Incorrect Insulin Administration: A Problem That Warrants Attention

Paula M. Trief,[1] Donald Cibula,[2] Elaine Rodriguez,[3] Bridget Akel,[3] and Ruth S. Weinstock[3]

IN BRIEF Incorrect administration of insulin (e.g., too little, too much, or at wrong times) can result in transient and serious hypo- and hyperglycemia, wide glycemic excursions, and diabetic ketoacidosis. The authors systematically assessed the insulin-related knowledge and injection skills of a sample of adults with diabetes and found that errors in self-administering insulin, including choosing an incorrect insulin dose, were common. Injection site selection and diabetes numeracy were also concerns. Correct timing of injections and confidence in choosing correct doses, but not skills scores, related to better A1C and blood glucose levels.

Approximately 31% of diabetes patients are treated with insulin (1). Specifically, 15.4% (± 1.4%) use insulin only, and 13.6% (± 11.1%) use insulin plus oral medications (2). Insulin therapy, which is necessary to achieve glycemic control for all individuals with type 1 diabetes and many with type 2 diabetes, is related to two important acute complications: hyperglycemia and hypoglycemia. The cost/benefit considerations of insulin treatment have been examined in older adults, most of whom had type 2 diabetes. The authors reported that better glycemic control led to fewer hospitalizations and deaths due to hyperglycemia (3), but more hospitalizations and emergency room visits related to hypoglycemia (4). In a large sample of adults with type 1 diabetes of >20 years' duration, severe hypoglycemia was common in individuals with both low and high A1C levels, suggesting that having a high A1C does not protect against severe hypoglycemia. Diabetic ketoacidosis (DKA) frequency was highest in those with high A1C levels, and especially those with an A1C >10% (5). Therefore, in addition to A1C testing, self-monitoring of blood glucose that leads to adjustments in insulin administration is required.

Incorrect administration of insulin (e.g., too little, too much, or at the wrong times) can result in both transient and serious hypo- and hyperglycemia, wide glycemic excursions, severe hypoglycemia, and DKA. When glycemic control is poor, patients and providers commonly assume that this is because of poor behavioral adherence (e.g., insulin omission), dietary indiscretions, difficulties using carbohydrate counting (6), or sedentary lifestyle. However, in an analysis of insulin errors that resulted in emergency department visits for hypoglycemia, in addition to "intentional" errors, the authors identified other insulin errors, including "unintentionally took wrong insulin product," "meal-related misadventure," "pump-related misadventure," and "other misadventure" (7). Similarly, in the lay literature, one finds reports of cases in which a provider asked a patient to demonstrate his or her insulin injec-

[1]*Department of Psychiatry and Behavioral Sciences, State University of New York (SUNY) Upstate Medical University, Syracuse, NY*

[2]*Department of Public Health and Preventive Medicine, SUNY Upstate Medical University, Syracuse, NY*

[3]*Department of Medicine, SUNY Upstate Medical University, Syracuse, NY*

Corresponding author: Paula M. Trief, triefp@upstate.edu

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tion technique and thereby identified serious flaws. In one case, a patient was not properly using an insulin pen and so was unaware that, in fact, she was not getting any insulin at all (8). In another case, a patient was using a syringe that was not designed for the delivery of insulin and was therefore not getting enough insulin (9).

The authors are not aware of any studies in which the accuracy of patient self-administration of insulin has been systematically examined. The primary purpose of this study was to evaluate the insulin injection technique of a sample of ambulatory adult patients who regularly use insulin to assess their injection skills and knowledge related to self-administering correct insulin doses. In secondary analyses, the relationship of skill accuracy to glycemic control was assessed.

