Evaluation of Outcomes Using a Tablet-Based System to Support Glycemic Management Workflow Operations: A Retrospective Observational Study

Kei Teramoto 1 · Tsuyoshi Okura2 · Hiroshi Kondo1

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Abstract
The treatment of hospitalized patients with type 2 diabetes requires glycemic management to maintain the patients’ blood glucose levels within a normal range. We developed a blood glucose management system (BGM) system in 2015, which is a tablet-based workflow support system. This system enables medical staff to continually confirm the physicians’ instructions by measuring the blood glucose levels while using a tablet terminal.

In this study, we examined electronic medical records (EMRs) to evaluate the usage frequency of the BGM system and the time required for the glycemic management workflow in comparison to conventional PC terminals in a large hospital setting. The data includes 197,927 blood glucose level measurements that were taken in the general wards of Tottori University Hospital between January 2016 and June 2017. The usage frequency of the glycemic management workflow while using the BGM system was 145,864 times (approximately 74% of the total blood glucose measurements). The mean time until the completion of the glycemic management workflow in the case of hyperglycemia was 16 min 33 s, which is 26% shorter than using a PC terminal for treatment that involves injection or infusion (1454 times). The BGM system is proactively utilized by medical staff, thereby improving the operating efficiency. The results of this study indicate that the BGM system installed on tablet terminals can improve the efficiency in large-scale medical institutions that treat patients with diabetes.

Keywords Tablet terminals · Blood glucose management · Diabetes patient · Workflow management

Background
Diabetes is a disease that causes the blood glucose and hemoglobin A1c (HbA1c) levels to exceed the reference standard. According to a survey by the International Diabetes Federation, as of 2017, 425 million people across 194 countries have been diagnosed with diabetes, and this number is expected to increase to 699 million in 2045 [1, 2]. In Japan, diabetes affects 11.20% of the population, and 16% of the hospitalized patients are diabetic. Against the background of this global increase in the number of diabetic patients, medical institutions require medical treatment systems that are based on the premise of taking in diabetic patients. Glycemic management to maintain blood glucose (BG) levels within a normal range is important in the treatment of diabetic patients [3–6]. Nurses use BG testers to control the BG levels for hospitalized patients, and it is essential to regularly measure and implement procedures to maintain these levels within a normal range. In medical institutions that have introduced electronic medical record (EMR) systems, physicians use the order function to communicate the workflow for glycemic management to nurses [7]. Any deviation from the glycemic management workflow can lead to hyperglycemic or hypoglycemic conditions in patients.

Recently, tablet-based support systems for the workflows that are implemented by ward nurses, including the administration of medication and injection treatments, have attracted considerable attention [8–11]. These systems allow nurses to check patient information and the physician’s instructions in real time on a portable tablet terminal. For example, the nurses
can measure BG levels quickly and accurately if there was a BG level measurement workflow support application that is installed on their tablet terminal. Previous studies have cited examples of medical institutions that have introduced workflow applications for glycemic management by using tablets. However, there are only a few investigations that have focused on system design methods and the usage status after the introduction.

In 2015, we developed a blood glucose management (BGM) system, which consists of a tablet-based support system for the BG level measurement workflow. This system has since been introduced in our medical institution [12].

In the methods section, we describe the system design and the particular functions of the BGM system. In the results section, we present the results of investigations on the impacts of the clinical workflow for abnormal BG events and changes in the usage status while using the BGM system 18 months after its introduction in a large medical hospital. The discussion section describes the usage frequency of the system, its impact for the glycemic management workflow, and the issues with introducing a BGM system in large medical hospitals.

Methods

The BGM system provides functions to support the workflow required for glycemic management on a tablet terminal that is carried out by nurses. In this section, we present the glycemic management workflow while using the BGM system, and then describe the data transfer adapter that was developed along with the user training and methods for evaluating the usage performance.

Test environment

Data from patients that were younger than 20 years old were excluded as part of the research application to the ethics committee. This study was implemented in compliance with the Declaration of Helsinki, and the current code of ethics was approved by the institutional review board from the Faculty of Medicine at Tottori University (Approval Number: 1611A136). This was not a clinical study, and the data analysis was conducted retrospectively on the anonymized data; therefore, written informed consent was not obtained from the patients.

