FEATURE ARTICLE

Comparison of Two Electronic Systems for Obtaining Diabetes Care Indicators in Clinical Practice

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We compared the completeness of data captured by physicians in a diabetes outpatient clinic using a general electronic health record system versus one that was specifically geared to diabetes. Use of a diabetes-oriented data system was found to allow for greater capture of crucial variables required for diabetes care than a general electronic record and was well accepted by health care providers.

Treatment in patients living with type 2 diabetes requires multicomponent and patient-focused medical care. However, barriers, including costs, inadequate care, lack of access to the health care system, and difficulty obtaining complete medical records, pose challenges in the management of these patients (1,2). Health care technologies offer many potential benefits, including improved efficiency, improved quality of care, reduced costs, and control in terms of expanded treatment options. Furthermore, health technologies can offer patients more access to their own health status and records (3,4).

Since the implementation of electronic health record (EHR) systems, multiple studies have evaluated the utility of these electronic tools and their benefits in terms of patients' health (4). EHR systems have led to care improvements in critical clinical domains and promote adherence to recommendations for optimum diabetes management of diabetes, for which the regular assessment of blood glucose, blood pressure, and lipid levels, as well as provision of appropriate foot and eye care, are essential (5–7). Diabetes care has been found to improve significantly in response to a multicomponent intervention involving a database-linked EHR system; receiving adequate medical care reduced cardiovascular mortality by 30%, blindness by 90%, and end-stage renal disease by 50% (8).

Possible factors related to the improvement in diabetes care associated with EHR systems are the implementation of indicators or reminders within these systems that allow clinicians to easily see when biochemical studies should be performed (e.g., A1C, lipid, and microalbuminuria measurements), foot and retinal examinations should be scheduled, and evidence-based goals should be set or reviewed. Also, EHR systems have been found to promote the capture of essential information, with recording up to 84.8% of the total A1C values, 98.5% of systolic blood pressure readings, and 70.6% of LDL cholesterol values (8).

EHR systems specifically designed to improve diabetes care are not routinely used in clinical practice, especially in developing countries where the use of traditional health records is common. Implementing such an EHR system could benefit patients, health care professionals (HCPs), and health systems and provide HCPs with information to improve the quality of care they deliver. This study aimed to compare the data captured by the physicians of a diabetes outpatient clinic using a general EHR system versus a diabetes-oriented EHR system called (in Spanish) Sistema de Monitoreo Integral en Diabetes (SMID). Researchers evaluated the percentage of missing data in

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each system and HCP acceptance of the diabetes-oriented system.

Research Design and Methods

Study Setting

We designed a cross-sectional analytic study including patients who attended the diabetes outpatient clinic from July 2017 to July 2018 at the National Institute of Medical Sciences and Nutrition Salvador Zubirán (INCMNSZ) in Mexico City. The study was conducted in compliance with the principles of the Declaration of Helsinki.

Study Population

Individuals living with type 2 diabetes who were ≥18 years of age were included. Patients who were pregnant or lactating and those in whom anthropometric evaluation could not be performed (e.g., patients with an amputation or unable not able to stand up) were excluded.

Description of the Two EHR Systems

At the INCMNSZ, a general electronic record (GER) system is used in all clinics. It has an open format without prespecifying any mandatory variables related to specific diseases. The SMID, in contrast, is a technological tool linked to a database in an open electronic portal, in which users register in real-time the data generated in the care of patients with diabetes.

Pre-specified variables in the SMID include glucose, A1C, creatinine, lipid profile, liver function tests (i.e., ALT, AST, and γ-glutamyl transferase [GGT]), and albumin/creatinine ratio (ACR). Anthropometric evaluation requires registering waist circumference, weight, and height. The SMID automatically calculates BMI. Clinical assessment variables include vital signs (i.e., blood pressure and heart rate) and foot exam findings. Physical activity (i.e., evaluating the type of exercise [i.e., aerobic, resistance, or both] and minutes performed per week), nutritional plan, barriers to achieve treatment adherence, mental health, grieving, and motivational stages are also evaluated during the consultation. Supplementary Table S1 shows the set of variables recorded in each visit.

