



Economic impact of converting from 10-mL insulin vials to 3-mL vials and pens in a hospital setting

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Approximately 12% of patients discharged from hospitals are diagnosed with diabetes mellitus,¹ and an additional 11% of all hospitalized patients may meet the criteria for diabetes.² Thus, it is not surprising that insulin is one of the most frequently prescribed medications in hospitals.³ Insulin is also among the most frequently implicated medications associated with hospital medication errors.⁴

In the hospital setting, insulin can be distributed via individual patient supply (IPS) or via floor stock. With IPS, insulin vials and pens are labeled for specific patients and intended for single-patient use. In contrast, with floor-stock delivery, insulin vials can be used to dispense doses to multiple patients. However, several organizations, including the Centers for Disease Control and Prevention⁵ and the Institute for Safe Medication Practices,⁶ have recommended that multidose vials be dedicated to a single patient whenever possible. One advantage of the IPS system is its association with fewer medication errors compared with floor-stock vi-

Purpose. The economic impact associated with the conversion from 10-mL vials of insulin to 3-mL vials and pens at a community hospital was assessed.

Methods. Pharmacy purchasing and administrative data from Providence St. Vincent Hospital in Portland, Oregon, were used in this analysis. The hospital converted floor-stock 10-mL vials of insulin in October 2010 to individual patient supply (IPS) 3-mL vials and pens. Insulin acquisition costs from the nine-month preconversion period were compared with those during the nine-month postconversion period.

Results. Before the conversion, total acquisition costs were \$168,783 for 5,086,500 units of insulin. After the conversion, total acquisition costs were reduced by 8.6% (to \$154,303) and units purchased were reduced by 33.1% (to 3,404,900 units of insulin). The analyses

also examined the results of converting to 3-mL vials of rapid-, short-, or intermediate-acting insulin to 3-mL pens of long-acting insulin analog. Conversion from 10- to 3-mL vials was associated with a 37.6% reduction in units of insulin and a 23.5% reduction in acquisition costs. In contrast, switching from 10-mL vials to 3-mL pens was associated with a 10.1% increase in costs, despite the fact that there was a 11.5% reduction in units purchased.

Conclusion. Conversion from floor-stock 10-mL insulin vials to IPS 3-mL insulin vials or pens reduced the number of units of insulin purchased and expenditures for insulin. The overall cost savings was driven by the conversion from 10- to 3-mL vials, whereas cost increased for the conversion of 10-mL vials to 3-mL pens for long-acting insulin analogs.

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als.⁷ Offsetting the benefit of fewer medication errors, however, IPS has been associated with a higher degree of wastage. For example, one hospital reported 25% wastage associated with 10-mL vial use via floor stock, whereas an estimated 90% of insulin

would be wasted if 10-mL vials were used via IPS.⁵

While change in the delivery system of insulin has been found to reduce wastage and lower costs, the size of insulin vials can also affect how efficiently insulin is utilized. For

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example, a budget impact analysis revealed that switching from a 10-mL vial to a 3-mL vial was associated with a cost savings of \$15,482 and 120,000 units of reduced waste.⁸ Furthermore, in 2003, Grajower et al.⁹ argued that the cost associated with purchasing new vials when opened vials have not been completely utilized but have passed the beyond-use date (the allowable time to use a vial after it is first punctured) may lead to patients using vials after the beyond-use date. They stressed the importance of avoiding the use of vials past this date as part of good patient care. They ended their discussion on this topic by asking “Why can’t manufacturers make smaller bottles of insulin for those on smaller daily doses to reduce wastage?” Three-milliliter vials of insulin provide the potential for more efficient insulin usage and reduce the cost of wastage associated with IPS.

The purpose of this study was to assess the economic outcomes associated with the conversion from floor-stock 10-mL vials of insulin (regular or analog) to IPS 3-mL vials of rapid-acting insulin analogs, short-acting insulins, and intermediate-acting insulins and prefilled 3-mL pens of long-acting insulin analogs in a community hospital setting. As such, the data provide naturalistic evidence of insulin use and cost differences associated with alternative methods of insulin delivery.

