Technical requirement of clinical decision support system for diabetic patients

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Article Info	ABSTRACT
<p>Article type: Review</p>	<p>Introduction: Diabetes is a public health problem which is originating an increment in the demand for health services. There is an obvious gap exists between actual clinical practice and optimal patient care, clinical decision support systems (CDSSs) have been promoted as a promising approach that targets safe and effective diabetes management. The purpose of this article is reviewing diabetes decision support systems based on system design metrics, type and purpose of decision support systems.</p>
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<p>*Corresponding author: Azam Aslani</p> <p>PhD in Medical Informatics, National Agency for Strategic Research in Medical Education, Tehran, Iran</p> <p>Email: a.aslani@nasrme.ac.ir</p>	<p>Material and Methods: The literature search was performed in peer reviewed journals indexed in PubMed by keywords such as medical decision making, clinical decision support systems, Reminder systems, diabetes, interface, interaction, information to 2019. This article review the diabetes decision support systems based on system design metrics (interface, interaction, and information), type and purpose of decision support system.</p>
<p>Keywords: Diabetes Mellitus Decision Support Systems Clinical</p>	<p>Results: 32 of the 35 articles were decision support systems that provided specific warnings, reminders, a set of physician guidelines, or other recommendations for direct action. The most important decisions of the systems were support for blood glucose control and insulin dose adjustment, as well as 13 warning and reminder articles. Of the 35 articles, there were 21 user interface items (such as simplicity, readability, font sizes and so on), 23 interaction items (such as Fit, use selection tools, facilitate ease of use and so on) and 31 item information items (such as Content guidance, diagnostic support and concise and so on).</p> <p>Conclusion: This study identified important aspects of designing decision support system, It can be applied not only to diabetic patients but also to other decision support systems. Most decision support systems take into account a number of design criteria; system designers can look at design aspects to improve the efficiency of these systems. Decision support system evaluation models can also be added to the factors under consideration.</p>

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INTRODUCTION

Diabetes prevalence is increasing all over the world due to sociocultural changes (the global prevalence of worldwide diabetes is around 9%) [1]. It is becoming a public health problem which is originating an increment in the demand for health services [2]. Diabetes mellitus is one of the most common systemic diseases in the world and it occurs when the pancreas does not produce enough insulin or when the body cannot effectively use that insulin [3]. It is classified into two main types: Type 1 (previously known as insulin-dependent) diabetes

and type 2 (formerly known as non-insulin-dependent) diabetes [3]. However, many diabetic patients are even unaware of such complications. Though not contagious, it has already become a pandemic, drawing increasing attention and effort to solve this health crisis worldwide. According to the 8th IDF Diabetes Atlas, diabetes has affected 425 million people in 2007, and this number will rise to 629 million by 2045 as estimated [4]. In developing nations, more than the half of all diabetic cases goes undiagnosed. This can be attributed to the fact that T2D symptoms may be less marked than other types of diabetes (e.g., Type 1) [1]. Worldwide, approximately 415 million adults suffer from