The BGM system, which provides workflow support for glycemic management on a tablet terminal, was devised by specialist diabetes physicians and nurses, general ward nurses, and healthcare information technologists that are affiliated with Tottori University Hospital (TUH). TUH is a national university hospital that provides highly advanced medical treatment to an average of 1500 outpatients, and it has 697 beds and 33 clinical departments. The hospital has 400 physicians and 800 nurses. Two-hundred tablet terminals have already been introduced, and the ward nurses carry tablet terminals that are equipped with functions to input data to the EMR while they work. In this study, 197,927 blood glucose control tasks that were performed on 3677 inpatients at TUH were analyzed using EMR system logs to compare the utility of BGM. Of the inpatients observed, 76% had type I or type II diabetes.

Glycemic management workflow using the BGM system

The BGM system hardware comprises the BGM server, which is responsible for linking the EMR and the data, the tablet terminal (iPod touch), which runs the BGM software, and the data transfer adapter for transferring the BG levels and the measurement timing data from the simplified BG tester to the tablet terminal (Fig. 1).

The BGM server uses an independent application programming interface to obtain information on the patient undergoing BG measurements from the EMR server database. The BGM server provides an application that supports the glycemic management workflow to the tablet terminal. Figure 1 shows steps 1–5 of the glycemic management workflow when using the BGM system. In step 1, physicians issue the BG level measurement instruction order using the EMR and then register the importance of this instruction on a sliding scale. This sliding scale includes treatment with an insulin injection or infusion for the patient with abnormal BG levels. In step 2, a nurse operates the BGM software installed on the tablet and confirms the identity of the patient that is having their BG level measured. At this point, the operator is presented with a list of patients in their care according to the scheduled measurement times. An alert message is displayed on the BGM software screen when a BG level has not been recorded 30 min after the scheduled time for that patient. In step 3, the nurse confirms the patient’s identity by scanning the barcode on the patient’s wristband and then measures the patient’s BG level using the BG tester. The nurse then automatically transfers the BG level and measurement time recorded on the BG tester to the BGM software using the data transfer adapter. In step 4, the nurse sends the BG level and measurement time data recorded on the BGM software to the EMR. In step 5, the nurse performs the treatment for the patient with an abnormal BG level, while referring to the inputted sliding-scale by the physician.

Data transfer adapter

The data transfer adapter is a wireless communication module that enables the automatic transfer of BG and measurement time data recorded in the internal memory of the BG tester to the BG software input screen. The data transfer adapter is connected to a USB port on the BG tester (Lifescan OneTouch VerioPro PLUS), and it communicates with the
tablet via Bluetooth. The workflow of recording the BG levels while using the BG tester is presented in Fig. 2.

The nurse’s pair the tablet to the BG tester to import the BG level and measurement time data from the BG tester to the BGM software. The pairing process is performed by reading the two-dimensional barcode that is affixed to the BG tester, which contains the data to be imported, using the BGM software internal camera. The BG level and measurement time recorded on the internal memory are automatically deleted after the BG tester has transmitted the BG level and measurement time data to the BGM server.

**Operational training for using the BGM system**

Operation briefings to provide instructions on the BG level measurements while using the tablet terminals were provided
by specialist diabetes nurses to the ward nurses in each ward. Once a month, the tablet usage rate was reported to the supervisor that is responsible for diabetes treatment in each ward, and a debriefing session was held to discuss any problems with the system. Training to use these devices was implemented for 4 months and 14 months after the introduction of the system to improve the tablet usage rate.

After the introduction of the system, the nurses were able to implement the glycemic management workflow using the conventional PC terminals in the same way prior to the introduction of the BGM system. By doing this, the general ward nurses can check the glycemic management workflow using PC terminals at staff stations.

**Statistical methods**

The statistical analysis in this study was performed using R version 3.1.2. The chi-squared test and Fisher’s test were used to test the difference in the usage rates between the tablets and the PC terminals.

**Results**

To evaluate the usage of the BGM system, we analyzed its usage frequency, notification alert frequency, and the treatment workflow time for abnormal BG levels. The usage frequency of the tablets and PCs to input the BG data measured in TUH over 18 months was surveyed for the general wards. The notification alert was displayed on the tablet terminal when the BG level of the target patient was not recorded on the EMR within 30 min of the scheduled time. The time required for the treatment workflow was taken as the difference between the time from the scheduled BG measurement to the registration of the details for the treatment of abnormal BG levels during hyperglycemia or hypoglycemia.

