ORIGINAL ARTICLE

Self-Monitoring of Blood Glucose

Satish K. Garg¹ and Irl B. Hirsch²

Introduction

ANOTHER YEAR OF EXCITING NEW diabetes technology, another year using capillary blood glucose strips and meters. Although self-monitoring of blood glucose (SMBG) is approaching its 40th anniversary, it is still the pillar of home (and hospital) glucose monitoring for most of the world. There are some who predict SMBG will eventually evaporate—simply go away as better, more efficient ways to monitor glucose become available, but we do not believe this is the case. There are still too many countries who do not have access to SMBG and even more with minimal or no access to continuous glucose monitoring (CGM).

What are the greatest concerns as we enter 2018? First, no matter where one lives in the world, SMBG needs guaranteed accuracy. Poor-quality strips—often the only strips available in some countries—can result in dramatic alteration of insulin doses. Even in developed countries, cheaper strips that are manufactured without effective quality controls are the only strips allowed depending on the payer. This is even more concerning considering that these strips need to be used to calibrate CGMs.

Related to this, in 2017 the Diabetes Technology Society announced their blood glucose monitoring system surveillance program (1). Using the latest International Organization for Standardization standard (ISO 15197-2013) with 1035 subjects, only 6 of the 18 meters tested passed the standard. The surprising part of this is that some of the “name brand” meters did not pass, while some of the less commonly known meters did.

What is hoped for the future is more rigorous research using cloud-based SMBG data. Does immediate uploading of data to the cloud improve glycemic outcomes? Does it allow better review of glucose data by the diabetes provider during an office visit? And does combined uploading of SMBG data and insulin data from a blue-tooth-enabled “smart pen” improve outcomes and patient/physician satisfaction? The hope is that as these technologies mature the answers to these questions will become clear.

Key Articles Reviewed for the Article

Accuracy evaluation of four blood glucose monitoring systems in the hands of intended users and trained personnel based on ISO 15197 requirements

Freckmann G, Baumstark A, Jendrike N, Rittmeyer D, Pleus S, Haug C

Diabetes Technol Ther 2017; **19**: 246–254

Self-monitoring of blood glucose in non-insulin treated type 2 diabetes (The SMBG Study): study protocol for a randomized controlled trial

Parsons S, Luzio S, Bain S, Harvey J, McKenna J, Khan A, Rice S, Watkins A, Owens DR

BMC Endocr Disord 2017; **17**: 4

¹Barbara Davis Center for Childhood Diabetes, University of Colorado, Aurora, Colorado.

²University of Washington Medical Center, Seattle, Washington.

Young patients with type 1 diabetes poorly controlled and poorly compliant with self-monitoring of blood glucose: can technology help? Results of the i-NewTrend randomized clinical trial

Di Bartolo P, Nicolucci A, Cherubini V, Iafusco D, Scardapane M, Rossi MC

[Acta Diabetol 2017; 54: 393–402](#)

Efficacy of self-monitoring of blood glucose versus retrospective continuous glucose monitoring in improving glycaemic control in diabetic kidney disease patients

Yeoh EC, Lim BK, Fun S, Tong J, Yeoh LY, Sum CF, Subramaniam T, Lim SC

[Nephrology \(Carlton\) 2016 Dec 9. \[Epub ahead of print\] DOI 10.1111/nep.12978](#)

Correlation between parameters of self-monitoring of blood glucose and the perception of health-related quality of life in patients with type 1 diabetes mellitus

Paula JS, Braga LD, Moreira RO, Kupfer R

[Arch Endocrinol Metab 2017; 61: 343–347](#)

Can follow-up phone calls improve patients self-monitoring of blood glucose?

Brown-Deacon C, Brown T, Creech C, McFarland M, Nair A, Whitlow K

[J Clin Nurs 2017; 26: 61–67](#)

Association of a blood glucose test strip quantity-limit policy with patient outcomes: a population-based study

Gomes T, Martins D, Tadrous M, Paterson JM, Shah BR, Tu JV, Juurlink DN, Chu A, Mamdani MM

[JAMA Intern Med 2017; 177: 61–66](#)

Self-care disparities among adults with type 2 diabetes in the USA

Mayberry LS, Bergner EM, Chakkalakal RJ, Elasy TA, Osborn CY

[Curr Diab Rep 2016; 16: 113](#)

Usability evaluation of a blood glucose monitoring system with a spill-resistant vial, easier strip handling, and connectivity to a mobile app: improvement of patient convenience and satisfaction

Harvey C, Koubek R, Bégat V, Jacob S

[J Diabetes Sci Technol 2016; 10: 1136–1141](#)

Adherence of self-monitoring of blood glucose in persons with type 1 diabetes in Sweden

Moström P, Ahlén E, Imberg H, Hansson PO, Lind M

[BMJ Open Diabetes Res Care 2017; 5: e000342](#)

Blood glucose monitoring in type 2 diabetes – Nepalese patients' opinions and experiences

Sapkota S, Brien JE, Aslani P

[Glob Health Action 2017; 10: 1322400](#)

Clinical impact of blood glucose monitoring accuracy: an *in-silico* study

Campos-Náñez E, Fortwaengler K, Breton MD

[J Diabetes Sci Technol 2017; 11: 1187–1195](#)

Impact of self-monitoring of blood glucose log reliability on long-term glycemic outcomes in children with type 1 diabetes

Selvan C, Thukral A, Dutta D, Ghosh S, Chowdhury S

[Indian J Endocrinol Metab 2017; 21: 382–386](#)

