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A MULTICENTER STUDY EVALUATING PERCEPTIONS AND KNOWLEDGE OF INPATIENT GLYCEMIC CONTROL AMONG RESIDENT PHYSICIANS: ANALYZING THEMES TO INFORM AND IMPROVE CARE

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Abstract

Objective: In this descriptive study, we evaluated perceptions and knowledge of inpatient glycemic control among resident physicians.

Methods: We performed this study at four academic medical centers: the University of Mississippi Medical Center, University of Virginia Health System, University of Louisville Health Sciences Center, and Emory University. We designed a questionnaire, and Institutional Review Board approval was granted at each institution prior to study initiation. We then administered the questionnaire to Internal Medicine and Medicine-Pediatric resident physicians.

Results: A total of 246 of 438 (56.2%) eligible resident physicians completed the Inpatient Glycemic Control Questionnaire (IGCQ). Most respondents (85.4%) reported feeling comfortable treating and managing inpatient hyperglycemia, and a majority (66.3%) agreed they had received

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DISCLOSURE

The authors have no multiplicity of interest to disclose.

adequate education. Despite self-reported comfort with knowledge, only 51.2% of respondents could identify appropriate glycemic targets in critically ill patients. Only 45.5% correctly identified appropriate inpatient random glycemic target values in noncritically ill patients, and only 34.1% of respondents knew appropriate preprandial glycemic targets in noncritically ill patients. A small majority (54.1%) were able to identify the correct fingerstick glucose value that defines hypoglycemia. System issues were the most commonly cited barrier to successful inpatient glycemic control.

Conclusion: Most respondents reported feeling comfortable managing inpatient hyperglycemia but had difficulty identifying appropriate inpatient glycemic target values. Future interventions could utilize the IGCQ as a pre- and postassessment tool and focus on early resident education along with improving system environments to aid in successful inpatient glycemic control.

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INTRODUCTION

Uncontrolled inpatient hyperglycemia, in patients with or without diabetes mellitus (DM), is associated with increased rates of infection and mortality, longer length of hospitalization, increased postoperative re-admission rates, and many other adverse outcomes (1–5). Various studies in both critically and noncritically ill hyperglycemic inpatients demonstrate that improved inpatient glycemic control (IGC) can reduce rates of hospital complications, infections, and cost (6–9). As >90% of patients with DM are admitted for reasons unrelated to the disease and often cared for by staff without specific DM expertise, IGC is often poor (10). Numerous strategies have been attempted in efforts to improve IGC, including standardized insulin order sets (11–15), mentoring (16), diabetes care team intervention (17–19), computerized systems (20,21), physician and nurse education (11,22,23), and resident physician education (24–27).

The recent consortium for Planning Research in Inpatient Diabetes was formed to promote clinical research leading to advancement and improvement of IGC (28). The consortium outlined eight aspects of IGC to be addressed; the first suggested development and evaluation of provider education tools to improve knowledge of and address barriers to achieving appropriate IGC (28). Currently, few data are available regarding resident physician perspectives on IGC (29–32). Given that resident physicians are often the primary managers of IGC in many academic and community medical centers, it is important to understand their baseline knowledge and perception of this topic. If correctable issues (e.g., educational deficits, discomfort prescribing certain insulin regimens, fear of hypoglycemia, etc.) are identified, strategies may then be better formulated to address these deficiencies. In this descriptive study, we analyzed results of the Inpatient Glycemic Control Questionnaire (IGCQ), a survey tool developed for assessment of perceptions and knowledge of IGC among resident physicians.

METHODS

Research Locations

We performed this study at four academic medical centers: University of Mississippi Medical Center (UMMC), Jackson, MS; University of Virginia Health System (UVA), Charlottesville, VA; University of Louisville Health Sciences Center (UL), Louisville, KY; and Emory University Healthcare (Emory), Atlanta, GA.

