

# Effect of Case-Based Training for Medical Residents on Inpatient Glycemia

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**OBJECTIVE**—To determine whether an educational intervention for medical house staff improves blood glucose (BG) in hospitalized patients.

**RESEARCH DESIGN AND METHODS**—All 116 medicine residents at an academic medical center were assigned to online or classroom training on inpatient dysglycemia in fall 2008. Both groups were offered an online refresher course in spring 2009 addressing gaps in clinical practice identified on chart review. We assessed event BG, the first BG of any 3-h period, on two teaching wards.

**RESULTS**—A total of 108 residents (93.1%) completed the initial training. The primary outcome, median event BG, decreased from 152 mg/dL in August 2008 to 139 mg/dL in December 2008 ( $P < 0.0001$ ). Prevalence of event BG  $>200$  mg/dL decreased from 25.5 to 22.7% ( $P = 0.0207$ ), at the expense of more event BGs  $<70$  mg/dL (2.0–3.9%,  $P = 0.0124$ ).

**CONCLUSIONS**—A curriculum for medicine residents on inpatient glycemia led to lower inpatient BG.

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Inpatient hyperglycemia and hypoglycemia are associated with increased morbidity, mortality, and cost (1,2). Nonadherence to published guidelines (3), inadequate hypoglycemia precautions, delayed titration of insulin, and regular insulin sliding-scale use are widely prevalent practices associated with worse dysglycemia (4,5). Many residents (while acknowledging that inpatient dysglycemia is a common problem) profess limited knowledge and motivation to treat it (6,7).

Clinician-driven quality improvement strategies including clinician-directed audit-and-feedback cycles improved outcomes in resident-treated ambulatory patients with diabetes (8,9). We designed an interactive course that increased resident confidence and knowledge (10) and studied its effect on inpatient glycemia.

## RESEARCH DESIGN AND METHODS

All 116 medicine residents at Mount Sinai Hospital were asked to undergo a curriculum with 10 case studies illustrating the management of inpatient dysglycemia in fall 2008. Residents on ambulatory or elective rotations were assigned to two 90-min small-group classroom sessions. All other residents underwent online training of similar duration with flexible timing. Endocrinology fellows identified educational gaps in chart reviews after the initial course and generated a 45-min online refresher course with seven short modules for all participants in spring 2009. All online education used the MENTOR platform by PRESENT e-Learning, a Web 2.0 platform integrating narrated PowerPoint slides and interactive embedded didactic quizzes that had to be completed to progress through the modules (11). Demonstration modules

are available at <http://presentlearning.com/demo/RT/nutrition/player.html> and <http://presentlearning.com/demo/RT/insulin/player.html>. Participants were awarded \$600 for completing the entire training.

All point-of-care blood glucose (BG) values were obtained through the hospital-wide Remote Automated Laboratory System and data repository for 1–31 August 2008 (before the initial course), 1–31 December 2008 (after the initial course), and 19 May to 18 June 2009 (after the refresher course). BG data for the same timeframes in 2007/2008 provided year-over-year comparison.

We analyzed admissions to two general medicine wards with at least four BG measurements and a length of stay  $<45$  days to deemphasize nonmedical factors leading to extremely long or short stays. To avoid oversampling abnormal data (12), all BG values within a 3-h window were considered duplicates, and the earliest value was called “event blood glucose” (eBG). Moreover, each admission was assigned a study-specific designation: “hypoglycemia,” at least one eBG  $<70$  mg/dL; “euglycemia,” all eBGs within the 70–200 mg/dL range; “mild hyperglycemia,”  $\geq 50\%$  of eBGs in the euglycemia range of 70–200 mg/dL and no eBGs  $>300$  mg/dL, or  $\geq 75\%$  of eBGs in the euglycemia range and one eBG  $>300$  mg/dL; “moderate hyperglycemia,”  $<50\%$  of eBGs in the euglycemia range and no eBGs  $>300$  or  $<70$  mg/dL, or  $<75\%$  of eBGs in the euglycemia range and one eBG  $>300$  mg/dL; and “severe hyperglycemia,” two or more eBGs  $>300$  mg/dL. Admissions that qualified for both “hypoglycemia” and “severe hyperglycemia” received the additional designation “wide fluctuation.”

Given nonnormal eBG distribution, the primary outcome was change in median eBG from August 2008 to December 2008.

Statistical analysis was performed in Microsoft Excel 2010 (Microsoft, Seattle, WA) and SAS 6.2 (SAS, Cary, NC). For eBG, statistical significance between groups was calculated using the Wilcoxon rank sum test for continuous variables and Fisher exact test for categorical variables.

