Effectiveness of an online course for medicine residents on glycaemic management of hospitalized patients with diabetes

ARUN SARAVANAN SHANMUGANATHAN, SURYANARAYANA BETTADPURA SHAMANNA

ABSTRACT

Background. Hyperglycaemia and hypoglycaemia in hospitalized patients are associated with poor clinical outcomes. We assessed whether administration of an online educational course for medicine residents improves the glycaemic management of hospitalized patients with diabetes.

Methods. We conducted this quasi-experimental, pre-post study from January 2019 to April 2019. The contents of the course were in compliance with the American Diabetes Association Guidelines 2018. After participating in the online course, the change in the knowledge of residents was assessed by pre- and post-test questionnaire and changes in the inpatient diabetes care were assessed by case record review of the hospitalized patients with diabetes managed by them before and after the participation in the course.

Results. Fifty-six residents participated and completed the online course. Their average post-test scores increased by 11.6%. One hundred and eighteen patients managed by the residents in the same wards before and after the participation in the course were studied. After attending the course, glycaemic targets were predetermined in 75.4% of patients compared to 32.2% before and adequacy of glucose monitoring improved. The total hypoglycaemic event rate reduced significantly by 45.8% and this was accompanied by a trend towards improved glycaemic control. At the time of discharge, the patient awareness on insulin injection technique, hypoglycaemic symptoms and its home remedies were significantly increased.

Conclusion. The administration of an online course increases the knowledge level of residents, improves patient safety and may improve glycaemic control in hospitalized patients with diabetes.

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INTRODUCTION

India is the second largest country with people with diabetes. It affects more than 7.1% of the adult population.[1] Patients with diabetes have a 3-fold higher chance of hospitalization compared to those without diabetes.[2] Observational studies have reported a prevalence of hyperglycaemia and diabetes from 38% to 40% in hospitalized patients (any blood glucose concentration >140 mg/dl, i.e. 7.8 mmol/L). Inpatient hyperglycaemia is associated with an increased risk of complications, a longer hospital stay and increased mortality and target blood glucose are not met in a major proportion of patients.[2] Furthermore, hypoglycaemia is an important limiting factor in glycaemic management and is associated with increased morbidity and mortality in hospitalized people with diabetes.[3]

Hospitalized patients with diabetes form a heterogeneous group and glucose management in them poses a challenge for the residents.[4] Residents are the immediate caregivers and they should possess requisite knowledge for efficient glycaemic management of these patients. Therefore, improvements in residents training may represent an important strategy to improve the management of diabetes in hospitalized patients. Resident educational programmes have been tested previously and have been found to improve test scores.[5,6]

Online learning has become one of the most popular ways of gaining access to education[7] and is also suitable for imparting medical education. Conducting online courses gives more convenience and flexibility for residents to follow.[8] A systematic review by Huang *et al*., evaluating 12 heterogeneous studies on the effectiveness of digital education on diabetes, found it to be effective in improving diabetes management-related knowledge and skills in health professionals.[9] We tested an online course for medicine residents developed by us pertaining to all aspects of the management of diabetes in hospitalized patients. The research question was to see whether participation in the online course improves the knowledge of the residents as well as the clinical care given by them to hospitalized patients with diabetes.

METHODS

This quasi-experimental study was conducted in the Department of Medicine, Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry from January 2019 to April 2019. The study was approved by the Institutional Ethics Committee (Human studies) (JIP/IEC/2018/393) and an informed written consent was obtained from both the participating residents and patients. Hyperglycaemia was defined by any blood glucose concentration >140 mg/dl (7.8 mmol/L).[2] Hypoglycaemia was defined as a measured blood glucose concentration or capillary blood glucose by point of care testing value ≤70 mg/dl (3.9 mmol/L) or its symptoms managed by intravenous dextrose administration.[3] Recurrent

Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry 605006, India
ARUN SARAVANAN SHANMUGANATHAN, SURYANARAYANA BETTADPURA SHAMANNA
Department of Medicine