Questionnaire Design and Administration

We previously published a detailed description of the methods utilized to construct and preliminarily evaluate the IGCQ (33) (Fig. 1). We obtained Institutional Review Board (IRB) approval at each institution prior to questionnaire administration and then obtained verbal consent from participants and collected results anonymously at each site. We administered the IGCQ to internal medicine (IM) and medicine-pediatric (MP) resident and chief resident physicians to determine their viewpoints regarding the importance of IGC, knowledge of inpatient glycemic target values, and problems encountered when trying to achieve IGC. We distributed questionnaires in-person during resident physician conferences at UMMC, used Google Forms (Google; San Francisco, CA) for data collection at Emory, utilized IRB-approved software (QuestionPro Inc; San Francisco, CA) at UVA, and used SurveyMonkey Pro (SurveyMonkey; San Mateo, CA) at UL. We collected results during February-May 2015 (UMMC), March-June 2016 (Emory), November-December 2016 (UVA), and March-May 2017 (UL). We then tabulated survey results in an Excel (Microsoft; Redmond, WA) spreadsheet for data analyses. IGCQ Question 16 asked respondents to identify the single greatest barrier to successful IGC in “fill-in-the-blank” format. We identified several consistent response categories, so results were ultimately grouped as demonstrated in Figure 2.

Statistical Analyses

We performed univariate analysis of item responses using descriptive statistics (i.e., mean, frequency, and proportion). We then used a chi-square test to evaluate performance differences by postgraduate year (PGY) on knowledge-based questions. Differences were considered significant at $P < .05$. Based on results of prior survey evaluation, we categorized the IGCQ into two subscales, a “comfort with managing IGC” scale (IGCQ Questions 2–6) and a “barriers to IGC” scale (IGCQ Questions 11–15) (33). We compared associations between knowledge (as measured by IGCQ Questions 7–10) and PGY with total scores from the “comfort with managing IGC” subscale using a Kruskal-Wallis test. All statistical analyses were performed using either Excel or Winsteps (version 3.70.0.5) software.

RESULTS

Questionnaire Participation

A total of 246 of 438 (56.2%) eligible resident physicians completed the IGCQ overall. Participants were 61.8% male and 38.2% female, 90.6% IM and 9.4% MP, and 34.1% PGY1, 33.7% PGY2, 25.6% PGY3, and 6.5% PGY4. Institutional participation included 73/87 (83.9%) eligible resident physicians from UMMC, 64/107 (59.8%) eligible resident

physicians from UL, 60/145 (41.4%) eligible resident physicians from Emory, and 49/99 (49.5%) eligible resident physicians from UVA.

Questionnaire Responses

Table 1 details item responses for IGCQ Questions 1–15. Most respondents (85.4%) reported feeling comfortable treating and managing inpatient hyperglycemia, and a majority (66.3%) agreed they had received adequate education and preparation. Most respondents (87.4%) also reported feeling comfortable with their knowledge of basal plus bolus insulin regimens. Nearly half of respondents (49.2%) agreed that lack of discussion about glucose management on teaching rounds was a barrier to successful IGC. When asked to identify the single greatest barrier to successful IGC (IGCQ Question 16), “system issues” such as improper dietary components (e.g., pancakes with syrup for breakfast) and improper insulin dosing in relation to meal times (e.g., insulin given several hours after meal ingestion) were the most common response (Fig. 2). Lack of education (45 responses; 20.0%) was the second most common response, while fear of hypoglycemia was only the fourth most common response (27 responses; 12.0%).

Despite self-reported comfort with knowledge of IGC and believing they had received adequate education and preparation, only 51.2% of respondents could identify appropriate glycemic targets in critically ill patients (Table 2). Only 45.5% correctly identified appropriate inpatient random glycemic target values in noncritically ill patients, and only 34.1% of respondents knew appropriate preprandial glycemic targets in noncritically ill patients. A small majority (54.1%) were able to identify the correct fingerstick glucose value that defines hypoglycemia. Knowledge of critically ill IGC target values demonstrated significant improvement as PGY increased, but no significant improvements were noted with PGY for the other IGC target values (Table 2).

Subscale Analyses

Associations of knowledge and PGY with total scores from the “comfort with managing IGC” subscale demonstrated that self-reported comfort increased as PGY increased (Fig. 3 A), though comfort did not correlate with increasing knowledge (i.e., those who reported greater comfort were not consequently more knowledgeable) (Fig. 3 B).

DISCUSSION

Optimal glycemic control remains challenging for healthcare practitioners in the inpatient setting, while educating personnel about appropriate IGC practices has been suggested as an approach for ensuring greater patient safety and decreasing the morbidity and mortality associated with hyperglycemia (34). Recent studies have shown improvements in knowledge (24,26,27) and clinical IGC (25–27) after medical resident educational interventions. We examined resident physician viewpoints and knowledge of IGC to help inform the design of future educational interventions.