Self-monitoring blood glucose test strip utilization in Saskatchewan: a retrospective study

Kosar L, Alsabbagh W, Lu X, Lix LM, Shevchuk Y, Teare GF, Champagne A, Blackburn DF

Can J Diabetes 2017 May 9; pii: S1499-2671(16)30818-8 [Epub ahead of print] DOI 10.1016/j.jcjd.2017.01.004

Accuracy evaluation of four blood glucose monitoring systems in the hands of intended users and trained personnel based on ISO 15197 requirements

Freckmann G, Baumstark A, Jendrike N, Rittmeyer D, Pleus S, Haug C

Institut für Diabetes-Technologie Forschungs-und Entwicklungsgesellschaft mbH an der Universität Ulm, Ulm, Germany

Diabetes Technol Ther 2017; **19**: 246–254

Background

For people with diabetes, self-monitoring of blood glucose (BG) is an essential part of their treatment regimen. For this reason, blood glucose monitoring systems (BGMS) must meet certain minimum requirements for accuracy. Unfortunately, accuracy testing is often performed by trained operators, which does not necessarily predict accuracy in the hands of lay users.

Methods

The accuracy of four distinct BGMS (Accu-Chek Active, Accu-Chek Performa, ContourPlus, and OneTouch SelectSimple) was evaluated in the hands of trained personnel and lay users. Procedures were based on International Organization for Standardization (ISO) 15197:2013, clause 8, requirements. BGMS measurements made by trained and lay users were compared with those obtained from a glucose oxidase and a hexokinase laboratory analyzer. All usage errors made by lay users were documented. Assessments of accuracy were conducted using ISO 15197:2013/EN ISO 15197:2015 criteria (percentage of results within ± 15 mg/dL or $\pm 15\%$), more stringent criteria (10 mg/dL or 10%, and 5 mg/dL or 5%, respectively), and ISO 15197:2003 system accuracy criteria.

Results

Independent of the operator, the level of accuracy differed among the four BGMS assessed. One system had less than 95% of the values within each of the limits, and one exhibited marked differences in accuracy when used by either lay users or trained personnel. The most common errors made by lay users were failing to check the test strip code, incorrectly applying blood to the strip, and not using the blood drop immediately.

Conclusions

The accuracy of BGMS can differ when used by either trained personnel or lay users; therefore, it is important that

BGMS manufacturers provide systems that are easy to use and as insensitive to operator errors as technically possible.

Comments

There are several glucose meters available in the marketplace. Most of them perform fairly well; however, some meters do not go through rigorous testing and thus real-life results may be different. The first abstract highlights the marked differences with four different BGMS in terms of errors, incorrect application of blood, and not using the blood drop immediately. The authors conclude by an important statement that manufacturers should provide BGMS that are insensitive to operator errors as technologically possible.

In addition, I debate the need for new companies making new meters available, as the need for SMBG may go down with better availability of CGM, especially those that last longer (up to 14 days) and need no calibrations. In addition, in late 2016 the U.S. Food and Drug Administration (FDA) approved the first G5 system, which allows data to be used to dose insulin/take treatment actions as stand-alone without confirming the glucose values by BMBG. I guess the future will tell, but data clearly indicates larger uptake of CGM and will continue to do so in the near future and thus the market size of the traditional meters will go down, though may not disappear.

Self-monitoring of blood glucose in non-insulin treated type 2 diabetes (The SMBG Study): study protocol for a randomized controlled trial

Parsons S¹, Luzio S¹, Bain S¹, Harvey J², McKenna J¹, Khan A³, Rice S⁴, Watkins A⁵, Owens DR¹

¹Diabetes Research Unit, Swansea University, Institute of Life Sciences, Singleton Park, Swansea, UK; ²Diabetes Centre, Wrexham Maelor Hospital, Betsi Cadwaladr University Health Board, Wrexham, UK; ³Diabetes Centre, Glangwili Hospital, Hywel Dda University Health Board, Carmarthen, UK; ⁴Diabetes Centre, Prince Philip Hospital, Hywel Dda University Health Board, Llanelli, UK; ⁵Swansea Trials Unit, Swansea University, Swansea, UK

BMC Endocr Disord 2017; **17**: 4

Background

For patients with non-insulin-treated type 2 diabetes, the benefit of self-monitoring of blood glucose (SMBG) is unclear, and randomized controlled trials have returned inconsistent evidence, which only adds to the continued debate. Variations in study population and design, including the

SMBG intervention, have contributed to the lack of consistent findings. Structured SMBG is a system in which both health-care provider and the patient with diabetes are taught to detect patterns of glycemic abnormality and perform any necessary actions according to the BG profiles. This system can benefit patients in terms of lowering hemoglobin A1c (HbA1c) and increasing overall well-being. However, regardless of these potential benefits, guidelines issued by many national health agencies still restrict the use of SMBG in non-insulin-treated type 2 diabetes.

Methods

The SMBG Study is a multicenter, 12 month, randomized controlled trial in adults with established type 2 diabetes who have poor glycemic control (HbA1c ≥ 58 mmol/mol [7.5%]) and are not on insulin therapy. Participants will be randomized into one of three comparative groups: Group 1, the control group, will receive routine diabetes care; Group 2 will adopt structured SMBG treatment with clinical review every 3 months; and Group 3 will begin structured SMBG treatment with added telecare support provided once per month from a trained study nurse. A total of 450 patients from 16 primary and secondary care sites throughout Wales and England will be included in the study. HbA1c at 12 months will be the primary outcome measure. Secondary outcome measures will include weight, total cholesterol, body mass index, and HbA1c levels at 3, 6, 9, and 12 months.