Correspondence to SURYANARAYANA BETTADPURA SHAMANNA; *sujukumi@gmail.com*

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hypoglycaemia was defined by incidence of more than one episode of hypoglycaemia in any patient during hospitalization. According to the American Diabetes Association (ADA) Standards of Medical Care in Diabetes, hypoglycaemia in hospitalized patients was graded into three levels. Level 1 is glucose concentration <70 mg/dl (3.9 mmol/L) but >54 mg/dl (3.0 mmol/L) and level 2 is blood glucose <54 mg/dl (3.0 mmol/L) irrespective of symptoms. Level 3 is a severe event characterized by altered mental and/or physical status requiring assistance for recovery.[10] As per ADA 2018 guidelines, a glycaemic target range of 140–180 mg/dl (with values close to 140 mg/dl in fasting and below 180 mg/dl after meals) was suggested for most patients.[11] Higher glucose range (180–210 mg/dl) was considered acceptable in terminally ill patients and patients with risk factors for hypoglycaemia. Patient's clinical status, illness severity, nutritional intake, renal function and prior hypoglycaemia were the guiding factors to individualize the targets. Glycaemic status of the patients was monitored with fasting and pre-meal glucose values with point of care glucometers.

Our study had three phases. Phase 1 (PRE-phase) was the first cross-sectional survey for the assessment of resident's knowledge by pre-test and status of the management of patients by clinical case record review. Patients admitted to the intensive care unit were excluded. The clinical chart review included collecting general information of each patient comprising age, gender, duration and type of diabetes, primary diagnosis, associated complications (renal failure) and treatment received before hospitalization. The various diabetes-related parameters included fixation of glycaemic target, monitoring blood glucose, use of basal insulin, deploying sliding scale regimen for more than 72 hours, administration of correction insulin, control of fasting blood glucose at discharge, incidence of hypoglycaemia and its management and patient education at discharge. The severity of hypoglycaemia was graded according to the blood glucose values and its recurrence. Monitoring blood glucose was graded according to the timing and number of monitoring per day. It was considered good when monitoring had been done >4 times per day, adequate when it was done at least 3 times per day and poor when it was done <3 times per day. The ideal timing of glucose monitoring in a patient receiving insulin was before meals. Proper education of the patients at discharge was evaluated by a brief questionnaire related to discharge advise, insulin administration and hypoglycaemia.

Phase 2 was the design and administration of the online course to the residents. The course was designed as case-based learning along with PowerPoint presentation of the topics with audio narration, which were relevant to the frequently encountered scenarios in the management of hospitalized patients with diabetes. The content validation was done by another faculty member from the Department of Medicine. The following contents of the course were prepared in compliance with the ADA Guidelines 2018.[11]

1. Identification and management of hypoglycaemia
2. Prevention of hypoglycaemia
3. Glycaemic targets for hospitalized patients; management of hyperglycaemia and the principles of use of insulin
4. Glucose monitoring in hospitalized patients
5. Glycaemic management in special population (patient who is nil per oral or having persistent vomiting, patient with hypokalaemia or renal failure)
6. Management of complications of hyperglycaemia (diabetic ketoacidosis and HHS)
7. Discharge planning and patient education.

The course was conducted in six sessions (online PowerPoint presentations and lectures) and each session (online lecture) was for 30 minutes. A Google site for the course was created and the link for each session was provided. Case scenarios were prepared and linked to the site. The course can be accessed via the following link: *https://sites.google.com/view/hypoglycemia/home, https://sites.google.com/view/hyperglycemia/home.*

The active participation of the residents was encouraged by topic discussion on Google forum as well as face-to-face interaction at the end of each session.

Phase 3 **(**POST-phase) was the second cross-sectional survey similar to phase 1 but conducted after the residents' participation in the online course. It included the conduct of post-test to the residents and clinical case record review of the patients managed by the residents. The patients were included from the same wards as that of phase 1 and hence the same ward nurses and the same consultants took care of this second set of patients. The effectiveness of the online course was assessed by improvement in the residents' score in post-test and clinical parameters of the patients.