Methods

Data from Providence St. Vincent Hospital, a 523-bed community hospital located in Portland, Oregon, were used in this study. The hospital converted from floor-stock 10-mL vials of insulin to IPS 3-mL vials or 3-mL prefilled pens on October 1, 2010. The preconversion period was defined as the nine months from December 1, 2009, through August 30, 2010, while the postconversion period was defined as the nine months from December 1, 2010,

through August 30, 2011. The period from September 1, 2010, through November 30, 2010, was omitted from the analyses in order to allow for stabilization of purchasing practices over the immediate conversion period. The analyses included both regular and analog insulins.

Conversions of purchasing practices were generally based on the following decision rules. For rapid-acting insulin analogs, short-acting insulin, and intermediate-acting insulins, 10-mL vials were changed to 3-mL vials, with the cost per unit of insulin being the same with both vial sizes. Long-acting insulin analogs were converted from 10-mL vials to 3-mL prefilled pens, with the price of a unit of insulin in pens being higher than in vials. However, patients who required a dose of long-acting insulin analog that exceeded the maximum amount that can be administered in a single injection from a prefilled pen (80 units) received insulin via IPS 10-mL vials. For all patients outside of hospital areas where procedures were performed, insulin delivery was changed from floor stock to IPS, and 3-mL vials were used in the preparation of intravenous doses when possible. With IPS delivery, insulin was labeled with all of the required information needed in the retail setting and could therefore be taken home by the patient.

Outcomes of interest included acquisition costs and units of insulin purchased before and after conversion, measured by pharmacy purchasing data, as well as the amount of insulin wasted before the conversion occurred. Results of a 28-day insulin “floor sweep” during January and February 2009 are reported here and were applied to the preconversion period purchasing data to estimate the amount of insulin that was wasted. During the floor sweep, a pharmacy student assessed the floor stock of insulin every day on patient care units and collected (for later discarding) all opened insulin vials that had passed

their beyond-use date. The amount of beyond-use insulin was estimated based on vial size and measured amount of remaining volume. These amounts were used to derive an average annual wastage amount for each insulin type. We then applied these background insulin wastage rates to the amount of insulin that was purchased in the preconversion period. A sensitivity analysis was conducted to account for the fact that the cost of long-acting insulin analogs increased after the change in the delivery algorithm. Potential confounding factors were assessed and reported, including the number of patients treated with each insulin type (determined using pharmacy charge data) and any changes in the hospital’s insulin delivery and pharmacy protocols. The analyses are descriptive in nature.

Results

During the study period, there were no changes in the hospital’s formal insulin delivery and pharmacy protocols. Specifically, the pharmacy’s preferred brands of insulin (all included in this conversion) remained the same. Because there was no formal insulin delivery protocol implemented by the hospital during the study period, prescribers chose to deliver insulin as deemed fit for each patient.

A total of 7,315 patients were treated in the preconversion period, and 7,305 were treated during the postconversion period. A comparison of units of insulin purchased and costs revealed that conversion from floor-stock 10-mL vials to IPS 3-mL vials and pens was associated with a 33.1% reduction in the overall number of units of insulin purchased (from 5,086,500 to 3,404,900 units) as well as an 8.6% reduction in insulin acquisition costs (from \$168,783 to \$154,303) (Table 1).

In addition to examining acquisition costs for all insulins combined, we compared the subgroups of pens versus vials. Conversion from floor-

stock 10-mL vials to IPS 3-mL vials (for rapid-, short-, and intermediate-acting insulins) was associated with a 37.6% reduction in insulin units purchased (from 4,199,000 to 2,619,900 units). Among these IPS 3-mL vials, the largest relative reduction in units of insulin purchased was for intermediate-acting insulin (73.4% reduction), whereas the smallest reduction was for rapid-acting insulin analogs (7.6% reduction). The conversion of long-acting insulin analog from floor-stock 10-mL vials to IPS 3-mL pens was associated with an 11.5% reduction in units purchased (from 887,500 to 785,000 units). It should be noted that 27.4% of the long-acting insulin analog units purchased in the postconversion period were for IPS 10-mL vials, due to the hospital's policy of vial use for patients requiring more insulin in a single injection than what the pre-filled pen can deliver.