Throughout the year-long study, investigators will monitor participant well-being as well as their attitude toward SMBG. Recruitment began in December 2012, with the last participant visit due in September 2016.

Discussion

This study will attempt to determine whether structured SMBG benefits to patients with poorly controlled type 2 diabetes receiving non-insulin treatment. The data will also clarify whether telecare support provides additional value to patients. Finally, the study will analyze the overall acceptability of SMBG as a tool for self-management of type 2 diabetes.

Young patients with type 1 diabetes poorly controlled and poorly compliant with self-monitoring of blood glucose: can technology help? Results of the i-NewTrend randomized clinical trial

Di Bartolo P¹, Nicolucci A², Cherubini V³, Iafusco D⁴, Scardapane M², Rossi MC²

¹AUSL Diabetes Unit Romagna, Ravenna, Italy; ²COR-ESSEARCH – Center for Outcomes Research and Clinical Epidemiology, Pescara, Italy; ³Department of Pediatrics, Polytechnic University of Marche, Ancona, Italy; ⁴Department of Pediatrics, Second University of Naples, Naples, Italy

Acta Diabetol 2017; **54**: 393–402

Aims

The iBGStar + DMAP (experimental meter + telemedicine system) was compared with a traditional glucose meter (Control) in adolescents/young adult patients with type 1 diabetes.

Methods

i-NewTrend was a multicenter, open-label, randomized trial involving adolescents/young adults (14–24 years old) being treated with basal-bolus insulin, who have glycated hemoglobin (HbA1c) values $\geq 8.0\%$ and are poorly compliant with SMBG (i.e., $< 30\%$ of the recommended frequency). Change in HbA1c and SMBG compliance (achieving $\geq 30\%$ of the recommended frequency) after 6 months were primary endpoints. Quality of life was also evaluated. An observational phase in which both groups used the experimental device was carried out after the trial.

Results

A total of 182 patients were included in the trial (51.1% male; age 17.7 ± 3.0 years; diabetes duration 8.8 ± 4.7 years; HbA1c levels $10.0 \pm 1.4\%$). Participants were randomly assigned to iBGStar (n=92) and to Control (n=90). Dropout rates were 6.5% for iBGStar and 8.9% for Control. At the end of 6 months, HbA1c change ($\pm$ SE) in iBGStar was $-0.44 \pm 0.13\%$ and in Control, $-0.32 \pm 0.13\%$ ($P=0.51$). HbA1c changes in the posttrial phase (changes from 6 months; $\pm$ SE) were $-0.07 \pm 0.14\%$ in iBGStar and $-0.31 \pm 0.14\%$ in Control ($P=0.24$). The compliance endpoint was reached by 53.6% in iBGStar and 55.0% in Control ($P=0.86$). In both groups there was an increase from 1.1 to 2.3 for mean daily SMBG measurements, without decreasing quality of life. Reduction in HbA1c levels was greater in compliant subjects ($-0.60 \pm 0.23\%$ in iBGStar; $-0.41 \pm 0.21\%$ in Control; $P=0.31$). Within the iBGStar group, subjects who used telemedicine (38.0%) reduced HbA1c by $-0.58 \pm 0.18\%$.

Conclusions

We found that iBGStar was not superior to the traditional meter. Irrespective of strategy, increasing the number of SMBG tests from one to two per day was associated with HbA1c reduction in both groups, without pharmacologic interventions. Identifying new technologies that are effective and acceptable to patients is an option for improving adherence to diabetes care.

Efficacy of self-monitoring of blood glucose versus retrospective continuous glucose monitoring in improving glycaemic control in diabetic kidney disease patients

Yeoh EC¹, Lim BK², Fun S¹, Tong J¹, Yeoh LY³, Sum CF¹, Subramaniam T¹, Lim SC¹

¹Diabetes Centre, Singapore; ²Clinical Research Unit, Singapore; ³Department of Renal Medicine, Khoo Teck Puat Hospital, Singapore

Nephrology (Carlton) 2016 Dec 9. [Epub ahead of print] DOI [10.1111/nep.12978](https://doi.org/10.1111/nep.12978)

Aims

Patients with diabetic kidney disease (DKD) who are taking antidiabetic medications are at higher risk of both hypoglycemia and hyperglycemia. The 3-month study compares glycemic control (via HbA1c levels) and hypoglycemia incidence in subjects with stage 3 DKD [estimated glomerular filtration rate = $30\text{--}60$ mL/(min $\cdot$ 1.73 m²)], receiving retrospective CGM-guided antidiabetic therapy vs. self-monitoring of blood glucose (SMBG).

Methods

Thirty patients with HbA1c > 8% were randomly assigned to 6-day retrospective CGM (n = 14) or SMBG (n = 16). In the CGM group, CGM was worn at the beginning and at 6 weeks. At baseline and 3 months, HbA1c levels and hypoglycemia events (self-reported and BG < 4 mmol/L from CGM/SMBG data) were assessed, and any necessary medication adjustments were made. Education on hypoglycemia avoidance was provided to all participants.