**BGM system usage frequency**

The number of BG measurements using the BGM system and the PC terminals (non-BGM system) from the date the system was introduced (January 1, 2016) to July 31, 2017 in the general wards is illustrated in Fig. 3.

The total number of BG measurements taken in the general wards was 197,927, and 145,864 of these were taken when using the BGM system ($P < 0.01$). Figure 3 shows the usage performance of the BG measurements for each device on a monthly basis. In the general wards, the usage frequency of the tablets was higher than the PC terminals (excluding the third month after the introduction). Seven months after the introduction, the tablet usage rate exceeded 70%, and this exceeded 80% for 11 months after the introduction.

**Notification alert of the delayed BG measurement schedule**

When the BG level of the target patient was not recorded on the EMR within 30 min of the scheduled time, the BGM system sends a notification that displays a measurement delay alert to the nurse responsible for that patient. Notification alerts were sent to the overseeing nurse’s tablet at 30-min intervals until the blood glucose measurements were complete. This function, however, was not implemented in the non-BGM system. The alert function was triggered in 21,850 cases (15%) in the general wards. Upon checking the alert times, it was determined that for the post-meal BG measurements, which were normally implemented 2–3 h after a meal, accounted for approximately 48% of the alerts.
Impact of the treatment workflow for hyperglycemia/hypoglycemia

When treating patients with diabetes, it is important to ascertain abnormal BG levels as quickly as possible and to implement a prompt treatment that is in line with the measured level. Treatments for patients in a hypoglycemic state include the oral intake of glucose or an injection or infusion to increase the BG. Treatments for patients in a hyperglycemic state include the injection or infusion of insulin to reduce the BG. In this study, we investigated the time from when the instructions were issued by the physicians to when the details of the treatment for abnormal BG levels were recorded in the EMR. The treatment criteria were set as BG < 70 for hypoglycemic states and BG > 300 for hyperglycemic states. Table 1 summarizes the results for the time required until the completion of the workflow in the BGM system and the non-BGM environment.

During the survey period for this study, 2710 of the 232,194 cases (0.01%) required medical treatment for either hyperglycemia or hypoglycemia. By observing the corresponding order of frequency, 2456 cases required an injection or infusion treatment for hyperglycemia, 184 cases required an oral intake of glucose, and 70 cases required an injection or infusion treatment for hypoglycemia.

The mean time for the completion of the glycemic management workflow for hypoglycemia was 44% shorter when using the BGM system ($P < 0.01$) in comparison to using a PC terminal for treatment that involves an oral intake of glucose, and it is 34% shorter ($P < 0.01$) for treatment that involves an injection or infusion. The mean time until the completion of the glycemic management workflow in the case of hyperglycemia was 27% shorter when using a tablet ($P < 0.01$) than when using a PC terminal. This confirms that the workflow for the abnormal BG events can be completed in a shorter period of time when using a tablet instead of a PC terminal.

User survey for BGM

To evaluate the effective of the BGM system, a paper-based user survey was conducted among 30 ward nurses. Nurses were asked to evaluate the following survey items on a four-point scale: i) work efficiency, ii) effect on input errors, and iii) measurement delay reduction effects. Table 2 presents the survey results. As can be seen from the results, the use of BGM improved work efficiency and reduced input errors of blood glucose values or delays due to scheduled measurement times, which often leads to incidents.

Discussion

This study investigated the usage of the BGM system as a tablet-based workflow support system and the operational efficiency of the workflow for abnormal BG events. Recently, tablet-based decision support systems have been widely accepted in real hospital settings; however, the usage conditions of a tablet-based workflow support