Comparison of the Two EHR Systems

Physicians received a 60-minute training on use of the SMID and were provided with a username and password. They were asked to record patients' clinical visits in the SMID.

To compare the information captured using both systems and avoid bias, physicians recorded variables in the SMID during each consultation. This information was compared with the data recorded in the previous visit using the conventional GER system.

Researchers further explored HCP acceptance of the SMID via a questionnaire designed for this purpose. This survey consisted of 17 questions: 1 question to collect contact information, 15 multiple-choice questions on demographics and impressions of the SMID, and 1 open-ended question in which respondents could suggest changes to the SMID. The questionnaire covered aspects of the SMID-user interface such as the amount of time respondents used the system and their impressions of its usefulness, attractiveness, and ease of use. The full questionnaire is presented in Supplementary Table S2.

Statistical Analysis

Continuous data are reported as mean ± SD or median (interquartile range [IQR]) according to normal distribution evaluated with the Kolmogorov-Smirnov test. Frequency distribution is presented alongside respective percentages for categorical variables. To compare differences among the frequency of reported categorical variables in the two electronic systems, we performed a χ^2 test. Statistical analyses were performed using SPSS statistical software, v. 25 (IBM Corp., Armonk, NY), and Prism software, v. 7 (GraphPad, San Diego, CA). *P* values ≤0.05 were considered statistically significant.

Results

Study Population

We included 370 consecutive patients, of whom 210 (56.8%) were women, with a median age of 62 years (IQR 53–70). Median biochemical values included fasting glucose 134 mg/dL (IQR 109.5–179.5, with 45% of the patients between 80 and 130 mg/dL) and A1C 8.5% (IQR 7.4–10.1, with 12.5% of the patients having an A1C <7%). Table 1 shows the clinical and metabolic characteristics of patients.

Comparison of SMID and GER System

In Table 2 and Figure 1, we compare the percentage of registered variables in both systems. The number of essential variables required to evaluate a patient with type 2 diabetes was higher in the SMID. The SMID automatically calculates some key parameters to evaluate therapeutic goals, including non-HDL cholesterol and BMI. These two variables were recorded in only 0.5 and 18.9% of the GER

system records, respectively, compared with 94.6 and 95.4% of the SMID records, respectively (P <0.0001). Also, the SMID requires some key variables to be recorded to finish and save the information. If this is not done, it is not possible to continue with the next patient.

Acceptance of the SMID

HCPs (18 endocrinology residents and nutritionists) who used the SMID were asked to complete the acceptance survey. Results showed that 33% used the SMID for <1 hour per week, 33% used it between 1 and 2 hours, 16% used it between 3 and 5 hours, 5.5% used it between 6 and 8 hours, and 11% used it for >8 hours. The SMID content was comprehensible for 88.5% of the respondents, and 83.3% considered it useful for monitoring patients. Only 44.4% of users liked the SMID's graphic design, but 50% considered the system to be easy to use. In answers to the open question, the principal suggestions for improving the system were to improve the design and to speed up patients' initial registration.

The experience of using the SMID was reported as good by 55.5% of respondents, 16.6% considered it very useful in daily clinical practice, and 55% considered it regularly useful. Although the system can generate graphs of the evolution of patients' parameters and download information materials on diabetes, 61% never generated graphs, and 50% did not download educational materials. The main flaw detected in the system was the password lock. (When the password is mistyped three times in a row, the system is locked to prevent data misuse.) This drawback was reported by 61% of the respondents. However, this problem was reported to be "occasional" by 61% and to occur "almost never" by 27% of those respondents. As a global evaluation, respondents were asked if they would recommend use of the SMID in other clinics, and 83.3% answered "yes."