Results

Mean ($\pm$ SD) estimated glomerular filtration rate for all participants was 42.9 ± 10.3 mL/min. A majority of the participants (86.7%) had been diagnosed with diabetes > 10 years prior to the study, and most (90%) of participants were on insulin therapy. From baseline to 3 months, HbA1c improved significantly, from $9.9 \pm 1.2\%$ to $9.0 \pm 1.5\%$ ($P < 0.001$), with no difference between groups (CGM, $9.8 \pm 1.2\%$ to $8.8 \pm 1.8\%$, $P = 0.009$; SMBG, $9.9 \pm 1.3\%$ to $9.1 \pm 1.1\%$, $P = 0.007$; $P = 0.869$ between groups). In the CGM group, percentage of time spent in hyperglycemia (BG > 10 mmol/L) decreased from baseline to 6 weeks ($65.4 \pm 22.4\%$ to $54.6 \pm 23.6\%$, $P = 0.033$), while there was a nonsignificant rise for hypoglycemia ($1.2 \pm 2.2\%$ to $4.0 \pm 7.0\%$, $P = 0.176$). There was no difference in self-reported and documented hypoglycemia events.

Conclusions

In this pilot study of DKD patients, short-term episodic use of CGM reduced time spent in hyperglycemia range without significantly increasing time-exposure to hypoglycemia. However, both CGM and SMBG were equally effective in improving glycemic control.

Comments

The first abstract is a rehash of a previous study evaluating the role of structured testing for SMBG in subjects with type 2 diabetes (T2D) not on insulin therapy. The second abstract highlights the role of a mobile phone with the iBGStar meter app. When ease of use is factored in in type 1 diabetes (T1D), it improves compliance and outcomes in patients with T1D. The third abstract compares the role of CGM-retrospective vs. SMBG in a small number of patients with diabetic kidney disease. Even though the data from CGM was retrospective in nature, it improved time in range with significant reduction of hypoglycemia when compared with SMBG. It is difficult to conceive that as the retrospective data from CGM vs. real-time SMBG data. Both of the options had similar glucose control.

Correlation between parameters of self-monitoring of blood glucose and the perception of health-related quality of life in patients with type 1 diabetes mellitus

Paula JS, Braga LD, Moreira RO, Kupfer R

Serviço de Diabetes, Instituto Estadual de Diabetes e Endocrinologia Luiz Capriglione (IEDE), Rio de Janeiro, RJ, Brasil

Arch Endocrinol Metab 2017; **61**: 343–347

Objective

A prospective study in adults with type 1 diabetes mellitus (T1D) was conducted to evaluate different parameters of short-term glycemic control and how they correlate with patients' perception of health-related quality of life (HRQoL).

Subjects and Methods

A total of 50 T1D patients (18–50 years of age) participated in the study. After 30 days of self-monitoring of blood glucose (SMBG), participants were evaluated with the questionnaires Problem Areas in Diabetes (PAID) scale and Diabetes Quality of Life (DQOL) measure. Glycated hemoglobin (HbA1c) was used to measure glycemic control, along with mean glucose levels (MGL) in data from the prior 30 days of SMBG (Accu-Chek 360°), glycemic variability (GV), and number of hypoglycemic episodes (< 70 mg/dL and < 50 mg/dL).

Results

Correlation analysis revealed that PAID was positively correlated with MGL ($r = 0.52$; $P < 0.001$) and HbA1c ($r = 0.36$; $P < 0.0097$); however, it was not positively correlated with either GV ($r = 0.17$; $P = 0.23$) or number of hypoglycemic episodes ($r = 0.15$; $P = 0.17$ for glucose < 70 mg/dL and $r = 0.02$; $P = 0.85$ for glucose < 50 mg/dL). After multiple linear regressions, only MGL remained independently related to PAID scores. Correlation analysis for DQOL revealed a positive correlation with MGL ($r = 0.45$; $P = 0.001$) only; DQOL was not positively related with HbA1c ($r = 0.23$; $P = 0.09$), number of hypoglycemic episodes ($r = 0.06$ $P = 0.68$), or GV ($r = 0.20$; $P = 0.16$).

Conclusion

Our analysis showed that MGL is the glycemic control parameter best correlated with short-term perception of HRQoL in T1D patients.

Can follow-up phone calls improve patients self-monitoring of blood glucose?

Brown-Deacon C¹, Brown T¹, Creech C¹, McFarland M¹, Nair A², Whitlow K²

¹Department of Nursing, University of Michigan-Flint, Flint, MI; ²Department of Internal Medicine, Henry Ford Hospital, Detroit, MI

J Clin Nurs 2017; **26**: 61–67

Background

Previous studies have shown the effectiveness of telephone intervention in improving patients' self-management of diabetes and other chronic disease conditions. With the overall goal of lowering hemoglobin A1c (HbA1c), the aim of this study was to assess the effectiveness of follow-up phone calls in improving the frequency of self-monitoring of blood glucose levels in two groups of patients with type 2 diabetes.

Methods

Forty-one patients with type 2 diabetes (HbA1c $\geq 7.5\%$) were included in this 3 month quality improvement study.

Participants were assigned to two groups: Group 1 received standard diabetic care, and Group 2 received standard diabetic care as well as follow-up phone calls within 2 weeks after their monthly visit to the internal medicine clinic. If indicated, HbA1c was done at the initial study visit.

Results

There were no statistically significant differences in either baseline or 3 month HbA1c levels between the two groups. Differences in mean HbA1c change between Group 1 and Group 2 were not statistically significant. Additionally, analysis revealed no statistically significant differences between groups 1 and 2 in the number of subjects who kept logs of their self-monitored blood glucose readings during the study.

