Insulin-Related Knowledge Among Health Care Professionals in Internal Medicine

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Abstract

Background. Inpatient diabetes treatment has become more complicated recently with the introduction of new insulin formulations and a new emphasis on tight blood glucose control. Insufficient knowledge of insulin contributes to errors in its use that may cause adverse patient outcomes.

Methods. Seventy-three faculty members, 113 residents, and 191 nurses from four hospitals completed a 20-item multiple-choice questionnaire that assessed knowledge of insulin nomenclature and characteristics and inpatient insulin use.

Results. The percentage of knowledge-based questions answered correctly was low: 51% for faculty, 59% for house staff, and 47% for nurses. Scores on questions testing knowledge of insulin nomenclature and characteristics were similar to scores on those addressing inpatient insulin use among faculty and house staff; however, nurses scored better on the former than the latter (60 vs. 34%, $P < 0.0001$). Knowledge of names and characteristics of newer insulins, such as glargine, aspart, and lispro, was poor compared to knowledge of older insulin formulations among all professional categories (46 vs. 78%, $P < 0.0001$). House staff performed better than faculty (62 vs. 49%, $P = 0.09$) and nurses (62 vs. 34%, $P < 0.0001$) on questions regarding inpatient diabetes management, but all groups frequently missed questions involving sliding-scale insulin use and dosing insulin in patients with type 1 diabetes.

Conclusion. Educational programs teaching insulin characteristics and inpatient diabetes management are needed for all categories of health care providers. Increased knowledge may help to improve patient safety in the hospital.

Insulin is one of the most commonly prescribed medications in the hospital; it can also be one of the most harmful medications if used inappropriately. The Joint Commission on Accreditation of Healthcare Organizations identified insulin as one of five "high alert" medications that have the greatest risk of causing injury to patients because of medication errors.[1] In addition to factors such as miscommunication among the health care team members, mistakes in dispensing, and failure of safety systems, insufficient knowledge of insulin and diabetes management on the part of health care providers contributes to errors in insulin management. Consequently, dangerous but preventable hyperglycemia and hypoglycemia sometimes result.[2]

Insulin treatment has become more complex in the past few years with the introduction of several new insulin analogs that allow for more physiological insulin replacement.[3] Over a very short time period, the number of insulin types commonly used by physicians and nurses has doubled, increasing the likelihood of medication errors. Old and new insulins with similar generic or trade names, such as "lente" and "Lantus" (glargine), have been confused.[4] Unfamiliarity with the rapid onset times of aspart and lispro, and failure to coordinate administration

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of these insulins with meals, is a frequent cause of hypoglycemia in the hospital.[5]

Studies in Europe and South Asia surveying physicians' diabetes knowledge have shown significant deficiencies[6,7], but only one focused on insulin knowledge,[8] and none have examined inpatient diabetes management. Two studies have demonstrated a need for improvement in general diabetes knowledge among nurses in community hospitals.[9,10] To date, we are unaware of any published evaluation of U.S. practitioners' knowledge of insulin use that includes the new formulations. Attention to evaluating house staff's knowledge is particularly important because a significant proportion of in-hospital insulin orders are written by residents. However, resident care of diabetes has only been studied in the ambulatory setting.[11]

In this study, internal medicine faculty members, house staff, and nurses from four teaching hospitals in the Baltimore, Md., area participated in an anonymous survey that included questions pertaining to insulin nomenclature, duration of action, solution characteristics, dosing, and use in the hospital setting. The goal was to identify topics for educational programs in the area of diabetes management, with the ultimate goal of improving the quality of care for hospitalized patients with diabetes.

Methods

A questionnaire (Figure 1) based on the recent literature and updated American Diabetes Association (ADA) guidelines was prepared. It consisted of 20 multiple-choice questions with a single best answer. Questions addressed topics including insulin nomenclature, duration of action and other characteristics of specific insulin types, insulin dosing in type 1 diabetes, and insulin use during hospitalizations. In addition, participants were asked for information about their postgraduate year of training, self-described comfort level for managing patients with diabetes, and how they usually learn about new medications.