diabetes, and the numbers are projected to rise to 552 million by 2040 [5]. The growth of diabetes prevalence is causing an increasing demand in health care services which affects the clinicians' workload as medical resources do not grow at the same rate as the diabetic population [2]. Diabetes is associated with diminished quality of life disabling complications, high health care costs, and reduced life expectancy [6]. Moreover, diabetes is the major cost on the economic balances of national health systems (IDF indicates for the year 2015 a level of expenditure for the treatment of diabetic patients equal to 11.6% of the total world health expenditure). The International Diabetes Federation (IDF) stated that early diagnosis and opportune treatments can save lives while preventing or significantly delaying devastating complications [1]. A challenge faced by decision makers in management of diabetes is that, in many instances, there is a persistent gap between recommended care guidelines and current practice. For the treatment of diabetes, achievement of target glucose levels is difficult because physicians have no benchmark to make decisions about whether to start, continue, or adjust insulin doses or injections. Since clinicians should regularly assess the risk of HG in patients with DM, an automated, point-of-care approach to estimating risk may help clinicians to save time and identify strategies to limit risk of HG among their patients [7]. Therefore, an obvious gap exists between actual clinical practice and optimal patient care. The need for cost-effective improvements in managing and treating diabetes is evidently important [5]. Clinical decision support systems (CDSSs) have been promoted as a promising approach that targets safe and effective diabetes management [5]. Decision support tools can help clinicians with the inspection of monitoring data, providing a preliminary analysis to ease their interpretation and reduce the evaluation time per patient [2]. Clinical decision support system (CDSS) is a computer tool which broadly covers autonomous or semiautonomous tasks ranging among symptoms diagnosis, analysis, classification, and computer-aided reasoning on choosing some appropriate medical care or treatment [8]. a CDSS can be defined as "a system that is designed to be a direct aid to clinical decision-making in which the characteristics of an individual patient are matched to a computerized clinical knowledge base, and patient-specific assessments or recommendations are then presented to the clinician(s) and/or the patient for a decision" [8]. CDSSs, at the simplest level, are tools to help clinicians and patients make better informed decisions during use of the EHR. In the best examples, successful CDSSs reduce medical errors, increase health care quality and efficiency, and guide appropriate care decisions. These are challenging tasks, and thus successful CDSSs remain

difficult to develop and implement [9]. The purpose of this paper is to investigate diabetes decision support systems based on system design criteria that include interface, interaction, information and type of decision support systems.

MATERIAL AND METHODS

The review of literature was conducted on assessing Clinical Decision Support systems for managing Diabetic Patients. The literature search was performed in PubMed using keywords and limited to Humans and English language articles. MEDLINE is the medical database that is most frequently used in systematic reviews to find information and is accessible via different interfaces. Various studies have confirmed that PubMed is the interface that authors most frequently use. This interface has advantages such as free access, slightly greater sensitivity than MEDLINE-Ovid in searches for systematic reviews, status as the most current database, and information from sources other than MEDLINE, such as online books and articles from life sciences journals, making PubMed the preferred option for conducting literature searches [10]. However Restricting searches to MEDLINE may capture almost all eligible studies [11-13]. The following Medical Subject Headings terms were used for searching publications: ("decision support system" OR CDSS OR "medical decision making" OR "clinical decision support systems" OR "Reminder systems" AND "diabetes") AND ("interface" OR "interaction" OR "information"). The inclusion criteria and flow chart of search results are presented in Fig 1.

We studied 35 articles by examining 346 articles. We excluded articles that assessing care management processes (CMPs) of diabetes, clinical preventive services (CPS), and computerized physician order entry (CPOE) not embedded in CDSS. Also articles that evaluated impact of diabetes decision support systems on diabetes patients or assessing Cost of Decision Support Systems was omitted. We included articles describing the design of decision support systems for diabetes and examined decision support systems from the aspects of system design (user interface, interaction, and information), type of system, and alerts and reminders, etc.

RESULTS

Types of CDSS

Systems that provide CDS come in three basic varieties:

1. Provide patient-specific, situation-specific alerts, reminders, physician order sets, or other recommendations for direct action, 32 article from 35 articles falls into this

category[2, 14-44]

2. "Info buttons 'use information about the current clinical context to retrieve highly relevant online documents [31].
3. Organizing and presenting information in a way that facilitates problem solving and decision making, one article from 35 articles falls into this category [45].

Fig 1: Flow chart of search result in PubMed

Objectives of CDSS

Articles focused on blood glucose control [14, 16-19, 21, 23, 28, 29, 32, 36, 39, 46], diabetes self-management [16, 19, 23, 26, 43], insulin dose adjustment [2, 18, 21, 27, 29, 34, 36-38, 40, 41, 44], pharmaceutical recommendations [15, 17, 24], therapeutic recommendations [2, 24-26, 33, 35, 37, 42, 44, 46], lifestyle improvement (physical activity monitoring and dietary) [2, 14, 18-20, 28, 29, 32, 33, 35, 36, 43], remote monitoring [33, 43], diabetes dashboard [45], cost effectiveness of decision support system [47], and prediction of diabetes risk (predicting the risk of retinopathy and cardiovascular disease) [22, 26, 30, 31].