Conclusion

Intervention via follow-up calls did not result in a statistically significant improvement in overall HbA1c; however, within Group 2, who received follow-up phone calls, there was a clinically significant change in HbA1c.

Relevance to Clinical Practice

The clinical significance of the change in HbA1c in Group 2 (received follow-up phone calls) supports the hypothesis that frequent telephone contact may likely improve adherence to diabetes self-management.

Association of a blood glucose test strip quantity-limit policy with patient outcomes: a population-based study

Gomes T^{1,2,3,4}, Martins D², Tadrus M^{1,2,3}, Paterson JM^{2,4,5}, Shah BR^{2,4,6,7}, Tu JV^{2,4,7,8}, Juurlink DN^{2,4,6,7,9}, Chu A^{2,7}, Mamdani MM^{1,2,3,4,7,10}

¹Li Ka Shing Knowledge Institute, St. Michael's Hospital, Toronto, Ontario, Canada; ²The Institute for Clinical Evaluative Sciences, University of Toronto, Toronto, Ontario, Canada; ³Leslie Dan Faculty of Pharmacy, University of Toronto, Toronto, Ontario, Canada; ⁴Department of Health Policy, Management, and Evaluation, University of Toronto, Toronto, Ontario, Canada; ⁵Department of Family Medicine, McMaster University, Toronto, Ontario, Canada; ⁶Department of Medicine, Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada; ⁷Department of Medicine, University of Toronto, Toronto, Ontario, Canada; ⁸Schulich Heart Centre, Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada; ⁹Department of Pediatrics, University of Toronto, Toronto, Ontario, Canada; ¹⁰St. Michael's Hospital, Toronto, Ontario, Canada

JAMA Intern Med 2017; **177**: 61–66

Background

Due to the high cost of blood glucose test strips, payers have introduced reimbursement quantity limits. The effect these limits have on patient outcomes is unknown. This study investigated whether the introduction of such quantity limits in August 2013 was associated with changes in patients' clinical outcomes.

Methods

From April 2008 to March 2015, a cross-sectional time series analysis was conducted in adult (≥ 19 years of age) residents of Ontario, Canada, with diabetes who were eligible for public drug coverage. Sensitivity analysis was used to study high-volume users of test strips, i.e., those most likely to be affected by quantity limits. Participants were divided into four distinct groups based on the method of diabetes therapy they were using: nonhypoglycemia-inducing oral diabetes agents, hypoglycemia-inducing oral diabetes agents, insulin, and no drug therapy. Emergency department visits for hypoglycemia or hyperglycemia was the primary outcome, while mean hemoglobin A1c (HbA1c) levels was the secondary outcome. Outcomes for all patients were measured each quarter, stratified by age group (< 65 years vs. ≥ 65 years) and diabetes therapy.

Results

In all, 834,309 people met the inclusion criteria. During the study period, rates of hypoglycemia and hyperglycemia decreased from 4.9 to 3.0 visits per 1000 Ontario drug benefit (ODB)-eligible patients and 4.2 to 3.6 visits per 1000 ODB-eligible patients, respectively, for patients < 65 years of age, and it was not significantly associated with the implementation of test strip quantity limits ($P=0.67$ and $P=0.37$, respectively). Rates of hypoglycemia and hyperglycemia also dropped for patients ≥ 65 years of age, from 2.9 to 1.3 visits per 1000 eligible patients and from 0.8 to 0.5 visits per 1000 eligible patients, respectively; these rates were also not significantly associated with implementation of quantity limits ($P=0.12$ and $P=0.24$, respectively). Results for mean HbA1c levels and in the sensitivity analysis also showed no significant association.

Conclusions

We found no association between the introduction of reimbursement quantity limits for blood glucose test strips and worsened short-term outcomes. These results suggest that test strip quantity limits can reduce costs without harming patients.

Self-care disparities among adults with type 2 diabetes in the USA

Mayberry LS^{1,2}, Bergner EM^{1,2}, Chakkalakal RJ^{1,3}, Elasy TA^{1,3}, Osborn CY^{1,2}

¹Center for Health Behavior and Health Education, Center for Diabetes Translation Research, Division of General Internal Medicine and Public Health, Vanderbilt University Medical Center, Nashville, TN; ²2525 West End Ave. Suite 370, Nashville, TN; ³1215 Twenty-First Ave South, Ste 6000, MCE North Tower, Nashville, TN 37232-8300

Curr Diab Rep 2016; **16**: 113

Background

Suboptimal glycemic control is more common among Hispanics and non-Hispanic blacks (NHBs) than non-Hispanic whites (NHWs). Disparities in the performance of self-care behaviors may contribute to this.

Methods

To synthesize knowledge on current self-care disparities, we reviewed studies from January 2011 through March 2016 that included NHWs, NHBs, and Hispanics with type 2 diabetes in the United States. Self-care behaviors included diet, exercise, medications, self-monitoring of blood glucose (SMBG), self-foot exams, and not smoking. Of 1241 articles identified in PubMed, 25 met our inclusion criteria.

Results

These studies report consistent disparities in medication adherence. Surprisingly, we found consistent evidence of no disparities in exercise and some evidence of reverse disparities: compared with NHWs, Hispanics had healthier diets and NHBs had more regular SMBG. Consistent use of validated measures could further inform disparities in diet and exercise.

Conclusions

Additional research is needed to test for disparities in self-foot exams, smoking behavior, and diabetes-specific problem solving and coping.