The questionnaire was previewed by several Endocrinology Depart-

ment faculty and fellows with expertise in diabetes and survey design to review the content and confirm that each question had a single best answer. The questionnaire was also reviewed by an expert in quality care management. Pilot tests were then given to 15 internal medicine residents and medical students participating in an endocrine elective and to fellows in other internal medicine specialties. Questions that appeared to be ambiguous during pilot testing were either corrected or removed from the final version of the questionnaire.

The survey was distributed to internal medicine house staff at four hospitals in the Baltimore area, including two tertiary care academic centers and two community teaching hospitals. Nurses and faculty members were surveyed at three of the hospitals: two tertiary care academic centers and one community hospital. An early attempt was made to distribute surveys at a large group meeting (Department of Medicine Grand Rounds), but because of a low recovery rate, future surveys were given out only at small group meetings. For the nurses, these meetings were routine staff meetings often held at change of shift, either in the morning or early evening. For house staff, these meetings were held either during morning report or during noon lectures. For the faculty, surveys were distributed either during Department of Medicine faculty meetings or during divisional staff meetings. The surveys were conducted at more than one meeting for most groups; this was an attempt to sample as many individuals as possible. Before each testing period, attendees were requested not to complete a questionnaire if they had already completed one.

At least one of the study investigators was present during the administration of the questionnaire and collected the forms after completion. Participation was voluntary, and responses were anonymous. Participants were given ~ 10 minutes to complete the questionnaire and were not permitted to ask questions, share answers, or refer to reference materials. The study procedures and

the questionnaire were approved by the Johns Hopkins Institutional Review Board.

A total of 405 questionnaires were distributed; 26 were not returned. Surveys returned entirely blank were counted as nonresponders and were not used in the analysis (*n* = 2). Because the target population was health care providers who are actively involved in the medical care of patients with diabetes, very few respondents were identified as medical students, nursing students, nurse practitioners, or fellows (*n* = 4; 1 medical student, 1 nursing student, 1 nurse practitioner, and 1 fellow); therefore, this subset was not included in the final analysis. Electronic scanning was used to score the questionnaires. Knowledge-based questions left unanswered on partially completed surveys were considered incorrect. If the scanner was unable to determine the intended answer to a question (because of an answer being crossed out), a data analyst who was not a study investigator and who was blinded to the correct answers, visually inspected the answer form to determine the participant's choice. Statistical analyses were performed using SAS software (Raleigh, N.C.). The mean percentage of questions answered correctly was calculated to estimate scores for groups according to professional category and comfort level. Comparison of scores between groups was performed using the Pearson χ^2 test. Statistical significance was considered to correspond to a *P* value ≤ 0.05.

Results
Study population
A total of 377 completed questionnaires were received and analyzed— 73 from faculty, 113 from residents, and 191 from nurses. The recovery rate of completed or partially completed surveys was 94% for both faculty and house staff and 92% for nurses. All of the residents, 99% of the nurses, 88% of the general medicine faculty, and 75% of the specialty faculty reported active involvement in the medical management or care of patients with diabetes. The responses to the questionnaire were similar across

Shade circles like this: ●
Not like this: ⊗ ⊘

Department of Medicine Insulin Use Knowledge Assessment

We are conducting a survey to gain an understanding of the current level of knowledge of insulin properties and administration among the medical and nursing staff. Please complete below and select one best answer for each question.

1. Please indicate your professional category:

○ General medicine faculty   ○ Medical student
○ Subspecialty faculty   ○ Nurse (0-5 yrs post-graduate)
○ Fellow   ○ Nurse (6-10 yrs post-graduate)
○ PGY3 resident   ○ Nurse (>10 yrs post-graduate)
○ PGY2 resident   ○ Nurse practitioner
○ PGY1 resident   ○ Nursing student
○ Sub-intern

2. Are you actively involved in the medical management or care of patients with diabetes mellitus (whether Type 1 or Type 2)?