Discussion

In this study, we described the use of the SMID and compared the completeness of key variables using two electronic systems in an outpatient diabetes clinic. The SMID is a patient-focused system that captures crucial aspects of the integral care of type 2 diabetes. On the other hand, the GER system is an open-format EHR without prespecified mandatory variables used by all HCPs. We found that users of both systems captured fundamental aspects of biochemical and anthropometric variables of patients with type 2 diabetes. Nevertheless, with the use of the SMID, a higher percentage of the variables was completed. The SMID was well accepted among HCPs.

TABLE 1 Characteristics of Included Patients (N = 370)

Female/male	210 (56.8)/160 (43.2)
Age, years	62 (53–70)
Time since diagnosis, years	18 (11–25)
Weight, kg	73.2 ± 15.5
BMI, kg/m^2	28.6 ± 5.1
Waist, cm	
Female	94.0 (86–102)
Male	97.5 (90–105)
Active smoking	24 (6.5)
Systolic blood pressure, mmHg	125 (120–133)
Diastolic blood pressure, mmHg	75 (70–80)
Triglycerides, mg/dL	135 (100–180.5)
Cholesterol, mg/dL	165 (138–193)
HDL cholesterol, mg/dL	
Female	48 (40–57)
Male	40 (36–47)
LDL cholesterol, mg/dL	93 (76–115)
Non-HDL cholesterol, mg/dL	117 (94.5–141.5)
Glucose, mg/dL	134 (110–179)
A1C, %	8.5 (7.5–10.1)
Creatinine, mg/dL	0.86 (0.69–1.10)
Uric acid, mg/dL	5.3 (4.4–6.4)
ALT, units/L	17 (13–27)
AST, units/L	18 (14–22)
GGT, units/L	29 (17–49)
ACR, mg/g	23 (8.6–103)

Data are n (%), mean ± SD, or median (IQR).

The implementation of EHR systems has been proposed as an essential tool to capture variables systematically for a comprehensive and integral evaluation of patients living with type 2 diabetes (9,10), and systematic reviews have shown that patients with type 2 diabetes benefit from implementation of an EHR system (11). However, in our study, there was a significant difference in the completeness of most of the variables captured using the SMID. Waist circumference, a key parameter for assessing central obesity, was rarely registered when using the GER system. The SMID makes entering this variable mandatory before an HCP can save the record and continue with the next register entry. This feature is associated with a higher rate of recording. Similarly, non-HDL cholesterol is automatically calculated by the SMID, favoring the use of this variable when considering lipid-lowering treatment.

TABLE 2 Percentage of Variables Registered With Each Electronic System (n = 370)

Variable	SMID System, %	GER System, %	*P*
Triglycerides	94.9	83	<0.001
Total cholesterol	94.9	82.7	<0.001
HDL cholesterol	94.9	82.2	<0.001
LDL cholesterol	94.3	82.4	<0.001
Non-HDL cholesterol	94.6	0.5	<0.001
Glucose	96.8	92.2	0.006
A1C	95.4	91.4	0.027
Creatinine	96.2	87.6	<0.001
Uric acid	40.4	53.9	<0.001
ALT	70	47.9	<0.001
AST	69.7	47.9	<0.001
GGT	8.4	7.0	0.491
ACR	77.8	78.9	0.721
Systolic blood pressure	99.7	95.9	<0.001
Diastolic blood pressure	99.7	95.9	<0.001
Weight	99.5	93.2	<0.001
Height	99.5	77.8	<0.001
BMI	95.4	18.9	<0.001
Waist circumference	99.5	4.9	<0.001
Smoking status	99.5	52.4	<0.001
Eye evaluation	99.2	93.8	<0.001
Dental evaluation	99.2	13.5	<0.001
Foot exam	97.8	84.1	<0.001

These findings suggest that implementing a focused-oriented electronic registry could be of great benefit in the management of patients with type 2 diabetes. The information collected can aid the development of strategies to improve diabetes care quality.