Usability evaluation of a blood glucose monitoring system with a spill-resistant vial, easier strip handling, and connectivity to a mobile app: improvement of patient convenience and satisfaction

Harvey C¹, Koubek R², Bégat V¹, Jacob S³

¹Department of Mechanical and Industrial Engineering, Louisiana State University, Baton Rouge, LA; ²Louisiana State University, Baton Rouge, LA; ³Cardio Metabolic Institute, Villingen-Schwenningen, Germany

J Diabetes Sci Technol. 2016; **10**: 1136–1141

Background

Self-monitoring of blood glucose (SMBG) is essential for proper management of diabetes mellitus. This study assessed the usability of the Accu-Chek Guide Meter, which includes features meant to increase usability and reduce handling problems, such as easier strip handling, a spill-resistant vial, and wireless connectivity to a mobile app.

Methods

A total of 197 participants from the United States and France were included in the study. Participants completed typical blood glucose testing tasks on the Accu-Chek Guide Meter and were able to review data such as last result, patterns, and target percentage on the meter and on the mobile app, after which they were asked to evaluate their experience. Participants evaluated their experience by completing a human factors usability survey rating 34 market statement questions using a 6-point scale (1 = strongly disagree, 6 = strongly agree).

Results

A Pearson chi-square proportions test was done for each of the 34 questions on the market statement survey. The results revealed a significant difference ($P < 0.0001$) between the disagree (1–3) and agree (4–6) responses. Participants responses were overwhelmingly positive, rating every aspect of

the system, including the test strips, strip vial, and data analysis on the meter as well as the mobile app, to be a good lifestyle fit and to provide a superior testing experience.

Conclusions

Participants in both the United States and France overwhelmingly rated the usability of new meter system as superior to their current meters.

Comments

The first abstract highlights different outcome measures in T1D. Short-term perception of HRQoL was best correlated with mean blood glucose levels. It is obvious that frequent contacts with patients by care providers may improve outcomes. Thus, a phone contact in the second abstract documented improved adherence. The third study is an important one from Canada, where the number of strips were limited for patients with T2D. The authors conclude that there was no difference in the short-term outcomes, suggesting that these policies can help reduce the cost associated with test strips. Healthcare disparities continue, and is the topic for the next abstract. This is a review article from 1241 articles from PubMed where 25 met the criterion. Almost all studies concluded the same, and thus future goals must include how to remove such barriers.

Adherence of self-monitoring of blood glucose in persons with type 1 diabetes in Sweden

Moström P¹, Ahlén E^{2,3,4}, Imberg H^{5,6}, Hansson PO⁴, Lind M^{3,4}

¹Department of Internal Medicine, Alingsås Lasarett, Alingsås, Sweden; ²Department of Medicine, Värnamo Hospital, Värnamo, Sweden; ³Department of Medicine, NU Hospital Group, Uddevalla, Sweden; ⁴Department of Molecular and Clinical Medicine, Institute of Medicine, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden; ⁵Statistiska Konsultgruppen, Gothenburg, Sweden; ⁶Department of Mathematical Sciences, Chalmers University of Technology and the University of Gothenburg, Gothenburg, Sweden

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Objective

The primary objective of the study was to determine what proportion of patients with type 1 diabetes self-monitor their blood glucose according to guidelines. Additionally, we examined possible predictors for good SMBG adherence as well as rationales for nonadherence, and the connection between SMBG frequency and glycated hemoglobin (HbA1c).

Methods

In this survey-based cross-sectional study, questionnaires were distributed randomly to 600 patients from five hospitals and clinics. Of these 600 patients, 314 patients met the criteria (≥ 18 years of age, diagnosis of type 1 diabetes, and not currently using continuous glucose monitoring) and were included in the study. Data analysis was performed separately

for the three sites at which $\geq 70\%$ of respondents were included in the study.

Results

Overall, 138 of 314 study participants (43.9% [95% CI 38.5%–49.4%]) completed SMBG ≥ 4 times daily. Results were similar for the three clinics at which $\geq 70\%$ of those surveyed were included in the analysis: 41.3% [34.7%–47.8%] performed SMBG ≥ 4 times per day. For participants from all clinics, the top three reasons for not performing SMBG more frequently were not remembering, lack of time, and self-consciousness. SMBG frequency was associated with HbA1c levels ($P < 0.0001$). Thirty percent of participants believed that health-care providers recommended SMBG be done ≤ 3 times per day.

Conclusions

Results of this study show that in Sweden $< 50\%$ of patients follow guidelines recommending SMBG ≥ 4 times per day, even though glucose meters and strips are generally available and free. Based on these findings, further support for patients to perform SMBG and increased availability of other glucose monitoring tools are called for.

Comments

Two common themes can be noted regarding this paper from Sweden. First, as in the United States, frequency of SMBG is associated with HbA1c levels (2). Second, many patients with type 1 diabetes do not see the utility of frequent testing, and excuses are made to rationalize the behavior. This is despite the meters and strips being provided at no cost. The technology itself is unlikely to improve in terms of convenience and accuracy, and despite the more widespread use of CGM, outcomes are still related to patient behaviors. As we approach the end of our third full decade of SMBG, it seems clear that technologies that minimize dependence on behavior could potentially improve outcomes in large numbers of patients with type 1 diabetes.