○ Yes
○ No

3. How comfortable do you feel medically managing patients with diabetes?

○ Very comfortable   ○ Somewhat uncomfortable
○ Somewhat comfortable   ○ Very uncomfortable

4. I usually learn about new medications through (choose all that apply):

○ Educational presentations
○ Journal articles
○ Medical textbooks or databases
○ Colleagues
○ Pharmaceutical representatives or advertisements

5. Humulin is:

○ Rapid-acting insulin   ○ Long-acting insulin
○ Intermediate-acting insulin   ○ An insulin brand name

6. 75/25 is:

○ 75% NPH, 25% lente   ○ 75% protamine, 25% regular
○ 75% protamine, 25% glargine   ○ 75% protamine, 25% lispro

7. 70/30 is:

○ 70% NPH, 30% regular   ○ 70% protamine, 30% lispro
○ 70% NPH, 30% glargine   ○ 70% glargine, 30% aspart

8. Glargine is:

○ NPH   ○ Basal insulin
○ Humalog   ○ Rapid acting insulin

9. In general, a rapid acting insulin:

○ Peaks within 6 to 8 hours   ○ Peaks within 1 hour
○ Peaks within 2 to 4 hours   ○ Has no peak

10. In general, NPH insulin:

○ Peaks within 4 to 10 hours   ○ Peaks within 2 to 4 hours
○ Peaks within 12 to 24 hours   ○ Has no peak

11. Which of the following cannot be physically mixed in the same syringe with other types of insulin?

○ Glargine   ○ Regular
○ NPH   ○ Aspart

12. Which of the following is a cloudy, rather than clear, solution?

○ Glargine   ○ Regular
○ NPH   ○ Aspart

13. Commercially available insulin pumps:

○ Need to be surgically inserted   ○ Use rapid acting insulin
○ Use NPH insulin   ○ Provide basal insulin only

14. The American Diabetes Association definition of hypoglycemia is a blood level less than:

○ 50 mg/dl   ○ 80 mg/dl
○ 70 mg/dl   ○ 100 mg/dl

15. In order to avoid complications, when a Type I patient is NPO:

○ Discontinue all insulin   ○ Continue only sliding scale insulin
○ Continue basal insulin   ○ Continue only rapid-acting insulin

16. Sliding scale insulin is best used:

○ a. To meet basal insulin requirements
○ b. To cover carbohydrates eaten in meals
○ c. As a supplement to scheduled insulin to correct hyperglycemia
○ d. As a guide for making changes to scheduled insulin doses
○ a & b
○ b & c
○ c & d
○ All the above

17. A typical daily insulin requirement for an adult with type 1 diabetes:

○ 0.2-0.4 units/kg   ○ 0.8-1.0 units/kg
○ 0.5-0.7 units/kg   ○ 1.2-1.4 units/kg

18. What percentage of the daily insulin requirement does basal insulin generally account for?

○ 10-20   ○ 40-50
○ 20-30   ○ 60-70

19. Diabetic ketoacidosis (DKA) can develop in:

○ Type 1 diabetics only   ○ Both Type 1 and 2
○ Type 2 diabetics only   ○ None of the above

20. In DKA, when converting from a continuous insulin infusion to subcutaneous insulin, start subcutaneous insulin approximately:

○ 2 hours before stopping the infusion
○ At the same time as stopping the infusion
○ 1 hour after stopping the infusion
○ 4 hours after stopping the infusion
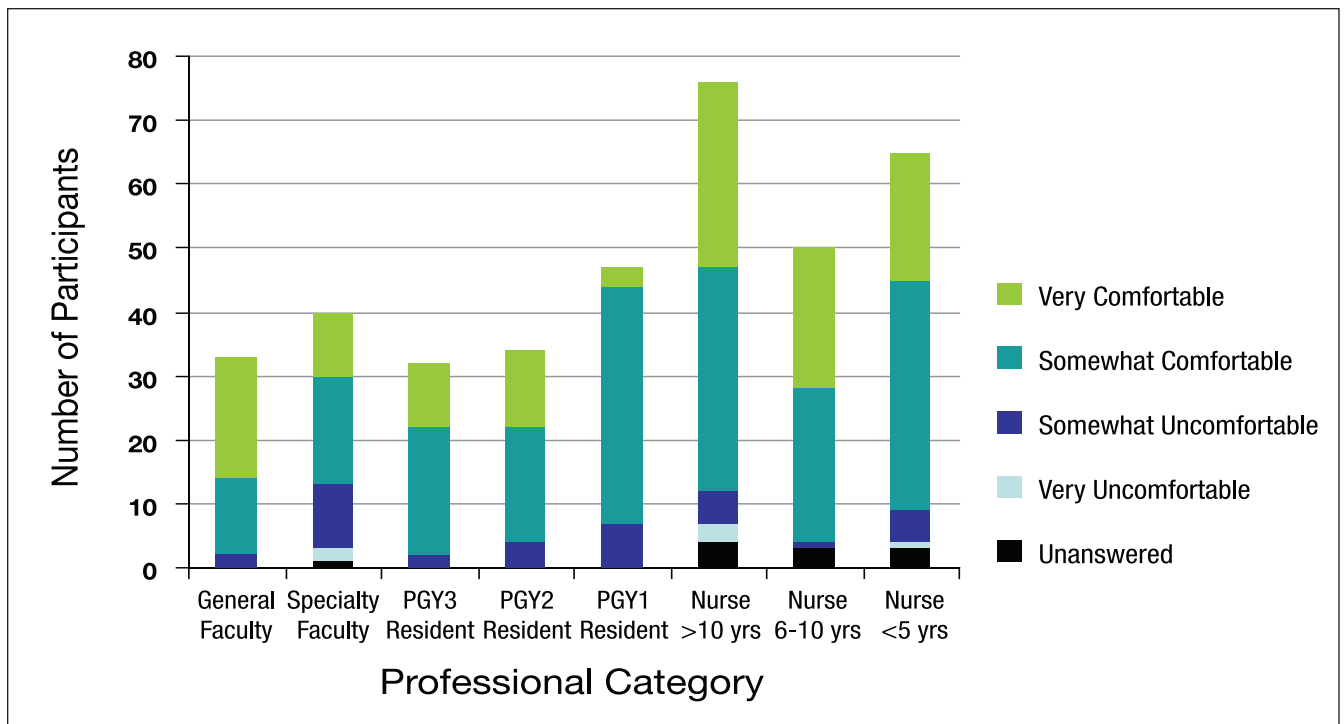
Figure 1. The questionnaire.

Figure 2. Self-reported comfort level for managing diabetes by professional category.

the four different hospital settings; therefore, we have pooled these results. Specialty faculty that participated included physicians from the following disciplines: cardiology, geriatric medicine, gastroenterology, pulmonary, and nephrology.

Participants reported learning about new medications from multiple sources, including educational presentations (66%), colleagues (55%), journal articles (49%), computer databases or textbooks (44%), and pharmaceutical representatives or advertisements (26%). The house staff reported learning about new medications via educational presenta-

tions (76%), journal articles (64%), medical textbooks (62%), colleagues (60%), and pharmaceutical representatives (36%), which was similar to the learning profile of faculty members: educational presentations (72%), journal articles (78%), medical textbooks (63%), colleagues (67%), and pharmaceutical representatives (14%). Nurses reported learning about new medications via educational presentations (57%), journal articles (33%), medical textbooks (41%), colleagues (44%), and pharmaceutical representatives (32%). The totals exceed 100% because respondents selected multiple

sources of learning (data not shown).

Figure 2 illustrates the self-reported comfort level for managing diabetes by professional category. The majority of general medicine faculty felt very comfortable managing diabetes; the majority of other categories described themselves as somewhat comfortable. Scores on questions related to insulin names and characteristics, those on questions addressing inpatient insulin use, and overall scores were higher for participants who reported being more comfortable managing diabetes, but the variation in scores across comfort-level groups was minimal (Table 1).

Table 1. Overall Scores According to Self-Described Comfort Level Managing Diabetes				
Self-Described Comfort Level Managing Diabetes	**Number of Participants***	**Mean Percentage Correct**		
		Insulin Names and Characteristics	**Inpatient Insulin Use**	**Overall**
Very comfortable	125	63	48	55
Somewhat comfortable	199	55	46	51
Somewhat or very uncomfortable	42	54	42	48
*Comfort level was missing for 11 respondents.				