However, some variables were recorded in a low proportion in the SMID and the GER system, including creatinine and ACR values. These data may alert physicians of the need to evaluate patients for microvascular and macrovascular complications systematically and facilitate needed treatment changes to avoid clinical inertia (11).

We found HCP acceptance of the SMID to be good; however, we did identify areas in need of improvement. Most of the SMID users considered it helpful for patient follow-up. Their experience using the SMID was mostly fair to good, although some functions of the SMID were not used, including its graph generation capabilities. Flaws in the SMID were reported to be occasional, and the password lock was the most frequently reported problem.

New strategies are needed to improve type 2 diabetes management. The implementation of a diabetes-specific electronic system might improve both the completeness of data capture and achievement of treatment goals while decreasing consultation time by providing HCPs with more information in less time during clinical visits (12). Having a system that generates statistics and graphs in real-time could also facilitate the routine evaluation of therapeutic goals in diabetes outpatient clinics (12,13).

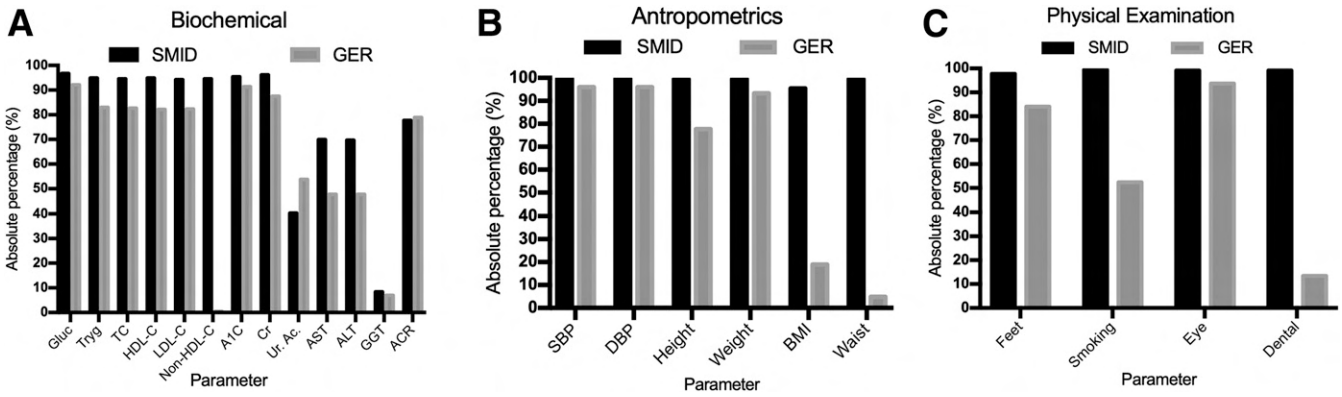

FIGURE 1 Absolute percentage of *A*) biochemical, *B*) anthropometrics, and *C*) physical examination variables recorded with the SMID and GER systems. Cr, creatinine; DBP, diastolic blood pressure; Gluc, glucose; HDL-C, HDL cholesterol; LDL-C, LDL cholesterol; SBP, systolic blood pressure; TC, total cholesterol; Tryg, triglycerides; Ur. Ac., uric acid; Waist, waist circumference.

The SMID ensures accuracy and a complete information registry and improves access to general information for physicians, patients, family members, and administrators. It also generates statistics in real time and alerts and guides health care personnel in decision-making, providing educational materials to support consultations.

Some limitations of this study should be acknowledged. This was a cross-sectional analysis of the implementation and use of the system. It was not possible to compare the time required to record the information in each system because the information recorded using the traditional GER system was evaluated from records of the previous visit. In addition, we did not measure changes in treatment when using each system. In addition, vibration sensation, a standard exam included in foot evaluation, is not in the current version of the SMID.