Statistical analysis

The sample size for the number of hospitalized patients required during the pre- and post-phases (118 each) was calculated based on a consideration that the baseline event rate of hypoglycaemia would be 30% and the risk reduction would be 50% (alpha error 5%, beta error 20%). Descriptive statistics have been used to summarize the data. Mean and standard deviation has been used for continuous variables and proportions for categorical variables. The pre-test and post-test scores have been compared with paired *t*-test. The proportions of various parameters pertaining to glycaemic management have been compared between the pre-phase and post-phase groups of patients using Chi-square test. The difference in fasting plasma glucose values at admission and discharge between the two patient groups were compared using analysis of covariance. Statsdirect software, version 2.7.9 was used for this purpose.

RESULTS

Fifty-six residents gave informed consent and took part in the online course. The course was completed in 5 weeks. One hundred and eighteen patients were recruited in both the pre-educational course phase (pre-phase) and the post-educational course phase (post-phase) of the study and 116 patients completed the study in each phase.

Knowledge of the residents (pre- and post-phase)

A total of 56 residents from medicine participated in both the pre-test and post-test. Both the tests had the same 24 questions and the maximum mark was 30. The average score was 12.71 (42.3%) in the pre-test. The maximum mark secured in the pre-test was 24 by one resident. The average score in the post-test was 16.16 (53.8%), a statistically significant increase of 11.5% ($p<0.0001$). The maximum mark secured in the post-test was 27 by three residents. Thirty-one residents (55%) secured more than 50% of the marks in post-test compared to 14 (25%) in the pre-test, which was statistically significant ($p<0.0001$).

Assessment of the intervention among patients

One hundred and eighteen hospitalized patients with hyperglycaemia in the same medical wards were studied before and after the educational intervention.

Clinical characteristics of the patients. The average age of the participants was similar in both the groups. Men were in higher proportion in the group studied before the intervention. The average fasting blood glucose at admission in phase 1 was 288.9 mg/dl (16.0 mmol/L) and in phase 3 was 314.3 mg/dl (17.5 mmol/L). The baseline characteristics which include duration of diabetes, associated comorbid conditions and patients with special situations were comparable in both phases (Table I).

Assessment of in-hospital diabetes management. There was a significant improvement in determination of the glycaemic target and quality of blood glucose monitoring by the residents after participation in the online course (Table II). Glycaemic target was determined in 75.4% of the patients in the second observational survey compared with 32.2% before the intervention (p<0.0001). About 47% of patients had good glycaemic monitoring in the post-phase compared with 21.2%

TABLE I. Baseline characteristics of the patients (*n*=118)

Characteristic	First survey, *n* (%)	Second survey, *n* (%)	p value
Men	74 (62.7)	65 (55)	–
Mean age (in years)	53.1	52.3	0.63
Elderly (age >60 years)	31 (26.3)	25 (21.2)	0.36
Type of diabetes			
Type 2	110.0 (93.2)	108 (91.5)	–
Type 1	5 (4.2)	1 (0.8)	
Other types	3 (2.5)	9 (7.6)	
Duration of diabetes (years)			
<5	53 (44.9)	47 (39.8)	–
5–10	23 (19.5)	32 (27.1)	
>10	42 (35.6)	39 (33.1)	
Prior treatment			
Insulin	45 (44.5)	46 (44.2)	–
Oral drugs	31 (30.6)	44 (42.3)	
Diet alone	4 (3.9)	1 (1)	
Alternate medicines	4 (3.9)	4 (3.8)	
No treatment	17 (16.8)	9 (8.7)	
Average fasting sugar at admission (mg/dl)	288.9	314.3	0.18
Received steroids	11 (9.3)	13 (11)	
Associated comorbid conditions			
Hypertension	42 (35.6)	37 (31.4)	–
Hypothyroidism	8 (6.8)	6 (5)	
Coronary artery disease	21 (17.8)	27 (22.9)	
Cerebrovascular disease	4 (3.4)	7 (5.9)	
Chronic kidney disease	19 (16.1)	16 (13.6)	
Special situations			
Nil per oral	5 (4.2)	6 (5)	0.77
Enteral (tube) feeding	14 (11.9)	14 (11.9)	1.0
With eGFR <60 ml/minute*	66 (56)	56 (47.5)	0.19
Renal replacement therapy	24 (20.3)	21 (17.8)	0.73
Sepsis	12 (10.2)	14 (11.9)	0.67
Altered sensorium	11 (9.3)	10 (8.5)	1.0