Overall scores according to professional category

For the 16 knowledge-based questions, the overall percentage answered correctly was ~ 51% for faculty, 59% for house staff, and 47% for nurses (Table 2). Faculty members and house staff scored similarly on the eight questions addressing insulin characteristics and on the eight questions addressing inpatient insulin use; however, nurses scored significantly better on the former (60 vs. 34%, $P < 0.0001$).

Overall scores for the General internal medicine faculty were slightly higher than for the specialty faculty (55 vs. 49%); the discrepancy was largely attributable to knowledge of insulin characteristics (58 vs. 50%). House staff scored eight percentage points better than faculty overall (59 vs. 51%), a difference mostly resulting from better scores on questions regarding inpatient insulin use (62 vs. 49%). Residents in their second and third years of training performed better than interns on questions testing insulin characteristics (63 vs. 48%), although this difference was not statistically significant. Nurses scored slightly better than physicians on insulin characteristics questions (60 vs. 55%), but significantly worse on questions testing knowledge of inpatient insulin use (34 vs. 57%, $P < 0.0001$). There was no notable difference in scores among nurses according to number of years since training.

Insulin nomenclature and characteristics

Questions testing knowledge of insulin nomenclature and characteristics

Table 2. Overall Scores According to Professional Category

Professional Category	Number of Participants	Mean Percentage Correct		
		Insulin Names and Characteristics	Inpatient Insulin Use	Overall
Faculty	73	54	49†	51
General medicine	33	58	51	55
Specialty	40	50	48	49
House staff (residents)	113	57	62†	59‡
PGY3	32	65	65	65
PGY2	34	60	64	62
PGY1	47	48	59	54
Nurses	191	60*	34*†	47‡
> 10 years	76	59*	32*	46
6–10 years	50	58*	36*	47
< 5 years	65	61*	35*	48
Total	377	58*	45*	52

P < 0.001 for the comparison among nurses between scores on insulin names and characteristics versus inpatient insulin use.
† P < 0.0001 for the comparison of inpatient insulin use scores for house staff versus nurses; P = 0.02 for the comparison of inpatient insulin use scores for faculty versus nurses.
‡ P = 0.03 for the comparison of overall scores for house staff versus nurses.
PGY, postgraduate year

Table 3. Percentage Correct on Questions Concerning Insulin Nomenclature and Characteristics

	General Faculty (*n* = 33)	Specialty Faculty (*n* = 40)	Res. PGY3 (*n* = 32)	Res. PGY2 (*n* = 34)	Res. PGY1 (*n* = 47)	Nurse > 10 Years (*n* = 76)	Nurse 6–10 Years (*n* = 50)	Nurse < 5 Years (*n* = 65)	Total (*n* = 377)
Humulin is: *An insulin brand name*	36	65	44	29	21	56	38	49	44
75/25 is: *75% protamine/ 25% lispro*	12	3	22	21	17	12	18	17	15
70/30 is: *70% NPH/ 30% regular*	94	95	94	94	89	90	88	88	91
Glargine is: *Basal insulin*	52	40	97	88	66	34	32	43	52
In general, a rapid-acting insulin: *Peaks within 1 hour*	70	53	50	74	49	50	52	54	55
In general, NPH insulin: *Peaks within 4–10 hours*	76	73	81	82	64	75	72	79	75
Which cannot be mixed with other insulin? *Glargine*	70	48	88	62	49	61	68	62	62
Which is a cloudy, rather than clear, solution? *NPH*	55	25	44	32	30	97	98	99	67
Overall % correct	58	50	65	60	48	59	58	61	58

were answered correctly 54, 57, and 60% of the time by faculty, house staff, and nurses, respectively. Table 3 reports responses to individual questions in this category. Questions about newer insulin formulations (Questions 6, 8, 9, 11) were more frequently answered incorrectly than questions about older insulin formulations (Questions 7, 10, 12) (46 vs. 78%, *P* < 0.0001). Nurses and physicians were equally familiar with the restriction on mixing glargine with other insulins (62 vs. 61%); however, nurses were more familiar with NPH insulin being cloudy rather than clear (98 vs. 34%, *P* < 0.0001). The correct response that Humulin is an insulin brand name was identified only 44% of the time; many respondents identified it as a rapid-acting insulin, probably as a result of confusing

"Humulin" with "Humalog," the brand name of lispro.