Blood glucose monitoring in type 2 diabetes – Nepalese patients' opinions and experiences

Sapkota S¹, Brien JE^{1,2}, Aslani P¹

¹Faculty of Pharmacy, The University of Sydney, Sydney, NSW, Australia; ²St. Vincent's Hospital Clinical School, UNSW, Sydney, NSW, Australia

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Background

Blood glucose monitoring is integral to diabetes care. In clinical practice, blood glucose monitoring is commonly conducted either at home by patients using glucometers or in laboratories by professionals. This study explored the perceptions and practices of blood glucose monitoring in Nepalese patients with diabetes.

Methods

Forty-eight Nepalese patients with type 2 diabetes were included in the study. Participants completed in-depth, face-

to-face interviews in Sydney, Australia, and Kathmandu, Nepal. Each interview was audio recorded, transcribed word for word, and thematically analyzed.

Results

Participants in Australia saw home monitoring of blood glucose as useful and completed home as well as laboratory monitoring at relatively regular intervals. In Nepal, most participants used the laboratory as their primary method of day-to-day monitoring, with only a small portion of patients monitoring blood glucose at home. Easy access to laboratories, little faith in glucometers, and the idea that home monitoring is more expensive all contributed to this behavior. However, monitoring was irregular in Nepal overall. The Australian health-care system enables less expensive self-monitoring of blood glucose, and Nepalese patients in Australia tended to better understand the purpose of home monitoring.

Conclusions

A disparity exists in perceptions and practices related to blood glucose monitoring. To facilitate regular monitoring of blood glucose, it is crucial for patients to understand the importance of blood glucose monitoring and for them to have access to affordable resources. Patient and health-system factors both are key to guaranteeing continued diabetes monitoring and management.

Comments

While the importance of access to diabetes supplies has always been acknowledged, understanding the role of this technology is also important. This report highlights how some cultures are still in need of very basic education. Affordability and a clearer understanding of the role of SMBG are still challenges in many places.

Clinical impact of blood glucose monitoring accuracy: an *in-silico* study

Campos-Náñez E¹, Fortwaengler K², Breton MD¹

¹Center for Diabetes Technology, University of Virginia, Charlottesville, VA; ²Roche Diabetes Care, Mannheim, Germany

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Background

Glycemic control is central to the management of diabetes, and to maintain this control patients rely on blood glucose (BG) monitoring devices. With the increasing accuracy of some self-monitoring devices, it has become crucial to understand how the accuracy of these systems is related to clinical outcomes, and to determine the potential benefits of analytical accuracy.

Methods

This 30-day *in silico* study included patients with type 1 diabetes mellitus using continuous subcutaneous insulin infusion therapy and an assortment of BG meters and was

carried out using the FDA-approved University of Virginia/Padova Type 1 Simulator. Simulated meter models were constructed from publicly available data regarding the characteristics of the 43 commercial meters. We controlled random events in each parallel run to isolate clinical performance differences that are directly associated with characteristics of each meter.

Results

Our analysis clearly showed a significant and inverse effect of meter systematic bias on HbA1c ($P < 0.01$). Meter systematic bias also affects the number of severe hypoglycemia events. Meter error, which is defined as the portion of measurements beyond 5% of the true value, does act as a predictor of severe hypoglycemia events ($P < 0.01$), but without meter bias, error has a nonsignificant effect on HbA1c. Bias and error both have significant effects on total daily insulin and on the required number of daily glucose measurements ($P < 0.01$). Furthermore, these relationships can be accurately modeled using linear regression on meter bias and error.

Conclusions

Bias and error are two components of glucose meter accuracy that definitely affect clinical outcomes. The results showed that error has little effect on HbA1c but tends to raise the number of severe hypoglycemia episodes. Meter bias exhibited a significant effect on all metrics: a positive systemic bias will reduce HbA1c, but it will increase the number of severe hypoglycemia attacks, total daily insulin use, and the daily number of finger sticks.

Comments

Up until now, blood glucose meters have mostly been rated in terms of error around the mean. It would be more informative, however, for meter companies to report both error and bias for a more complete assessment of meter accuracy.

Impact of self-monitoring of blood glucose log reliability on long-term glycemic outcomes in children with type 1 diabetes

Selvan C¹, Thukral A², Dutta D³, Ghosh S², Chowdhury S²

¹Department of Endocrinology, M.S. Ramaiah Medical College, Bengaluru, Karnataka, India; ²Department of Endocrinology and Metabolism, Institute of Postgraduate Medical Education and Research, Seth Sukhlal Karnani Memorial Hospital, Kolkata, West Bengal, India; ³Department of Endocrinology, Post Graduate Institute of Medical Education and Research, Dr. Ram Manohar Lohia Hospital, New Delhi, India

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Background

When modulating insulin regimens, which aid in achieving glycemic control in type 1 diabetes mellitus (T1DM), self-monitoring of blood glucose (SMBG) logbooks are useful. Discrepancies in SMBG charting, however, may impede their

utility. This study evaluated the accuracy of SMBG log entries and its effect on long-term glycemic control.

Methods

The study included 101 children with T1DM. Logged entries of SMBG were compared with values stored in glucometer memory and discrepancies were evaluated. Over a period of 44 months, the relationship between these discrepancies and HbA1c was assessed.