The conversion from 10- to 3-mL vials was associated with a \$22,016 (23.5%) reduction in acquisition costs (from \$93,863 to \$71,847). The largest absolute cost savings was associated with the conversion of short-acting insulin (\$10,452), and the smallest absolute cost savings was associated with conversion of rapid-acting insulin analogs (\$4,562). In contrast, conversion of long-acting insulin analogs from floor-stock 10-mL vials to IPS 3-mL pens was asso-

ciated with a 10.1% increase in costs (from \$74,920 to \$82,456). Here, the IPS 10-mL vials accounted for 22.7% of the total postconversion costs for long-acting insulin analogs.

An estimated 36.4% of insulin vials were wasted during the preconversion period (Table 2). On average, each wasted vial contained approximately 9 mL of insulin.

There was only one change in costs when comparing insulin costs in the preconversion and postconversion periods—the cost of long-acting insulin analogs increased in the postconversion period. A sensitivity analysis revealed that omitting the effect of this price increase on postconversion acquisition costs resulted in a cost increase of only 6.8% (from \$74,920 to \$79,986) after converting floor-stock 10-mL vials to IPS 3-mL pens.

Discussion

This study compared insulin acquisition costs, units purchased, and wastage associated with a conversion from floor-stock 10-mL vials to IPS 3-mL vials and pens in a community hospital. Several modifications occurred under this change in insulin delivery methods: a change in delivery system from floor stock to IPS, a change from 10 to 3 mL in unit size, and a change from vials to pens for patients using long-acting insulin analogs. This study found that con-

version was associated with fewer units of insulin purchased as well as a reduction in drug acquisition costs. These cost savings were driven by conversion from 10- to 3-mL vials. Adding strength to these results, several factors remained constant throughout the study period. Specifically, the numbers of patients treated with the insulins involved in the study were similar across the preconversion and postconversion periods. There were also no changes in the hospital's formal insulin delivery or pharmacy protocols.

Previous research has also examined the question of converting insulin delivery with regard to vial size (from 10 to 3 mL) and delivery system (vials to pens). For example, consistent with our research, conversion from 10-mL vials to pens was shown by other investigators to be associated with less medication waste⁶ and a reduction in the units purchased.⁷ Furthermore, in contrast to our results, conversion from vials to pens was found by Ward and Aton¹⁰ to reduce six-month costs from \$124,181 to \$60,655. However, it should be noted that the reduction in costs in that study may have been driven by the facts that (1) patients received different brands of insulin during the preconversion and postconversion periods in order to switch from vials to pens and (2) patients in our study were given vials if they re-

Table 1.

Insulin Purchases Before and After Conversion to Smaller Vials and Pens^a

Insulin Type	Amount of Insulin Purchased (units)		Insulin Acquisition Cost (\$)	
	Before Conversion	After Conversion	Before Conversion	After Conversion
Rapid-acting analog	1,353,000	1,249,700	60,195	55,633
Short acting	2,040,000	1,156,200	24,133	13,682
Intermediate acting	806,000	214,000	9,535	2,532
Long-acting analog	887,500	785,000	74,920	82,456
Total	5,086,500	3,404,900	168,783	154,303

^aThe conversion consisted of purchasing 3-mL instead of 10-mL vials of rapid-acting insulin analogs, short-acting insulins, and intermediate-acting insulins and purchasing 3-mL pens instead of 10-mL vials of long-acting insulin analogs. For long-acting insulin analogs, 10-mL vials were purchased after the conversion for patients requiring more insulin analog per dose than could be administered with a single pen. For all insulins, a floor-stock system was used before the conversion and an individual patient supply system was used afterward.

quired doses that were more than the pen could inject, as opposed to being dispensed multiple pens.