Use of insulin and inpatient diabetes management
Table 4 presents the proportions answered correctly for individual questions testing knowledge of inpatient insulin use. Approximately 75% of house staff and general faculty correctly chose to continue basal insulin in a patient with type 1 diabetes who was not eating, but only 18% of nurses correctly answered this question. Only one-third of participants recognized the correct goals of sliding-scale insulin (to supplement scheduled insulin to correct hyperglycemia and to guide changes in scheduled insulin doses); a greater number incorrectly viewed it as an appropriate way to deliver insulin to cover carbohydrates

eaten. The typical amount of insulin required by a patient with type 1 diabetes (0.5–0.7 units/kg/day) and the percentage of the daily insulin requirement that represents the basal component (40–50%) were answered correctly by only ~ 33% of the faculty and nurses and ~ 60% of the house staff. The majority of participants recognized that diabetic ketoacidosis (DKA) can develop in patients with type 2 diabetes as well as type 1 diabetes, whereas the majority of house staff and general faculty, but not specialty faculty and nurses, correctly answered that subcutaneous insulin should be started 2 hours before stopping the insulin infusion in DKA.

Discussion
Inpatient diabetes management has drawn much attention during

Table 4. Percentage Correct on Questions Concerning Insulin Use

	General Faculty (*n* = 33)	Specialty Faculty (*n* = 40)	Res. PGY3 (*n* = 32)	Res. PGY2 (*n* = 34)	Res. PGY1 (*n* = 47)	Nurse > 10 Years (*n* = 76)	Nurse 6–10 Years (*n* = 50)	Nurse < 5 Years (*n* = 65)	Total (*n* = 377)
Commercially available insulin pumps: *Use rapid-acting insulin*	52	60	63	56	43	43	48	32	47
The ADA definition of hypoglycemia is a blood glucose less than: *70 mg/dl*	42	48	41	44	45	34	40	45	42
To avoid complications, when a type 1 patient is NPO: *Continue basal insulin*	70	48	81	74	77	12	22	23	44
Sliding-scale insulin is best used: *As a supplement to scheduled insulin to correct hyperglycemia* and *As a guide for making changes to scheduled insulin doses*	24	38	53	38	34	16	12	12	25
A typical daily insulin requirement for an adult with type 1 diabetes is: *0.5–0.7 units/kg*	30	30	50	71	55	24	26	34	37
What percentage of the daily insulin requirement does basal insulin generally account for? *40–50%*	36	30	47	59	60	16	14	26	33
Diabetic ketoacidosis (DKA) can develop in: *Both type 1 and 2 diabetes*	91	80	97	88	72	71	72	75	79
When converting from a continuous insulin infusion to subcutaneous insulin in DKA, start subcutaneous insulin approximately: *2 hours before stopping the infusion*	64	48	91	79	89	37	52	32	57
Overall % correct	51	48	65	64	59	32	36	35	45

the past few years. In 2004, the American Academy of Endocrinology convened an expert panel to review and propose standards for in-hospital diabetes management.[12] This position statement was co-sponsored by the ADA, the American Heart Association, and other prominent health care groups.[12] What has not been well appreciated is health care providers' lack of knowledge about various insulin preparations and their appropriate uses, an important obstacle to the successful implementation of the recommendations. Using a 20-item, multiple-choice, single best answer questionnaire, this study provides an assessment of knowledge of new insulin formulations and inpatient diabetes management among faculty, house staff, and nurses.