Most resident physicians reported feeling comfortable managing inpatient hyperglycemia but had difficulty identifying appropriate IGC target values from consensus guidelines (1). System environment improvement is one potential intervention identified by this study that

could aid in successful IGC. Examples of specific system environment changes could include ensuring that dietary components are appropriate for patients with hyperglycemia and/ or DM (e.g., electronic health systems that prompt providers to order a “consistent-carbohydrate diet” for hyperglycemic and DM patients) and ensuring that insulin dose timing is appropriate in relation to meal delivery (e.g., prandial insulin given around the time of meal ingestion as opposed to several hours after). Early resident physician education is another intervention that could lead to improved IGC. Knowledge of recommended IGC target values was relatively low overall in our study but did trend towards improvement as residents progressed through training. Consistent with this finding, a recent retrospective study demonstrated that patients admitted to an internal medicine service by a senior resident were more likely to receive guideline-based care than those admitted by a junior trainee (35). Targeted IGC educational interventions initiated at the beginning of residency training could potentially improve guideline adherence, comfort, and knowledge before trainees become senior residents and subsequently attending physicians.

Recent calls have been made for IGC education to reach a larger population of learners and be adopted as a formal component of hospitals’ quality planning, aiming to integrate clinical practice guidelines and optimize inpatient diabetes care (36). The Centers for Medicare and Medicaid Services recently contracted with Health Services Advisory Group to provide services for the Medication Measures Special Innovation Project, which is designed to develop measures that can be used to support quality healthcare delivery (37). Two pending measures related to inpatient glycemic control (NQF 2362: Glycemic Control – Hyperglycemia and NQF 2363: Glycemic Control – Severe Hypoglycemia) have been submitted to the National Quality Forum and received recommendations for endorsement (37), indicating potential interest for inclusion of IGC as a quality measure. As IGC becomes an increasing target in healthcare delivery, interventions to improve IGC will gain further attention. Future studies could utilize the IGCQ to examine the effects of various educational and system interventions related to IGC. For example, the IGCQ could be administered both before and after an educational intervention to assess potential improvement in comfort as measured by the “comfort with managing IGC” subscale. The IGCQ also contains four knowledge-based questions and could be used to evaluate improvements in knowledge after these same educational interventions. The “barriers to IGC” subscale could be used to evaluate the effectiveness of system environment changes aimed at decreasing or removing barriers to IGC. Finally, the IGCQ could be used to evaluate whether knowledge correlates with improved IGC in real-world clinical practice.

Strengths of this study include its multicenter approach and relatively large number of respondents. To our knowledge, this is the largest evaluation of resident physician perceptions and knowledge of IGC currently published in the medical literature. The sample size of 246 respondents from a population of 438 resident physicians (response rate of 56.2%) resulted in a margin of error of 5.5% at the 99% confidence level. A 5 to 10% margin of error at the 95% confidence level is generally considered acceptable for survey research (38). Positive attributes of the IGCQ include its ease of use, free availability in the public domain, and potential future adaptation to assess resident perceptions and knowledge of other chronic diseases (31). The IGCQ also scored well when evaluated by the Medical Education Research Study Quality Instrument (MERSQI), a tool developed to appraise

methodological quality in medical education research (39). The IGCQ's MERSQI score was 14.0, higher than the mean total of 10.7 for accepted manuscripts in one study (40).

There are several potential limitations of this study that should be noted. First, the response rate of 56.2% was quite good for a survey study but does leave some doubt as to how well our findings reflect the attitudes of nonresponding resident physicians. If those who preferentially responded had strong beliefs regarding IGC (positive or negative), this may have caused potential bias in the results. Participants enrolled in this study also may or may not be representative of all resident physicians across the country, as our cohort were trainees at four separate academic medical centers and may have slightly different perspectives on IGC than those training at other academic or community medical centers. Second, each participating institution had different institutionally licensed and/or IRB-approved survey software, so we were unable to standardize survey administration across all centers. We do note that participation rate was highest at UMMC, where questionnaires were distributed in-person during resident physician conferences and completed on paper (as opposed to online). This delivery method clearly improved participation, so future studies utilizing the IGCQ could consider administering the survey in-person to maximize participation. Third, data were collected at various time points throughout the academic year, which may impact participant self-assessment. For example, residents may self-assess as more comfortable managing IGC later in the year than earlier in the year. Fourth, there are limitations of this study that are common to questionnaire research in general. Respondents may read and interpret each question differently and therefore reply based on their own interpretation of the question (i.e., "agree" to someone may be "neither agree nor disagree" to someone else). Fifth, our questionnaire items did not address every single issue currently affecting IGC but did attempt to address a wide range of issues based on recent consensus guidelines and other research (1,6,7,9). We designed questionnaire items to focus on resident physicians' perceptions, beliefs, and knowledge rather than asking "yes/no" questions or asking respondents to recall a multitude of facts. Finally, we based knowledge questions of suggested IGC targets from the most recent consensus guidelines (1) at the time the IGCQ was constructed. These consensus guidelines from two professional societies have not been updated since the IGCQ was created; however, other suggested guidelines were published during development of the IGCQ (41,42). The suggested IGC targets were not changed, so we do not believe this played a role in data interpretation, but it remains relevant to note that newer guidelines were published.