Methods

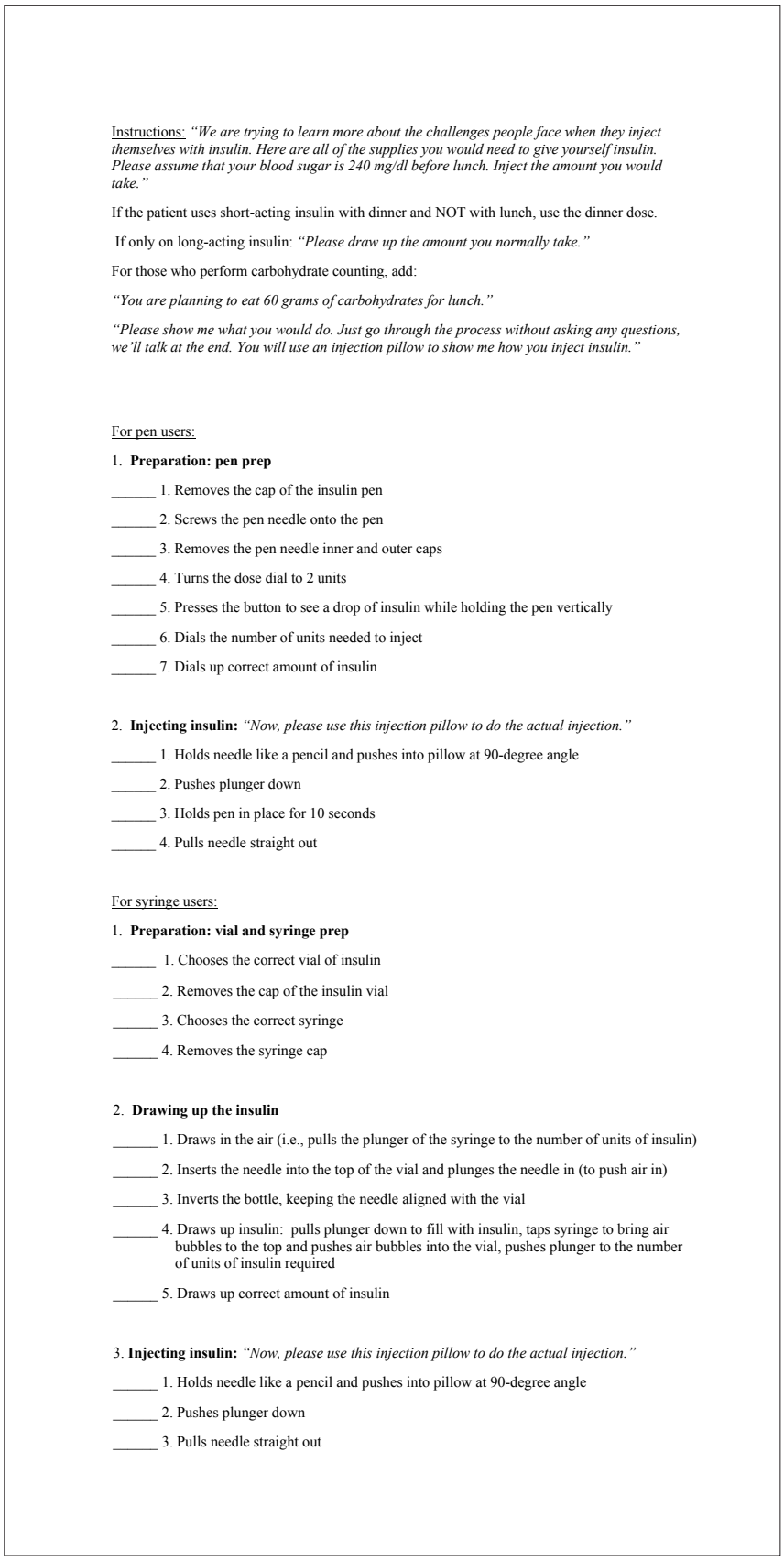
Study Sample and Procedures

Researchers recruited adult patients with diabetes who were ≥21 years of age, had been on insulin therapy for ≥2 years, and were personally responsible for their injections. Potential participants (n = 93) were identified and contacted by phone to assess their interest. There were no significant differences between participants (n = 60) and refusers (n = 33) in terms of age, sex, race/ethnicity, insurance type, A1C, or years on insulin therapy. Participants were told that, "We are trying to learn more about the challenges people face when they inject themselves with insulin," in an effort to minimize any performance anxiety. Sixty patients (44 pen users and 16 syringe users) provided consent (including allowing access to medical records) and participated before or after a clinic visit. They completed two questionnaires (described below). They were then provided with all supplies they would use for their typical insulin injection (i.e., short-acting and/or long-acting insulin and syringes or pens) and asked to demonstrate their technique. They injected insulin into an "injection pillow," commonly used when patients demonstrate technique. A nurse or trained research assistant observed each participant and noted his or her behavior on a Behavioral Insulin Administration Skills (BIAS) scoring rubric (Figure 1). When participants finished their demonstration, the observer provided them with feedback to correct any errors and a gift card.