* includes patients with renal dysfunction due to acute kidney injury and/or chronic kidney disease. eGFR estimated glomerular filtration rate

TABLE II. Assessment of in-hospital diabetes management (*n*=118)

Characteristic	Pre-phase, *n* (%)	Post-phase, *n* (%)	p value (95% CI)
Determination of target blood glucose	38 (32.2)	89 (75.4)	<0.0001 (0.31–0.53)
Adequacy of glucose monitoring			
Good	25 (21.2)	56 (47.4)	<0.0001 (0.14–0.37)
Adequate	83 (70.3)	58 (49.2)	
Poor	10 (8.5)	4 (3.4)	
Sliding scale regimen alone for >72 hours	24 (20.3)	17 (14.4)	0.23 (–0.15–0.03)
Administration of correction insulin	53 (64.6)	62 (74.7)	0.24 (–0.05–0.20)
Average fasting sugar at discharge (mg/dl)	175.1	172.4	–
Mean reduction in fasting sugar (mg/dl)	113.8	141.9	0.43 (–53.7–14.86)
Patients who were aware of insulin injection technique upon discharge (*n*=98)	71 (72.5)	86 (87.8)	0.002 (0.06–0.30)
Patients who were aware of hypoglycaemic symptoms and home remedies (*n*=116)	43 (37)	71 (61.2)	<0.001 (0.11–0.35)

CI confidence interval

TABLE III. Hypoglycaemic events in hospitalized patients (*n*=118)

Hypoglycaemia	Phase 1	Phase 3	p value, (change) (CI)
Number of patients	32 (27.1)	22 (18.6)	0.12, (–0.19–0.02) (31.25% reduction)
Recurrent	12 (10.2)	4 (3.4)	0.04, (–0.14–0.00) (66.7% reduction)
Event rate	48	26	0.002, (–0.06–"0.30) (45.8% reduction)

CI confidence interval

TABLE IV. Risk factors among the patients who had hypoglycaemia

Risk factor	Hypoglycaemia		p value
	Phase 1 (*n*=32)	Phase 3 (*n*=22)	
Age >60 years	9 (31)	5 (25)	0.44
Patients nil per oral	2 (5)	1 (6)	0.38
Renal replacement therapy	17 (24)	8 (21)	0.04
GFR <60 ml/minute	22 (66)	12 (56)	0.14

GFR glomerular filtration rate

before the intervention (p<0.0001). There were no significant changes in the prescription habits of the residents. There was only a marginal improvement in the use of correctional insulin in hospitalized patients—74.7% of patients received correction insulin in phase 3 compared with 64.6% before the intervention (p=0.24). The degree of reduction in the fasting plasma glucose from baseline was higher in the post phase but it was not statistically significant. About 15% more patients were aware of the correct insulin injection technique at the time of discharge (after the intervention). Similarly, 24.2% more patients were aware of the common hypoglycaemic symptoms and home remedies at the time of discharge (after the intervention). It corresponds to an increase in awareness of insulin injection technique by 21.1% and awareness of hypoglycaemic symptoms and its home remedies by 65.1%, both of which were significant.

Assessment of hypoglycaemic events. There were 48 hypoglycaemic events in the first observational survey including three level 3 hypoglycaemic events (Table III). After the intervention, there were 26 hypoglycaemic events of which none were level 3 hypoglycaemia. A 31.3% reduction in the number of patients who had hypoglycaemia and 66.7% reduction in number of patients who had recurrent hypoglycaemia were observed among hospitalized patients after the intervention, resulting in a significant reduction in the total hypoglycaemic event rate by 45.8% (p=0.002). This reduction in hypoglycaemic events was accompanied by efficient glycaemic control of more reduction of fasting plasma glucose value of 28.1 mg/dl (1.6 mmol/L) at the time of discharge.

The various risk factors among patients who had hypoglycaemia in phase 1 and phase 3 of the study were compared (Table IV). Patients with compromised renal function, receiving renal replacement therapy and not administering correction insulin were the predominant risk factors among the patients who had experienced hypoglycaemia.

DISCUSSION

This study assessed the effectiveness of the online course on 'Diabetes care in the hospital for medicine residents'. An improvement in the residents' test scores and fasting plasma glucose control (statistically not significant) and a reduction in hypoglycaemic events were observed in this study.