CONCLUSION

In summary, herein we presented the largest evaluation of resident physician perceptions and knowledge of IGC currently published in the medical literature. This project was also the first to preliminarily evaluate a survey tool that can be utilized in future research (33). Most respondents reported feeling comfortable managing inpatient hyperglycemia but had difficulty identifying appropriate IGC target values. Further work is needed to determine how to best improve these knowledge gaps among resident physicians. Thus, future interventions could utilize the IGCQ as a pre- and postassessment tool and focus on improving system environments and early resident education to aid in successful IGC. The

IGCQ could also be used to assess perceptions and knowledge of IGC amongst hospitalists, endocrine fellows, and advanced care providers.

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Abbreviations:

DM	diabetes mellitus
Emory	Emory University Healthcare
IGC	inpatient glycemic control
IGCQ	Inpatient Glycemic Control Questionnaire
IRB	Institutional Review Board
PGY	postgraduate year
UMMC	University of Mississippi Medical Center
UVA	University of Virginia Health System
UL	University of Louisville Health Sciences Center

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Inpatient Glycemic Control Questionnaire

Demographics

What is your residency program? _____ Internal Medicine _____ Medicine-Pediatrics

Please indicate PGY: _____ 1 _____ 2 _____ 3 _____ 4

What is your sex? _____ Male _____ Female

1. How many problems per patient do you believe impairs your ability to manage inpatient glycemia?
 1. 2-5 2. 6-7 3. ≥ 8
2. As the number of problems per patient or total number of patients under my individual care begins to make me feel uncomfortable, my ability to appropriately manage inpatient glycemia is impaired.
 1. Agree 2. Neither Agree nor Disagree 3. Disagree
3. I feel that I have received adequate education and preparation for managing inpatient glycemia.
 1. Agree 2. Neither Agree nor Disagree 3. Disagree
4. I feel that I am too busy and have too many other responsibilities to adequately manage inpatient glycemia as a resident on an inpatient medicine service.
 1. Agree 2. Neither Agree nor Disagree 3. Disagree
5. I feel comfortable treating and managing inpatient hyperglycemia.
 1. Agree 2. Neither Agree nor Disagree 3. Disagree
6. I feel comfortable with my knowledge of basal plus bolus subcutaneous insulin regimens.
 1. Agree 2. Neither Agree nor Disagree 3. Disagree
7. In the hospital, at what glucose level do you first regard your patient as having hypoglycemia?
 1. <80 2. <70 3. <60 4. <50 5. <40
8. In the hospital, what preprandial (pre-meal) glucose level do you target in your non-critically ill patients?
 1. <200 2. <180 3. <160 4. <140 5. <120
9. In the hospital, what random glucose level do you target in your non-critically ill patients?
 1. <200 2. <180 3. <160 4. <140 5. <120

10. In the hospital, what glucose range do you target for your critically ill patients?
1. 200-240 2. 160-200 3. 140-180 4. 120-160 5. 100-140
11. I believe that fear of causing hypoglycemia is a barrier to successful inpatient glycemic control.
1. Agree 2. Neither Agree nor Disagree 3. Disagree
12. I believe that lack of knowledge of how to best treat hypoglycemia is a barrier to successful inpatient glycemic control.
1. Agree 2. Neither Agree nor Disagree 3. Disagree
13. I believe that lack of knowledge of basal plus bolus insulin regimens is a barrier to successful inpatient glycemic control.
1. Agree 2. Neither Agree nor Disagree 3. Disagree
14. I believe that lack of discussion about glucose management on teaching rounds is a barrier to successful inpatient glycemic control.
1. Agree 2. Neither Agree nor Disagree 3. Disagree
15. I believe that cross-coverage and handoffs between residents is a barrier to successful inpatient glycemic control.
1. Agree 2. Neither Agree nor Disagree 3. Disagree
16. Please list the **ONE** factor that you believe is the greatest barrier to successful inpatient glycemic control:
- _____

We appreciate you taking time out of your day to complete this survey. Thank you for your participation.

