06, which could have affected the patient's ability to switch to or continue using insulin pens after exposure to this method in the hospital.

Conclusion

Increased patient satisfaction and continuation of the method of insulin administration used in the hospital at home were reported by patients who received insulin pens compared with patients who received conventional insulin vials and syringes during hospitalization. A substantial cost saving was projected for patients in the insulin pen group if insulin pens had been dispensed during their entire hospital stay.

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