Table 1

| Treatment details at onset of the hypoglycemia | Treatment details at the onset of hyperglycemia |
|---------------------------------------------|---------------------------------------------|
| Type of treatment | Oral intake of glucose | Treatment with injection or infusion | Treatment with injection or infusion |
| Used device | BGM system | Non-BGM | $P$ value*1 | BGM system | Non-BGM | $P$ value | BGM system | Non-BGM | $P$ value |
| Total number of patients | 18 | 28 | N.S. | 32 | 35 | N.S. | 92 (58) | 89 (40) | N.S. |
| Occurrence rate of abnormal BG levels (%)*3 | 94 (0.04%) | 90 (0.04%) | N.S. | 33 (0.02%) | 37 (0.02%) | N.S. | 1454 (0.12%) | 1002 (0.21%) | <0.01 |
| Mean value of the BG level | 60.6 | 59.8 | N.S. | 51.9 | 58.8 | N.S. | 337 | 336.5 | N.S. |
| Median value of the BG level | 61.5 | 61.1 | – | 58.2 | 64.3 | – | 326.1 | 326.2 | – |
| Mean time until completion of the BG management workflow | 0:12:44 | 0:22:35 | <0.01 | 0:16:55 | 0:25:45 | <0.01 | 0:16:33 | 0:22:41 | <0.01 |
| Median time until completion of the BG management workflow | 0:07:54 | 0:18:02 | – | 0:15:25 | 0:23:45 | – | 0:13:57 | 0:19:14 | – |

*1 Fisher’s extract test
*2 N.S.: not significant
*3 The occurrence rate is defined as the occurrence number of the abnormal BG level divided by the total occurrence number that is measured for the BG level
system for the glycemic management workflow have not been clarified. Glycemic management when using tablet-based workflow support systems can reduce the human error by medical staff, which improves the medical workflow.

**BGM system usage rate**

The usage status of the system in the general wards and critical care wards was investigated for an 18-month period following the introduction of the system. The results indicated that 18 months after the introduction, approximately 90% of the BG measurements in the general wards were being implemented with the tablet-based BGM system. In the first three months after the introduction, there was no major difference between the tablet and the PC terminal usage rates (Fig. 3). The reason for this was that the ward nurses did not fully understand the operating methods of the BG measurements workflow when using the tablet. As described earlier, the BG level measurements workflow when using the tablet requires the person taking the BG measurements to alternately operate the tablet and the BG tester in accordance with the five-step procedure (see Fig. 1). Therefore, the nurses felt that the workflow procedures were more rigid than the previous method of registering the BG levels that are measured with the BG tester in the EMR at a time that suited the nurses, thus, resulting in reduced freedom of operability. When BGM systems are used in medical institutions, they have the advantage of being able to standardize the workflows to a unified BG measurement workflow. However, a sufficient training period is required to enable the nurses to implement a series of processes in line with the necessary procedures. There are reports of the system introduction progressing smoothly over a short timeframe and this is achieved by repeatedly evaluating the usability during the system design stage to improve the operability and learnability [8, 13]. In this study, the usability was not adequately evaluated for the BGM system specifications; however, incorporating such an approach may improve the introduction of systems like the BGM system, which requires alternating the operation of tablets and medical devices.

As presented in Table 1, the results show an average required workflow time of 16 min and 33 s and 22 min and 41 s for BGM and PC, respectively. Simple comparisons of the average time of workflow required for changing the insulin flow rate during hyperglycemia between BGM and conventional PC show a reduction by 6 min and 8 s when BGM was used. This supports the results of the user survey mentioned above. Although labor costs were not included in the calculations, since insulin treatment due to hyperglycemia is frequently conducted for diabetic patients, this is anticipated to result in reduced labor costs owing to the reduction in working hours.

**Accuracy of the BG management workflow**

BG management is important in maintaining BG levels within a normal range in diabetic patients. Nurses use a BG tester to regularly measure the BG level of diabetic patients and they are required to implement a treatment to maintain the BG level within a normal range. In the case of abnormal BG levels discovered by nurses, this study compared the time from when a physician ordered the BG measurements to the completion of previously instructed treatments and the recording of these details in the EMR when using the BGM system or conventional PC terminals.

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**Table 2** Results of User Survey of BGM

| Question                                                                 | Number of responses | Percentage (%) |
|-------------------------------------------------------------------------|---------------------|----------------|
| 1. Did blood glucose control improve when BGM was used?                 | Number of responses | Percentage (%) |
| 1–1 Greatly improved                                                   | 5                   | 17             |
| 1–2 Improved                                                           | 18                  | 60             |
| 1–3 Did not change                                                     | 7                   | 23             |
| 1–4 Worsened                                                           | 0                   | 0              |
| 2. Did blood glucose value input errors into EMR decrease when BGM was used? | 21                  | 70             |
| 2–1 Greatly decreased                                                  | 6                   | 20             |
| 2–2 Decreased                                                          | 3                   | 10             |
| 2–3 Did not change                                                     | 0                   | 0              |
| 3. Did blood glucose value measurement delays decrease when BGM was used? | 9                   | 30             |
| 3–1 Greatly decreased                                                  | 15                  | 50             |
| 3–2 Decreased                                                          | 6                   | 20             |
| 3–3 Did not change                                                     | 0                   | 0              |
| 3–4 Increased                                                          | 0                   | 0              |