Longitudinal studies are needed to evaluate the effect of the SMID in achieving treatment goals and decreasing diabetes complications. In addition, a cost-effectiveness analysis would be useful. A next step could be to use an app to link information between HCPs and patients to optimize the data captured regarding diabetes control and promote diabetes self-management.

Conclusion

Use of the SMID was associated with a higher percentage of captured variables essential to the treatment of diabetes. The SMID was also useful in generating information about the current situation within the diabetes clinic. The SMID was well accepted by HCPs and could be applied in other outpatient diabetes clinics.

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DUALITY OF INTEREST

No potential conflicts of interest relevant to this article were reported.

AUTHOR CONTRIBUTIONS

P.A.-V., N.E.A.-V., A.C.G.-U., and S.H.-J. developed the concept of the study and performed and interpreted statistical analyses. P.A.-V., F.M.R.-D., and B.G.P.-M. registered patients. P.A.-V., N.E.A.-V., F.J.G.-P., C.A.A.-S., A.C.G.-U., and S.H.-J. participated in manuscript drafting and processing. P.A.-V. provided mentorship and supervision. Each author contributed important intellectual content during manuscript drafting or revision and accepted accountability for the overall work by ensuring that questions pertaining to the accuracy or integrity of any portion of the work were appropriately investigated and resolved. All authors read and approved the final version of this manuscript. P.A.-V. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

REFERENCES

1. Ali SM, Giordano R, Lakhani S, Walker DM. A review of randomized controlled trials of medical record powered clinical decision support system to improve quality of diabetes care. Int J Med Inform 2016;87:91–100

2. Cleveringa FGW, Gorter KJ, van den Donk M, van Gijsel J, Rutten GEHM. Computerized decision support systems in primary care for type 2 diabetes patients only improve patients' outcomes when combined with feedback on performance and case management: a systematic review. Diabetes Technol Ther 2013;15:180–192

3. Love TE, Cebul RD, Einstadter D, et al.; DIG-IT Investigators. Electronic medical record-assisted design of a cluster-randomized trial to improve diabetes care and outcomes. J Gen Intern Med 2008;23:383–391

4. Cebul RD, Love TE, Jain AK, Hebert CJ. Electronic health records and quality of diabetes care. N Engl J Med 2011;365:825–833

5. Montori VM, Dinneen SF, Gorman CA, et al.; Translation Project Investigator Group. The impact of planned care and a diabetes electronic management system on community-based diabetes care: the Mayo Health System Diabetes Translation Project. Diabetes Care 2002;25:1952–1957

6. Roshanov PS, Misra S, Gerstein HC, et al.; CCDSS Systematic Review Team. Computerized clinical decision support systems for chronic disease management: a decision-maker-researcher partnership systematic review. Implement Sci 2011;6:92

7. O'Reilly D, Holbrook A, Blackhouse G, Troyan S, Goeree R. Cost-effectiveness of a shared computerized decision support system for diabetes linked to electronic medical records. J Am Med Inform Assoc 2012;19:341–345

8. Pradeepa R, Prabu AV, Jebarani S, Subhashini S, Mohan V. Use of a large diabetes electronic medical record system in India: clinical and research applications. J Diabetes Sci Technol 2011;5:543–552

9. Ciemins EL, Coon PJ, Fowles JB, Min SJ. Beyond health information technology: critical factors necessary for effective diabetes disease management. J Diabetes Sci Technol 2009;3:452–460

10. Patel V, Reed ME, Grant RW. Electronic health records and the evolution of diabetes care: a narrative review. J Diabetes Sci Technol 2015;9:676–680

11. Lessing SE, Hayman LL. Diabetes care and management using electronic medical records: a systematic review. J Diabetes Sci Technol 2019;13:774–782

12. Varroud-Vial M. Improving diabetes management with electronic medical records. Diabetes Metab 2011;37(Suppl. 4):S48–S52

13. Bertsimas D, Kallus N, Weinstein AM, Zhuo YD. Personalized diabetes management using electronic medical records. Diabetes Care 2017;40:210–217