Measures

Collected data and study measures included:

1. Participants' demographic characteristics: age, sex, race/ethnicity, years of education, household income, diabetes type, years using insulin, insulin regimen (i.e., fixed doses, multiple daily injection based on an insulin algorithm, or insulin-to-carbohydrate ratios.)
2. Participants' insulin-related information, including:
   a. Insulin-related behaviors. Three insulin-related items from the Self-Care Inventory–Revised (10), including how frequently in the past month the individual had taken a correct dose, had taken insulin at the right time, and had adjusted insulin based on glucose level, food intake, and exercise, with possible answers of "always," "usually," "sometimes," "rarely," or "never."
   b. Insulin-related confidence. How confident were individual participants in their ability to choose the correct dose of insulin and to self-inject, with possible answers "very," "moderately," "somewhat," or "not at all" confident.
   c. Diabetes-related numeracy. Diabetes-related numeracy has been shown to relate to glycemic control (11). Three problems from the validated Diabetes Numeracy Test (DNT) (12) were included. One measured numeracy for determining insulin dose based on blood glucose level, one was a simple "sliding scale" (algorithm), and one was a test of numeracy for using an insulin-to-carbohydrate ratio plus a sliding scale (algorithm).
   d. Skin problems or nonrotation of injection site. Participants showed the observing nurse where they inject, and sites were rated as "no problem/appropriate site," "area of lipohypertrophy," or "other problem." Participants were asked if they changed (rotated) their injection site ("always," "sometimes," or "no, inject in same site").
   e. Correct insulin handling. Participants were asked if they ever used insulin that had passed its expiration date ("yes" or "no"), how often they checked the expiration date on the vial or pen, and how long they used a vial or pen after the initial use.
3. BIAS rubric. We developed a scoring rubric for pen and syringe users based on standard injection education (Figure 1). The final rubric was vetted by a group of experienced diabetes educators and endocrinologists to ensure that it measured appropriate and realistic behaviors. Items were marked "1" if performed or "0" if not. We computed a total score for all observations and scores for subsections of "pen or syringe preparation," "pen or syringe injection," and "drawing up of insulin" (syringe users only). We also noted whether they chose the correct doses (units) of insulin.
4. Glycemic control. A1C levels were recorded. Participants were asked how frequently they typically tested their blood glucose each day. Means and standard deviations (SDs) of glucose meter readings for the previous 2 weeks were calculated for 40 participants who brought their meters. Participants were asked how many



Instructions: *"We are trying to learn more about the challenges people face when they inject themselves with insulin. Here are all of the supplies you would need to give yourself insulin. Please assume that your blood sugar is 240 mg/dl before lunch. Inject the amount you would take."*

If the patient uses short-acting insulin with dinner and NOT with lunch, use the dinner dose.

If only on long-acting insulin: *"Please draw up the amount you normally take."*

For those who perform carbohydrate counting, add:

"You are planning to eat 60 grams of carbohydrates for lunch."

"Please show me what you would do. Just go through the process without asking any questions, we'll talk at the end. You will use an injection pillow to show me how you inject insulin."

For pen users:

1. **Preparation: pen prep**

_____ 1. Removes the cap of the insulin pen

_____ 2. Screws the pen needle onto the pen

_____ 3. Removes the pen needle inner and outer caps

_____ 4. Turns the dose dial to 2 units

_____ 5. Presses the button to see a drop of insulin while holding the pen vertically

_____ 6. Dials the number of units needed to inject

_____ 7. Dials up correct amount of insulin

2. **Injecting insulin:** *"Now, please use this injection pillow to do the actual injection."*

_____ 1. Holds needle like a pencil and pushes into pillow at 90-degree angle

_____ 2. Pushes plunger down

_____ 3. Holds pen in place for 10 seconds

_____ 4. Pulls needle straight out

For syringe users:

1. **Preparation: vial and syringe prep**

_____ 1. Chooses the correct vial of insulin

_____ 2. Removes the cap of the insulin vial

_____ 3. Chooses the correct syringe

_____ 4. Removes the syringe cap

2. **Drawing up the insulin**

_____ 1. Draws in the air (i.e., pulls the plunger of the syringe to the number of units of insulin)

_____ 2. Inserts the needle into the top of the vial and plunges the needle in (to push air in)

_____ 3. Inverts the bottle, keeping the needle aligned with the vial

_____ 4. Draws up insulin: pulls plunger down to fill with insulin, taps syringe to bring air bubbles to the top and pushes air bubbles into the vial, pushes plunger to the number of units of insulin required