Also consistent with our findings, prior research found that conversion from 10- to 3-mL vials reduced 12-month costs by \$14,720.37 and resulted in an 18.8% decrease in wastage.¹¹ To our knowledge, our study is the first to empirically report the total amount of insulin wasted in a hospital via floor-stock 10-mL vials. Over one third of all insulin vials purchased during the preconversion period were estimated to be wasted, with most of the original insulin volume remaining in each vial. These data highlight the inefficient use of 10-mL unit sizes, even when used as multipatient floor-stock delivery. No comparison of wastage amounts in the preconversion and postconversion periods could be made because the hospital labeled the IPS units to go home with patients at hospital discharge. This virtually eliminated insulin waste in the patient care areas. It is likely that the hospital experienced a savings beyond what is presented here due to the reduction of wasted insulin.

While the investigations mentioned above consisted of naturalistic studies conducted in hospitals, another study used a budget impact model to compare the impact of alternative methods of insulin de-

livery.⁵ Holding hospital delivery constant (floor stock or IPS), that analysis concluded that conversion from 10-mL vials or pens to 3-mL vials resulted in lower costs. Those results are consistent with the finding of our study that suggested higher costs associated with pen usage and lower costs associated with conversion to smaller vials. However, in contrast to our findings, the previous modeling research estimated that conversion from floor-stock 10-mL vials to IPS 3-mL vials was associated with higher costs and increased wastage.⁵ The results of our research, in contrast to the budget impact model, suggest that the cost savings associated with conversion from 10- to 3-mL vials may offset any potential cost increases associated with conversion from floor-stock to IPS delivery. Therefore, improvements in quality that are associated with IPS delivery may not necessarily result in an increase in costs.

Our study had several limitations. First, the analysis was based on pharmacy drug acquisition costs and administrative data. As a result, no information on patient-specific dosing or patient outcomes was considered. Furthermore, given that the study was conducted at the hospital level, it was not possible to account for differences in patient characteristics and general health status. In addition,

given that the change in drug delivery included the size of insulin vial (from 10 to 3 mL), method of delivery (from vials to pens), and hospital delivery method (from floor stock to IPS), the study design did not allow for identifying the impact of each of these factors individually. As a naturalistic study, the analysis could not control for other differences in insulin delivery when comparing the preconversion and postconversion periods. However, there were no substantial changes in protocols or formulary practices during the study period, though basal-bolus insulin regimens were being prescribed more frequently, as seen by the relative increase in the proportion of rapid- and long-acting basal insulin units purchased. It is also possible that the protocol was not strictly followed and that nurses used insulin from one patient's vial for another patient. Our study also estimated insulin wastage based on volume remaining in vials and therefore may be slightly imprecise. Finally, it should be noted that this study was descriptive in nature and did not formally test whether there was a statistically significant reduction in units purchased or acquisition costs.

Conclusion

Conversion from floor-stock 10-mL insulin vials to IPS 3-mL insulin

Table 2.

Estimated Wastage of Insulin Before Conversion

Insulin Type	No. Vials Removed During 28-Day Collection ^a	Estimated % Vials Wasted ^b	Estimated No. Vials Wasted During Preconversion Period ^c	Mean ± S.D. Volume of Insulin per Wasted Vial (mL)
Rapid-acting analog	35	35.3	477.9	8.5 ± 2.0
Short acting	51	26.1	533.3	9.1 ± 1.4
Intermediate acting	36	57.5	463.5	9.3 ± 1.85
Long-acting analog	29	42.1	387.3	7.5 ± 3.3
Total	151	36.4	1862.0	8.7 ± 2.2

^aVials were removed from patient care units if they were open and past their beyond-use date; they were considered wasted.

^bCalculated by annualizing the number of vials removed during the 28-day collection period (during January and February 2009) and dividing by the total number of vials purchased in 2009.

^cCalculated by multiplying the percentage of vials wasted times the number of vials purchased during the nine-month preconversion period (December 2009 through August 2010).

vials or pens reduced the number of units of insulin purchased and expenditures for insulin. The overall cost savings was driven by the conversion from 10- to 3-mL vials, whereas cost increased for the conversion of 10-mL vials to 3-mL pens for long-acting insulin analogs.

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