*1 Number of medical staff surveyed = 30
The mean time until the completion of the hypoglycemia and hyperglycemia workflow was shorter when using the BGM system. The significant reduction in the time taken by the nurses to complete the workflow required for BG management will lead to improved operations for the nurses that are in charge of multiple diabetic patients.

The BGM system has a notification function that sends an alert message to the tablet when the BG measurements are not recorded in the EMR within 30 min of the scheduled measurement time. This study shows that the alerts were triggered in 14% (23,293 instances) of the total number of BG measurement workflows.

When the timing of the alerts was checked, it was determined that post-meal BG measurements, which should be taken 2–3 h after a meal, accounted for approximately 48% of these alerts. Post-meal BG measurements are performed for almost all diabetic patients; hence, there is a high concentration of BG measurements in this period. Thus, delays in BG measurements are more likely to occur during this time. Delayed BG measurements can be caused by prioritizing other tests and other treatments; therefore, not all workflow deviations are associated with human error. However, delayed BG measurements may result in medical staff overlooking hyperglycemia and hypoglycemia conditions in hospitalized patients. Hypoglycemia with a BG level remaining at or below 50 mg/dL puts patients at risk of acquiring dangerous conditions, which includes the loss of consciousness and a coma (severe hypoglycemia). This alert function prevents delayed and forgotten BG measurements and this may prevent patients from developing serious conditions at the onset of hypoglycemia.

**Usability issues**

The data transfer adapter automatically transfers the BG measurements recorded on the BG tester to the BGM software. This requires the same number of BG testers and tablets. If the data link between the BG testers and tablets is fixed on a one-to-one basis, the cost burden will increase. Thus, in TUH, the BG data transfer process was implemented using a data transfer adapter. This involved the process of pairing the tablets and the BG testers, which was implemented at the time of the data transfer. The nurses required approximately 3–5 s for this pairing process, which slightly impeded the usability of the BGM system. More recently, a method of importing the measurement data recorded on medical devices to the tablet terminals via radio frequency identification (RFID) readers has been developed. If it were possible to import BG data directly from the BG tester when using the tablet, data transfer adapters would not be needed and both the operability and cost of the system would improve.

**Incident prevention effect with the BGM system**

Incidents related to the BG measurements include the incorrect input of the BG levels, delays caused by the forgotten BG measurements, and a mistaken insulin administration [14]. The incorrect input of the BG levels is caused by transcription errors that can occur when inputting the results of the BG tester measurements into the EMR. This leads to an erroneous application of the sliding scale, which risks causing hyperglycemia or hypoglycemia. The data transfer adapter developed in this study automatically transfers the BG level and the measurement time recorded on the tester onto the BGM software screen. This completely eliminates the incidents that are caused by the incorrect input of the BG levels by the nurses. According to an incident report analysis by Okura et al., the introduction of the BGM system reduced the number of forgotten BG measurements from 4.8 ± 1.4 incidents per month before the introduction of the system to 2.6 ± 1.5 incidents per month [13]. The function that alerts the nurses to the delayed BG measurements is believed to have reduced the incidence of the forgotten BG measurements. Incidents involving insulin injection include errors of drug selection and dosage. Overdoses of insulin, in particular, can cause a serious disturbance of consciousness due to hypoglycemia. There is no function in the BGM system to prevent these incidents. However, if it is possible to match up the drugs set on a sliding scale with the drugs prior to the application on a tablet when using the BGM software, then it should be possible to avoid mistaken drug administration. The tablet-based BGM system reduces the occurrence of serious incidents that adversely affects glycemic management.

**Limitations**

Factors such as the frequency of the nurses’ operating tablets and the length of the work experience may affect the usage frequency of the BGM system. This study did not conduct a questionnaire on the operability of the system or obtain background information on the nurses when using the BGM system due to the restrictions of the ethics application. As stated in the discussion section, if it is possible to match up the content of the tablet training stage with the nurses’ background information, it may be possible to improve the usage rate within a short timeframe after the introduction.