_____ 5. Draws up correct amount of insulin

3. **Injecting insulin:** *"Now, please use this injection pillow to do the actual injection."*

_____ 1. Holds needle like a pencil and pushes into pillow at 90-degree angle

_____ 2. Pushes plunger down

_____ 3. Pulls needle straight out

FIGURE 1. Behavioral Insulin Administration Skills (BIAS) scoring rubric.

times in the past year they had experienced a severe hypoglycemic event, defined as a time they went to the emergency department or were hospitalized because of low blood glucose.

Analyses

Means, SDs, and simple percentages of scores on all measures were calculated for the groups. Self-reports of insulin-related confidence and behaviors (Table 1) for pen versus syringe users were compared using χ^2 and Fisher's exact tests. Differences in mean A1C scores by subject characteristics were examined using *t* tests for binary variables and omnibus *F* tests and tests for trend for multinomial ordinal variables (data not shown) (Table 2). Linear regression was used to analyze univariate relationships between A1C and continuous variables and to model A1C with multiple covariates. Dichotomized (median split) BIAS scores for pen and syringe users were compared according to subject characteristics using χ^2 and Fisher's exact tests. All significance tests and confidence interval procedures were two-sided, with a priori α =0.05, using IBM SPSS Statistics for Windows, version 22.0 (IBM Corp.; Armonk, N.Y.).

Results

Participants

The majority of participants were female (58.3%) and white (75.9%). The mean age was 57.3 years (± 13.5, range 25–80). Most participants had a high school degree or higher education level (86.7%), low to moderate income (67.3% <$40,000), and type 2 diabetes (78.3%). Participants had been using insulin for a mean of 14.8 years (± 11.4) and were in relatively poor glycemic control, with a mean A1C of 8.7% (± 1.6), and 11.7% reported having at least one severe hypoglycemia episode in the past year. Most (80%) were on multiple daily injection regimens. Mean age, A1C, and number of severe hypoglycemia episodes did not differ between pen

TABLE 1. Participants' Self-Reported Insulin-Related Attitudes and Behaviors

	Total (*n* = 60)	Pen (*n* = 44)	Syringe (*n* = 16)	*P*
Confident in determining correct dose (%)				1.00*
Not at all	0.0	0.0	0.0	
Somewhat	16.7	15.9	18.8	
Moderately	15.0	15.9	12.5	
Very	68.3	68.2	68.8	
Confident in proper injection (%)				1.00*
Not at all	0.0	0.0	0.0	
Somewhat	6.7	6.8	6.3	
Moderately	10.0	11.4	6.3	
Very	83.3	81.8	87.5	
Administers correct insulin dose (%)				0.778
Always	56.7	54.5	62.5	
Usually	30.0	29.5	31.3	
Sometimes or never	13.3	15.9	6.3	
Administers insulin at correct times (%)				0.096
Always	28.3	20.5	50.0	
Usually	50.0	54.5	37.5	
Sometimes or never	21.7	25.0	12.5	
Insulin adjustment required (%)				0.144
Always	21.7	15.9	37.5	
Usually	30.0	29.5	31.3	
Sometimes or never	48.3	54.5	31.3	
Number of hypoglycemic episodes in the past year (%)				0.370
0	88.3	90.9	81.3	
≥1	11.7	9.1	18.8	
Diabetes numeracy: total correct (%)				0.863
0	10.0	9.1	12.5	
1	28.3	27.3	31.3	
2	33.3	36.4	25.0	
3	28.3	27.3	31.3	
Skin problems at injection site (%)				0.060
None	61.7	54.5	81.3	
Lipohypertrophy and other problems	38.3	45.5	18.7	
Rotates injection sites (%)				0.738
Always	74.6	72.7	80.0	
Not always	25.4	27.3	20.0	
Checks expiration date (%)				0.951
Always	43.1	42.9	43.8	
Not always	56.9	57.1	56.3	

TABLE CONTINUED ON P. 29 →

TABLE 1. Participants' Self-Reported Insulin-Related Attitudes and Behaviors
continued from p. 28