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Table 1—BG values, event BG values, and BG visit categories

	August 2007	December 2007	May 2008	August 2008 (preintervention)	December 2008 (after initial course)	May 2009 (postrefresher)
BG values and eBG						
All point of care BG	3,194	4,127	3,275	3,125	3,593	4,601
Mean BG* (SD)	165.0 (80.7)	166.1 (81.3)	172.1 (82.9)	170.5 (73.2)	159.2 (77.5)	164.8 (79.9)
Median BG (25th–75th percentile)	142 (111–197)	146 (110–201)	150 (117–204)	154 (122–200)	139 (106–192)†	144 (112–199)
Analyzed eBGs	1,155	1,508	1,434	1,484	1,180	2,186
Mean eBG (SD)	166.7 (81.1)	173.7 (82.1)	174.7 (80.2)	167.5 (74.0)	160.1 (78.9)	165.3 (75.4)
Median eBG (25th–75th percentile)	141 (113–197)	152 (113–215)	155 (119–209)	152 (115–202)	139 (106–192)†	147 (115–198)†
Number of eBGs <70 mg/dL (%)	28 (2.4)	30 (2.0)	35 (2.4)	30 (2.0)	46 (3.9)†	70 (3.2)
Number of eBGs 70–200 mg/dL (%)	851 (73.7)	1,040 (69.0)	998 (69.6)	1,076 (72.5)	866 (73.4)	1,596 (73.0)
Number of eBGs >200 mg/dL (%)	276 (23.9)	438 (29.0)	401 (28.0)	378 (25.5)	268 (22.7)†	520 (23.8)
Patient visit categories: number of admissions (%)						
Analyzed inpatient admissions	68	74	88	82	67	112
Hypoglycemia†	17 (25.0)	20 (27.0)	16 (18.2)	18 (22.0)	28 (41.8)‡	35 (19.6)
Euglycemia	19 (27.9)	14 (18.9)	19 (21.6)	16 (19.5)	14 (20.9)	22 (19.6)
Mild hyperglycemia	2 (2.9)	5 (6.8)	9 (10.2)	7 (8.5)	4 (6.0)	10 (8.9)
Moderate hyperglycemia	19 (27.9)	19 (25.7)	27 (30.7)	26 (31.7)	14 (20.9)	24 (21.4)
Wide fluctuation	6 (8.8)	6 (8.1)	4 (4.5)	2 (2.4)	8 (11.9)‡	9 (8.0)
Severe hyperglycemia†	17 (25.0)	22 (29.7)	21 (23.9)	17 (20.7)	15 (22.4)	30 (26.8)
All hyperglycemia†	38 (55.9)	46 (62.2)	57 (64.8)	50 (61.0)	33 (49.3)	64 (57.1)

To avoid oversampling abnormal data, all BG values within a 3-h window were considered duplicates, and the earliest value was called eBG. \*All BG and eBG data are given in mg/dL. For an approximate conversion to mmol/L, divide by 18. †Includes wide fluctuation. ‡Significant change from the preceding time period.

**RESULTS**—Of 116 eligible medicine residents, 108 (93.1%) completed training in fall 2008: 52 of 55 (94.5%) graduated from the classroom sessions, and 56 of 61 (91.8%) assigned residents underwent online learning. Of these 108 residents, 102 (94.4%, or 87.9% of the class of 116) completed the online refresher course in spring 2009.

In the six analyzed timeframes, 8,947 eBGs were generated from the two studied wards (Table 1). Median eBG was lower after the initial course, in December 2008 (139 mg/dL), compared with August 2008 (152 mg/dL,  $P < 0.0001$ ) or December 2007 (152 mg/dL,  $P < 0.0001$ ). After a significant rise to 147 mg/dL by May 2009 ( $P = 0.0005$ ), median eBG was still lower postrefresher than a year earlier, in May 2008 (155 mg/dL,  $P = 0.0003$ ), but not significantly lower than in August 2008 (Table 1). The share of eBGs >200 mg/dL in December 2008 was lower (22.7%) than preintervention in August 2008 (25.5%,  $P = 0.0207$ ) or December 2007 (29.0%,  $P = 0.0059$ ).

Prevalence of hypoglycemic eBGs (<70 mg/dL) almost doubled, to 3.9% in December 2008, from 2.0% in both August 2008 ( $P = 0.0124$ ) and December 2007 ( $P = 0.0033$ ). Similarly, more admissions were marked by hypoglycemia in December 2008 (41.8%) compared with August 2008 (22.0%,  $P = 0.0124$ ) and December 2007 (27.0%,  $P = 0.0764$ ). Admissions designated “wide fluctuation” fell significantly from 8.1% in December 2007 to 2.4% in August 2008 ( $P = 0.0432$ ). However, prevalence was steady at 8–12% for all other time periods assessed and not significantly different from December 2007.

**CONCLUSIONS**—Our curriculum is one of the largest educational interventions teaching inpatient diabetes management to medicine residents. Its wide adoption bolsters the validity of patient BG outcomes.

The intervention achieved its primary aim: lower median eBG and fewer eBGs >200 mg/dL. However, this accomplishment came at the expense of a doubling of hypoglycemic events. In chart analyses, endocrinology fellows identified increased prevalence and worse documentation of hypoglycemia, as well as wide BG fluctuation as the main weakness of patient care after the initial course. This may have resulted from overemphasizing tight glycemia (13), deficits in the educational intervention, or a discrepancy between

learning and action. The frequent hypoglycemic events prompted remediation in the refresher course. Increased BG toward the end of the academic year may therefore have been caused by this countermeasure. Future course material must incorporate updated BG targets and emphasize hypoglycemia prevention.

The modest number of analyzed admissions is a limitation of this study. Moreover, inpatient glycemia is subject to many confounders beyond resident control; altered BG targets may apply for different populations (14), and patients may not comply with hospital diets, monitoring, or treatment. Other caregivers or electronic ordering systems may influence diet or medication administration (15).

In conclusion, our project is among the largest studies examining the effect of resident education on inpatient glycemia. Future investigations will need to emphasize prevention and treatment of hypoglycemia and incorporate updated BG targets. Using the scalability and modularity of online education, the program will expand to other hospitals and providers.

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