Although 100% of the house staff and nurses and 80% of the faculty were actively involved in managing patients with diabetes, the minority felt very comfortable managing diabetes. The overall percentage of questions answered correctly was low: 51% for faculty, 59% for house staff, and 47% for nurses. Because house staff generally have greater exposure than faculty to educational conferences taught by endocrinologists, it is not surprising that their scores were slightly higher. Nurses scored significantly lower than physicians on questions related to insulin use (dosing and infusions). On the other hand, nurses more frequently had a better understanding of insulin nomenclature and its characteristics. These differences likely reflect the nature of the role each type of provider has in the management of hospitalized patients with diabetes.

Consistent with previous studies pointing to the misuse of sliding-scale insulin in the hospital,[13] one of the questions with the lowest correct response rate pertained to the use of sliding-scale insulin. In our study, the majority of participants answered that the sliding scale can be used to meet basal or mealtime insulin requirements, an approach that frequently leads to postprandial hyperglycemia and hypoglycemia.[13] Although the sliding scale is deeply ingrained in inpatient care, Baldwin

et al.[14] recently reported success in their effort to re-educate internal medicine residents about how to manage diabetes without the sliding scale. Through a program of direct ward teaching and pocket guidelines, sliding-scale use was eliminated, and subsequently glucose control was improved.

Knowledge of the typical daily insulin requirements and basal insulin requirements in type 1 diabetic patients is required to avoid insulin overdosing, and our survey indicates a need for improvement in this area. Recognition that patients with type 1 diabetes require basal insulin at all times is crucial because stopping insulin can result in DKA and death. Nevertheless, 25% of all house staff and the majority of faculty and nurses answered this question incorrectly.

To our knowledge, this is the first study to assess knowledge of new insulin formulations and inpatient diabetes management in both physicians and nurses. In teaching hospitals, medicine residents often have the primary responsibility for diabetes management. Staff nurses, who administer insulin and other treatments, are in a crucial position to recognize dangerous orders or other mistakes in diabetes management. By questioning physicians in these cases or refusing to give inappropriate treatments, adverse outcomes may be avoided. If, as suggested by others,[15,16] a coordinated team approach would improve patient outcomes, it becomes clear that all groups of health care providers need to understand the fundamentals of insulin properties and use.

Several limitations in our study merit discussion. Our survey was designed by a panel of endocrinologists with particular expertise in diabetes to assure content validity, but we did not formally statistically validate the questionnaire. Although it was pilot-tested before distribution, only house staff, fellows, and medical students participated in the pilot test, and thus it is possible that nurses and faculty may have different interpretations of the questions. Although the questionnaire was reviewed by an expert in survey

development and quality care management, the test was not reviewed by an expert in test design and development, nor was it validated.

Although we sampled groups on multiple occasions to increase our participation rates, we were not able to reach every faculty member, house officer, or nurse affiliated with the four hospitals. Because inclusion in our survey required being present at a group meeting, our subjects may represent a motivated subgroup more likely to have participated in medical education programs in the past. Without this selection bias, we hypothesize that group scores would be even lower. Additionally, the questionnaires were conducted under conditions in which the respondents could not consult reference materials or colleagues, a scenario that does not mimic real-life situations. Nonetheless, given that most respondents self-reported feeling very or somewhat comfortable in diabetes management, we may reasonably expect that many would not seek additional information when confronted in the clinical setting with diabetes management issues addressed by our questionnaire.

In summary, this study demonstrates the need for educational initiatives regarding insulin formulations and inpatient management of diabetes for health care professionals. Because most participants identified educational presentations and colleagues as main sources of knowledge about new medications, successful initiatives may include presentations at group meetings, as well as a special focus on teaching resident and nurse leaders who can then teach larger groups on a regular basis. Dedicated diabetes management teams, led by nurse practitioners and endocrinologists, may also enhance diabetes education in the hospital.

Since completing our study, we have presented the results to the participating groups. We have found that structuring the discussion around the rationale behind each correct answer helps to increase participant attention and interest. Using the survey as a post-test may be effective for assessing the impact

of these discussions. Future studies are needed to understand how inpatient diabetes education can best be optimized, particularly because the forums and selections for learning might be different between nurses and physicians, and to show that improved knowledge leads to fewer insulin-related medical errors and improved quality of care for hospitalized patients with diabetes.

Acknowledgments

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