	Total (*n* = 60)	Pen (*n* = 44)	Syringe (*n* = 16)	*P*
Uses expired insulin (%)				0.885
No	86.4	86.0	87.5	
Yes	13.6	14.0	12.5	
Correct knowledge of insulin duration (%)				0.018
No	16.9	9.3	37.5	
Yes	83.1	90.7	62.5	
Brought glucose meter (%)				0.760
Yes	66.7	68.2	62.5	

**Fisher's exact test; other* P *values reflect* χ^2 *analyses.*

TABLE 2. Mean A1C (%) by Participant Characteristics

Participant Characteristics	Mean (SD)	*n*	*P*
Sex			0.745
Male	8.6 (1.8)	24	
Female	8.7 (1.5)	35	
Race			0.016
African American or Hispanic	9.5 (1.7)	14	
White	8.3 (1.5)	43	
Education			0.004*
Some high school	9.5 (1.5)	8	
High school degree or some college	9.0 (1.7)	31	
Associate's degree or higher	7.8 (1.3)	20	
Annual household income (USD)			0.568
<20,000	9.1 (1.7)	19	
20,000–39,999	8.4 (1.7)	17	
40,000–79,999	8.9 (1.7)	9	
≥80,000	8.3 (1.5)	9	
Medical insurance			0.005*
Medicaid or none	9.7 (1.7)	7	
Medicare	8.7 (1.7)	26	
Private or Workers' Compensation	8.2 (1.4)	26	
Injection method			0.736
Pen	8.6 (1.6)	44	
Syringe	8.8 (1.7)	15	
Diabetes type			0.034
Type 1	8.0 (1.0)	13	
Type 2	8.9 (1.8)	46	

TABLE CONTINUED ON P. 30 →

TABLE 2. Mean A1C (%) by Participant Characteristics
continued from p. 29

Participant Characteristics	Mean (SD)	*n*	*P*
Insulin regimen			0.567
Fixed dose	9.2 (1.0)	7	
Multiple injections with algorithm	8.7 (1.8)	48	
Insulin-to-carbohydrate ratio	8.1 (0.9)	4	
Confident in determining correct dose			0.005*
Not at all	—	0	
Somewhat	9.6 (0.9)	10	
Moderately	9.7 (2.4)	9	
Very	8.2 (1.4)	40	
Confident in proper injection			0.115*
Not at all	—	0	
Somewhat	9.8 (0.5)	4	
Moderately	9.1 (2.2)	6	
Very	8.5 (1.6)	49	
Administers correct insulin dose			0.334*
Always	8.5 (1.8)	33	
Usually	8.9 (1.6)	18	
Sometimes or never	9.0 (1.2)	8	
Administers insulin at correct times			0.007*
Always	8.0 (1.2)	17	
Usually	8.7 (1.7)	29	
Sometimes or never	9.6 (1.8)	13	
Insulin adjustment required			0.296
Always	9.2 (2.1)	13	
Usually	8.3 (1.5)	18	
Sometimes or never	8.7 (1.5)	28	
Number of hypoglycemic episodes in the past year			0.712
0	8.7 (1.7)	52	
≥1	8.9 (1.0)	7	
Diabetes numeracy: total correct			0.116*
0–1	9.1 (1.8)	23	
2	8.5 (1.7)	20	
3	8.3 (1.2)	16	
Skin problems at injection site			0.208
None	8.5 (1.5)	36	
Lipohypertrophy and other problems	9.0 (23)	23	
Rotates injection sites			0.359
Always	8.6 (1.7)	43	
Not always	9.0 (1.5)	15	

**P values associated with test for linear trend.*

and syringe users, nor did they differ on any other characteristics.

Participants were quite confident in their ability to properly inject insulin, with 93.3% responding that they were "moderately" or "very" confident, but they were somewhat less confident in their ability to choose the correct dose, with 83.3% responding that they were "moderately" or "very" confident (Table 1).

BIAS Rubric

Overall, 81.9% (± 10.8%) of the total observations were recorded as correct. Syringe users had fewer errors than pen users. Thus, the mean (SD) total BIAS score for syringe users was 89.1% (± 9.0%) compared to 80.8% (± 10.4%) for pen users (t[58] = 2.82, P = 0.007). Because the skills needed differ somewhat between the groups (i.e., syringe users draw up insulin, whereas pen users prime the pen), we stratified subsequent analyses by mode of insulin delivery.