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Fig. 1.
The Inpatient Glycemic Control Questionnaire.

Fig. 2.
Single greatest barrier to successful inpatient glycemic control (as identified by response to Inpatient Glycemic Control Questionnaire Question 16).

Fig. 3. Associations between “comfort with managing inpatient glycemic control” subscale scores and postgraduate year (PGY) (*A*) and knowledge, as represented by number correct in response to Inpatient Glycemic Control Questionnaire Questions 7–10 (*B*). Horizontal lines represent means.

Table 1

Item Response Frequencies for IGCQ Questions 1–15

Question	Answer choice				
	1	2	3	4	5
1. How many problems per patient impairs your ability to manage inpatient glycemia?	118 (48.0%)	74 (30.1%)	54 (21.9%)		
2. As the number of problems per patient or total number of patients under my individual care begins to make me feel uncomfortable, my ability to manage inpatient glycemia is impaired.	144 (58.5%)	51 (20.7%)	51 (20.7%)		
3. I feel that I have received adequate education and preparation to manage inpatient glycemia.	163 (66.3%)	54 (22.0%)	29 (11.8%)		
4. I feel that I am too busy to adequately manage inpatient glycemia as a resident on an inpatient medicine service.	31 (12.6%)	58 (23.6%)	157 (3.8%)		
5. I feel comfortable treating and managing inpatient hyperglycemia.	210 (85.4%)	20 (8.1%)	16 (6.5%)		
6. I feel comfortable with my knowledge of basal plus bolus insulin subcutaneous insulin regimens.	215 (87.4%)	21 (8.5%)	10 (4.1%)		
7. In the hospital, at what glucose level do you first regard your patient as having hypoglycemia?	49 (19.9%)	140 (56.9%)	55 (22.4%)	2 (0.8%)	0 (0.0%)
8. In the hospital, what preprandial (premeal) glucose level do you target in your noncritically ill patients?	12 (4.9%)	75 (30.5%)	47 (19.1%)	85 (34.6%)	27 (11.0%)
9. In the hospital, what random glucose level do you target in your noncritically ill patients?	65 (26.4%)	111 (45.1%)	40 (16.3%)	26 (10.6%)	4 (1.6%)
10. In the hospital, what glucose range do you target for your critically ill patients?	7 (2.9%)	77 (31.3%)	128 (52.0%)	23 (9.3%)	11 (4.5%)
11. I believe that fear of causing hypoglycemia is a barrier to successful inpatient glycemic control.	151 (61.4%)	43 (17.5%)	52 (21.1%)		
12. I believe that lack of knowledge of how to best treat hypoglycemia is a barrier to successful inpatient glycemic control.	80 (32.5%)	44 (17.9%)	122 (49.6%)		
13. I believe that lack of knowledge of basal plus bolus subcutaneous insulin regimens is a barrier to successful inpatient glycemic control.	113 (45.9%)	40 (16.3%)	93 (37.8%)		
14. I believe that lack of discussion about glucose management on teaching rounds is a barrier to successful inpatient glycemic control.	121 (49.2%)	60 (24.4%)	65 (26.4%)		
15. I believe that cross-coverage and handoffs between residents is a barrier to successful inpatient glycemic control.	90 (36.6%)	56 (22.8%)	100 (40.6%)		

Abbreviation: IGCQ = Inpatient Glycemic Control Questionnaire.

For knowledge-based questions (7–10), correct answer choices are **bolded**.

Table 2**Identification of Appropriate Inpatient Glycemic Target Values**

Glycemic target	Correct responses (%)					P value^a
	Total	PGY1	PGY2	PGY3	PGY4	
Hypoglycemia (IGCQ Question 7)	54.1	52.4	59.0	49.2	56.3	.670
Preprandial glucose (IGCQ Question 8)	34.1	28.6	37.3	34.9	43.8	.529
Random glucose (IGCQ Question 9)	45.5	40.5	44.6	54.0	43.8	.436
Critically ill (IGCQ Question 10)	51.2	38.1	50.6	63.5	75.0	.004

Abbreviations: IGCQ = Inpatient Glycemic Control Questionnaire; PGY = postgraduate year.

^a P-value compares knowledge (i.e., correct responses) across PGYs to determine if there are any significant improvements in knowledge as PGY increases.