Results

In 32.67% of participating children, glucose charting errors were found. The most common error found was omission (42.42%), which was followed by fabrication (27.27%) and erroneous (18.18%) values and others (12.12%). There was no significant difference in age among children having accurate vs. inaccurate SMBG logs. During 44 months of follow-up, patients with accurate SMBG logs consistently had lower HbA1c than children with inaccurate logs, this relationship was statistically significant at 4, 16, 20, and 28 month follow-ups. The same was found for the proportion of children who achieved HbA1c < 7% and 7–9%. Fourteen patients had logbook omissions: 9 omitted only high values, 3 had omissions only of low values, 1 had both high and low value omissions, and 1 had omissions of normal values. Among logs with fabrication, in 2 of 9 incidents, parents were responsible for the fabricated value. In the other 7, the child was responsible. Children with fabricated values consistently had the highest HbA1c values among all types of inaccurate BG chartings, and this was statistically significant at 32 and 36 month follow-ups.

Conclusions

At our center, there is a significant problem regarding SMBG log reliability among children with T1DM. On long-term follow-ups, children with accurately logged SMBG values tended to have better glycemic control.

Comments

Logbook SMBG reliability is not a new concern—this problem was present in the days prior to SMBG with urine glucose testing. This is why the review of glucose records should routinely include both written and downloaded glucose values from an SMBG meter (or CGM). While there are some disadvantages for routine SMBG written logbooks, some believe it encourages patients to think more about each insulin dose. In adults, some will agree to write down the majority of their glucose records, but in the pediatric population most children/adolescents find this difficult to impossible. A good compromise is for patients to write down their records 3–5 days prior to their visit so that both written logs and the download can be reviewed. It is interesting how blood sugars tend to improve during the period of writing them all in a logbook.

Self-monitoring blood glucose test strip utilization in Saskatchewan: a retrospective study

Kosar L¹, Alsabbagh W², Lu X³, Lix LM⁴, Shevchuk Y¹, Teare GF³, Champagne A⁵, Blackburn DF¹

¹College of Pharmacy and Nutrition, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; ²School of Pharmacy, University of Waterloo, Waterloo, Ontario, Canada; ³Health Quality Council, Saskatoon, Saskatchewan, Canada; ⁴Department of Community Health Sciences, University of Manitoba, Winnipeg, Manitoba, Canada; ⁵Drug Plan and Extended Benefits Branch, Saskatchewan Ministry of Health, Regina, Saskatchewan, Canada

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Objectives

This study describes trends in the utilization and cost of blood glucose test strips (TSs) in Saskatchewan, Canada.

Methods

Using population-based health administrative databases, a retrospective analysis of TS use in Saskatchewan between January 1, 1996, and December 31, 2013, was conducted. Data regarding the annual number of TS dispensations, strips dispensed, and unique beneficiaries as well as the total costs were gleaned from the prescription drug database. Analysis at the patient level was also completed to describe the patterns (i.e., light, moderate, or heavy) of TS use by the full cohort and by diabetes treatment. Based on the most recent data (2013), an estimate of potential cost savings resulting from a newly implemented restriction policy were also estimated.

Results

Between 1996 and 2013, there was a dramatic increase in TS usage, in terms of both number of users and average number of TSs received. The percentage of light TS users (those receiving <4 per week) decreased by 20%, while the percentage of heavy users (those receiving >8 TSs per week) increased by 19%. At least one-third of all users, irrespective of treatment type, were classified as heavy TS users. Additionally, a 30% decline in the use of high-risk oral hypoglycemic medications among all TS users was observed during the same time period.

Conclusions

Had the newly imposed TS coverage limits been in place in 2013, the costs of strips exceeding those limits in Saskatchewan would have totaled \$2.5 million. Although TS utilization is within paradigms of chronic disease care, the significant costs and lack of evidence regarding patient outcomes calls for better strategies for reducing unnecessary use.

Comments

This interesting report spans 17 years; in 1996, the main results of the United Kingdom Prospective Diabetes Study (UKPDS) had not been released, and in most developed countries HbA1c levels were higher than they are now. In this study, there is no mention of glycemic control or hypoglycemia during the study period. This

is particularly important in the type 2 population, since evidenced-based treatment targets were not released until after publication of the UKPDS. In more recent years, hypoglycemia risk theoretically was reduced with the use of more nonsulfonylureas, yet this possibly could have been overshadowed by more aggressive insulin use with lower glucose targets. Most of the research on the utility of SMBG in non-insulin-treated type 2 diabetes had not been reported at the beginning of this study. It is difficult to criticize policy from a different era.

Closing Remarks

What takeaways about SMBG do we have as we enter 2018? First, traditional glucose testing will not be replaced by CGM anytime soon, if ever. Some of the most commonly used meters are not as accurate as we may have thought, and accuracy has become a more important metric. We still struggle with population-based assessments (and value) of the efficacy of SMBG in type 2 diabetes, but also in type 1. Ideal frequency of SMBG in adults with type 2 diabetes cannot be generalized, while reliability of SMBG from log-books remains problematic in children.

What do we need moving forward? In general, we need more research on the impact of cloud-based SMBG where data can be shared, perhaps with family members or health-care professionals. It will also be important to learn about the different roles of SMBG with different types of CGMs or closed-loop systems: Does going to a closed-loop or hybrid closed-loop mean a significant change in the use of glucose test strips? We are still interested in a formal randomized trial assessing the utility of patients and providers reviewing downloaded meter data. It is amazing that this formal trial has not yet occurred. Finally, the role of the glucose meter data with phone apps and blue-tooth-enabled pens acting as bolus calculators are something we have been waiting a long time for, and it seems like this technology is finally ready. Perhaps next year we will be able to report on that.

Author Disclosure Statement

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