Preparation. Participants correctly performed preparatory steps for insulin injection in 82.9% (± 15.3%) of observations. Pen users, who correctly performed 76.6% (± 13.1%) of preparatory observations, performed significantly worse than syringe users, who were 100% accurate (t[58] = 7.10, P <0.001). The most frequent preparatory steps omitted by pen users related to priming and included "presses button to see drop of insulin while holding pen vertically" (15.9% correct) and "turns the dose dial to 2 units" (40.9% correct).

Drawing up insulin. Pen users dialed the correct number of insulin units in 78.5% of observations, whereas syringe users were correct in 83.8% of observations. Thus, ~20% of these insulin users did not self-administer the correct dose. Observed omissions included "draws in the air" (62.5% correct) and "inserts needle into vial and plunges the needle in to push air in" (75% correct).

Injection. Participants correctly performed steps for injecting insulin in 87.9% (± 13.4%) of observations. For pen users, the mean correct injection score was 88.1% (± 13.7%). The most frequently observed omission was "holds pen in place for 10 seconds" (61.4% correct). For syringe users, the mean correct injection score was 87.5% (± 12.9%).

Poor Performers

We examined the characteristics that discriminated between those who scored above versus below the median overall scores. For pen users, two factors associated with scores below the median (median = 76.9%) were being on Medicaid or having no insurance, and having type 1 diabetes (100% of type 1 diabetes patients scored below the median compared to 58.3% of those with type 2 diabetes). For syringe users, the median score was 88.5%, and no patient characteristics discriminated between those scoring above or below the median.

Skin Problems or Nonrotation of Injection Site

Overall, 25.4% of participants reported that they did not always rotate their injection site. Also, 38.3% of participants had lipohypertrophy or other skin problems at their usual injection site. These problems were higher among pen users than syringe users (45.5 vs. 18.8%, P = 0.060). There was a trend for type 2 diabetes patients to have more injection site problems than those with type 1 diabetes (44.7 vs. 15.4%, P = 0.105).

Diabetes Numeracy

Only 28.3% of participants answered all three problems correctly, 33.3% had two correct answers, 28.3% had one correct answer, and 10% had no correct answers, with no significant difference between pen and syringe users. The DNT problem that assessed numeracy concerning insulin-to-carbohydrate ratios might not have been relevant to the majority of participants, who were prescribed insulin algorithms and were not using this skill. Only 6.7% of participants were using insulin-to-carbohydrate ratios to determine insulin doses, possibly because providers were concerned about poor numeracy skills.

Insulin-Related Behaviors

Overall, 56.9% of participants reported that they did not always check the expiration date on their vial or pen, and 13.6% reported that they sometimes used expired insulin. Although only 9% of pen users gave an incorrect answer when asked about insulin duration (i.e., how long they used a pen once it had been opened), 37.5% of syringe users gave incorrect answers (P = 0.018). When asked about their actual behavior in the past 1–2 months, 13.3% reported that they "sometimes" or "never" took the correct dose, 21.7% that they "sometimes" or "never" took insulin at correct times, and 48.3% that they "sometimes" or "never" adjusted insulin doses based on blood glucose values, food, or exercise, although 86.7% of participants were on regimens that would require insulin adjustment. There were no differences in these reported behaviors between pen and syringe users.

Relationship of Participant Characteristics and Skills to Glycemic Control

Four patient characteristics were significantly related to A1C (Table 2). These included education level (those with less education had higher A1C levels), race (African Americans and Hispanics had higher A1C levels than whites), insurance (those with Medicaid or no insurance had higher A1C levels than those with private insurance), and diabetes type (those with type 2 diabetes had higher A1C levels than those with type 1 diabetes). In addition, participants who reported that they sometimes or never administered insulin at correct times (P = 0.007) and those who reported having little confidence in their ability to determine correct doses (P = 0.005) had significantly higher A1C levels. There was a trend for those with the poorest diabetes numeracy to have higher A1C levels (P = 0.116). BIAS scores were not associated with A1C level.

Two participant characteristics were significantly related to mean blood glucose level. These included education level (those with less education had higher mean glucose levels [254.8 ± 87.9 vs. 167.5 ± 30.1 mg/dL]) and race (African Americans and Hispanics had higher mean blood glucose levels than whites [222.6 ± 63.6 vs. 179.9 ± 49.4 mg/dL). Participants who reported that they had little confidence in their ability to determine correct insulin doses (P <0.001), who reported less often administering insulin at correct times (P = 0.010), and who reported sometimes or never rotating injection sites (P = 0.006) had higher mean blood glucose levels. BIAS scores were not associated with mean blood glucose levels.