Knowledge of the residents

In the pre-test, the average score secured by residents was 42.7%, which improved to 53.8% after the participation in the online course. Vaidya *et al*. also did a self-conducted study with computer-based diabetes education curriculum.[12] In that study, the baseline average score was 72.7% and improved to 87.1% after attending the course. There was an all-round improvement in the knowledge of the residents relating to symptoms of hypoglycaemia, glycaemic targets, glucose monitoring, administration of correction insulin and glycaemic management in special populations after participation in the online course. A decline in the participation of residents was noted towards the later part of the course. A significant dropout of students had been observed in most large open online courses,[13] hence it is important to constantly motivate them.

Impact on patient management

After participation in the online course, there was an improvement in the setting of individualized glycaemic targets and adequacy of glucose monitoring. There was a slight reduction in the use of sliding scale insulin and a marginal improvement in the use of corrective dose of insulin. Mixed results have been seen in the previous studies. Gomez-Huelgas *et al*. by specifically targeting implementation of basal bolus regimens in hospitalized patients with educational intervention could not show improvement in frequency of glucose monitoring.[14] They achieved significant reduction in the use of sliding scale regimen and improvement in the use of basal bolus regime (increased to 52% in the post-intervention group from 9.6%), which was not seen in this study and that by Vaidya *et al*.[12] The reason for not having an increase in use of insulin with the basal component after the intervention in this study could be due to an already high basal insulin use among residents before participation in the course.

Educational intervention studies targeting hospitalized patients with diabetes have shown an improvement in knowledge and skills but that does not seem to translate into patient outcomes, although the evidence was sparse and had mixed results.[9] With residents' participation in the online course there was an improved glycaemic control, although the difference was not statistically significant. An improvement in glycaemic control after an educational intervention has been documented by Horton *et al*., Tamler *et al*. and Rajendran *et al*.[15–17] A similar yet significant reduction in fasting blood glucose level after a standard educational programme by a trained external expert was noted in the FADOI-DIAMOND study.[18] With the

residents' participation in the online course, 31.3% reduction in the number of patients who had hypoglycaemia was observed. Similarly, there was a 66.6% reduction in the number of patients who had recurrent hypoglycaemia, thus significantly reducing the total number of hypoglycaemic events by 45.8% after intervention. The rate of hypoglycaemia has increased in some studies and decreased in some others. Horton *et al*. had shown an increase in the rate of hypoglycaemia.[15] There was no rise in the rate of hypoglycaemia in the study by Tamler *et al*. and in the FADOI-DIAMOND study (12.3 *v*. 11.9% in pre- and post-phase, respectively).[16,18] In the study by Gomez-Huelgas *et al*., a significant reduction of 68.7% and in that by Rajendran *et al*. a reduction of 37% in the incidence of hypoglycaemia was observed with educational intervention.[14,17] The increased frequency of glucose monitoring and increased awareness of the residents to prevent hypoglycaemia would have contributed to this.

After residents' participation in the online course, patients' knowledge regarding their disease had significantly improved. More patients had received education on insulin administration, were aware of common hypoglycaemic symptoms and its home remedies after the intervention. A similar finding of significant improvement in patients' knowledge and skills related to the care of patients with diabetes was also seen by Ali after implementation of a nursing care education programme.[19]

The limitations of our study include: (i) it was a single institution study; (ii) to compare the knowledge of residents before and after participation in the course, the same set of questions were used in the pre-test and post-test. There is a possibility that awareness of the questions may have artificially contributed to the improvement in scores;[20] (iii) a lone metric for the assessment of glycaemic control during the hospital stay (difference in the fasting plasma glucose between admission and discharge) was used. However, measurement of the time spent in the target range with the use of continuous glucose monitoring system is a more robust measure for assessing the efficacy of in-hospital glycaemic control; and (iv) long-term sustainability of the improvements in residents' knowledge and patient outcomes after implementation of the online course still has to be determined.

Conclusion

The administration of an online course increased the knowledge of residents, improved patient safety and may improve glycaemic control in hospitalized patients with diabetes.

Conflicts of interest. None declared

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