This study has demonstrated that in the event of abnormal BG levels, the BGM system enables the workflow to be completed in a shorter timeframe than when using the conventional PC terminals. This result demonstrates an improved workflow, but it does not show that the duration of abnormal BG levels in diabetic patients has been shortened. Investigating the duration of abnormal BG requires not only an analysis of the system logs, as implemented in this study, but also requires the collection of data on the start time of the
treatment from when the nurses discovered the abnormal BG levels. In future studies, by examining usability tests against the user background, implementing operation training methods, and surveying the users, this can improve the introduction of the system to other medical facilities.

Conclusion

The results of this study confirm that a system supporting glycemic management workflow that uses a tablet-based application improves the operating efficiency and safety in clinical practice in comparison to the workflow when using conventional PCs. It is concluded that the BG system would be an important solution for improving the existing limitations in glycemic management workflow in medical facilities. Further work will focus on improving the usability based on the user questionnaires and applying the system to other hospitals.

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Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author upon a reasonable request. This manuscript includes all the available data in this study.

Compliance with ethics guidelines

This study was conducted in accordance with the ethical standards of our institutional research committee and with the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from all individual participants that were included in the study by the opt-out method.

Disclosures All of the authors have nothing to declare.

References

1. Ogurtsova K, da Rocha Fernandes JD, Huang Y, et al. (2017) IDF Diabetes Atlas: Global estimates for the prevalence of diabetes for 2015 and 2040. Diabetes Res Clin Pract 128:40-50.
2. Danaei G, Finucane MM, Lu Y, et al. (2011) National, regional, and global trends in fasting plasma glucose and diabetes prevalence since 1980: systematic analysis of health examination surveys and epidemiological studies with 370 country-years and 2.7 million participants. The Lancet 378:31-40.
3. Garrouste-Orgeas M, Timsit JF, Vesin A, et al. (2010) Selected medical errors in the intensive care unit: results of the IATROREF study: parts I and II. Am J Respir Crit Care Med 181:134-142.
4. Breuer TG, Meier JJ (2012) Inpatient treatment of type 2 diabetes. Dtsch Arztebl Int 109:466-474.
5. Bloomgarden ZT (2004) Inpatient diabetes control: approaches to treatment. Diabetes Care 27:2272-2277.
6. Amori RE, Pittas AG, Siegel RD, et al. (2008) Inpatient medical errors involving glucose-lowering medications and their impact on patients: review of 2,598 incidents from a voluntary electronic error-reporting database. Endocr Pract 14:535-542.
7. Herrmayer KL, Lofley AS, Reddy S, Narla SN, Epps NA, Zhu Y (2015) Challenges of inpatient blood glucose monitoring: standards, methods, and devices to measure blood glucose. Curr Diab Rep 15:10.
8. Quezada A, Juarez-Ramirez R, Jimenez S, Noriega AR, Inzunza S, Garza AA (2017) Usability Operations on Touch Mobile Devices for Users with Autism. J Med Syst 41:160.
9. Houze De l’Aulnoit A, Boudet S, Genin M, et al. (2018) Development of a Smart Mobile Data Module for Fetal Monitoring in E-Healthcare. J Med Syst 42:83.
10. Duhm J, Fleischmann R, Schmidt S, Hupperts H, Brandt SA (2016) Mobile Electronic Medical Records Promote Workflow: Physicians’ Perspective From a Survey. JMIR mHealth uHealth 4:e70.
11. Anderson C, Henner T, Burkey J (2013) Tablet computers in support of rural and frontier clinical practice. Int J Med Inform 82:1046-1058.
12. Kei T, Tsuyoshi O, Rie K, et al. (2017) Development and Evaluation of a Blood Glucose Management System for Reducing the Delay in Measurement. Stud Health Technol Inform 245:1058-1062.
13. Okura T, Teramoto K, Koshitani R, et al. (2018) A Computer-Based Glucose Management System Reduces the Incidence of Forgotten Glucose Measurements: A Retrospective Observational Study. Diabetes Ther 9:1143-1147.
14. Lee J, Han H, Ock M, Lee SI, Lee S, Jo MW (2014) Impact of a clinical decision support system for high-alert medications on the prevention of prescription errors. Int J Med Inform 83:929-940.