Severe Hypoglycemia

Approximately 11.7% of participants reported that they had experienced at least one severe hypoglycemic event in the past year. They were more likely to be African American or Hispanic (trend P = 0.051), to be poor (trend P = 0.060), to sometimes use expired insulin (P = 0.028), and to have poorer diabetes numeracy (P = 0.019).

Discussion

In this observational study of ambulatory, insulin-using adults with diabetes, we were dismayed by the high percentage of participants who demonstrated problems with site selection and rotation and reported using expired insulin, not taking recommended insulin doses, and not taking insulin at correct times—all behaviors that would likely affect glycemia. Also, a relatively low level of diabetes numeracy was found that could possibly contribute to errors.

There was also a high prevalence of errors related to insulin self-administration. In this small sample, a significant percentage omitted or improperly completed important steps, including making mistakes in preparing for injection, drawing up insulin (syringe users), priming (pen users), preparing correct doses, and injecting insulin. Pen users were particularly vulnerable to omissions. Each of these steps is considered to be important for the delivery of prescribed insulin doses to establish good glycemic control and avoid hypoglycemia. The fact that ~20% of participants did not administer the correct dose of insulin is particularly concerning. Glycemic control was poorer in those who lacked confidence in their ability to choose correct doses and who reported less often administering insulin at the correct times. It was also poorer in minority patients and in those with less education.

We did not find any relationship between observed insulin administration skills and glycemic control. This may be related to the small sample size and overall poor glycemic control. Also, we used a scoring system developed for the study that has not been validated and does not reflect the fact that different insulin self-administration steps are more dangerous or important than others. For example, a few "minor" errors may have less of an effect on glycemia than one "major" error.

Previous work that has examined insulin administration has focused on patients who intentionally omit insulin. For example, Peyrot et al. (13) reported that >50% of respondents to an Internet survey reported intentionally omitting insulin, and 20% reported doing so regularly. These authors identified several correlates of intentional omission, which led to an editorial calling for efforts to better understand patients' attitudes and beliefs that create psychological resistance to use of insulin (14). Focusing on compliance leads to recommendations to patients to adhere more closely to their prescribed self-care regimen and to providers to increase the dosage or frequency of insulin prescribed (15).

Our data suggest that significant proportions of patients may make errors in insulin use and administration that may affect glycemia. These errors do not relate to compliance, and they are not remedied by increasing the dosage or frequency of prescribed insulin. Patients in this study had had diabetes for a mean of 15 years, had suboptimal glycemic control, and experienced episodes of severe hypoglycemia. Most of them had at least a high school education, and they attended a multidisciplinary diabetes clinic at which diabetes education is available. Yet, the vast majority of them believed that they were taking their insulin correctly, whereas the evidence presented here suggests otherwise. We believe these data reinforce the need not only to ask patients what they are doing related to insulin delivery, but also to ask them to demonstrate their techniques and knowledge. Providers must reassess frequently (i.e., have patients perform "show and tell"), especially when patients are experiencing hypoglycemia, wide glycemic excursions, or otherwise poor glycemic control.

Strengths of the study include direct observations of insulin self-administration technique and availability of A1C and blood glucose data from meter downloads. One limitation is the small sample size. We hypothesize that, with a larger sample size, insulin self-administration errors would correlate with A1C and frequency of hypoglycemia, but this will require further study. Also, approximately one-third of the patients did not bring their glucose meters to the visits. These patients were more likely to have a low income. Whether they forgot their meters or were not monitoring their blood glucose levels because of cost or other issues is not known. Finally, in future work, it will be important to assess two other factors that may relate to insulin use behaviors that we did not measure: *1*) previous diabetes education and *2*) patient perceptions of how often they "should" (or remember that they have been instructed to) test their blood glucose compared to provider-

recommended frequency of glucose monitoring.

In conclusion, our finding that errors in self-administration of insulin are common in ambulatory adults with diabetes is of concern. These results strongly suggest that more attention to periodically reviewing and re-educating patients concerning proper insulin self-administration should be considered, and this may be particularly important for those with lower income and education levels. Future work should focus on improving our methods and the frequency of patient education to reduce errors, which, hopefully, will decrease episodes of both hyperglycemia and hypoglycemia.

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Duality of Interest

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