Reminder

Alerts and reminders of CDSS articles were reviewed, including: lifestyle alerts (meals and physical activity management) [2], pharmaceutical alerts and reminders (drug administration, for overdose) [15, 17, 23, 24], alert for hypoglycemic

management is an alert for abnormal laboratory results [17, 23, 26, 28, 37, 42, 45], an insulin dose adjustment [29], warning if a change in the patient's treatment plan is needed [33] and alert prediction of diabetes risk (predicting the risk of retinopathy and cardiovascular disease) [20].

Interface

Simplicity; words like "easy" and "simple" are recommended frequently with and without specific guidance. Simplicity includes the elements that are for ease of use that determinants of user acceptance of information technology [9, 48]. Techniques used to promote simplicity include consistent terminology, concise and unambiguous language, effective visualization, improved readability, and reduced density of information such as annotation, use of special format for reports [23, 38-42, 44]. To improve readability, it is suggested to consider the use of appropriate font sizes use meaningful colors, ensure acceptable contrast between text and background and make icons bold or bigger in size (customization tools) [22, 24, 38, 45]. Other interface parameters included, User-friendly interface [14, 29, 31, 33], graphical display of information e.g. graph, chart, chart pop-up recommendation [21, 24, 34, 35, 37, 39, 44, 45], use of graphical modeling tools[23, 28], organizing and optimizing information and reports [26, 28], applying step by step guide [14].

Interaction

Fit; for CDSSs to reach their full potential, complex data must be rapidly accessible and easily understood within a providers' workflow. It should use selection tools (e.g., dropdown boxes, field types) and sort options to facilitate ease of use and reduce cognitive load and potentially user error [23, 25, 34, 38-40, 43]. To complement provider workflow and reduce cognitive load [19, 32, 33], the CDSS should automatically pull data from the EHR/integrate into the charting system [28], meaning the CDSS is an integrated component of charting or the order entry system. Feedback; feedback refers to the ability of a system to send information back to the user about what action has been done and what result was accomplished. The system should provide decision support automatically as part of clinician workflow, meaning the CDSS is provided at the point of care or order [26, 38, 40, 42, 44]. It should have automated alerting [2, 19, 26, 45-47] and develop automatic prompting of users by the decision aid, as opposed to systems that rely on manual processes where clinicians are required to seek out the advice of the decision support system [43]. It should request documentation of reasons for not following CDSS recommendations by prompting clinicians to record

a reason when they do not follow the advised course of action rather than allowing the system advice to be bypassed without recording a reason [23, 37]. The system should allow the user to be able to modify orders and should integrate a reset button [36, 37]. Errors in data entry and selection occur, and users require the ability to make changes or begin using the tool again. Flexible design; CDSSs must be flexible and adaptable, able to explore multiple assumptions and incorporate new information as circumstances change [2, 40, 42, 45]. CDSSs offer a process for enhancing health related decisions and actions with pertinent, organized clinical knowledge and patient information [40, 46]. Information recipients can include patients, clinicians, and others involved in patient care delivery [23, 29, 35].

Information

Content guidance; a CDSS encompasses a variety of tools, including clinical guidelines, diagnostic support, computerized alerts and reminders, and contextually relevant reference information, explain and justify the recommendations [21, 37] and their source by providing reasons and research evidence, particularly for systems that require a reason for overriding advice (standard) [14, 19-21, 24-26, 29, 32, 33, 36-38, 40, 42, 44, 45, 47]. It should allow for the provision of advice, suggestions, and alternative recommendations to increase compliance and to respect the autonomy of the physician [21, 25, 37, 43]. It should provide additional resources or access to additional knowledge when needed, including justification of recommendations and rules, and scientific documentation structured depending on the user. It should make evidence-based recommendations the default and keep recommendations up to date (Evidence-based recommendations) [2, 14, 17-19, 22-25, 28, 30, 32, 34, 37, 39-41, 43, 44, 46]. Clean and concise; all components should be designed so their meaning is not ambiguous. Information should demonstrate clarity by being presented as clean and concise [26, 30, 35, 37, 42, 44, 45]. In Table 1, the interface, interaction, information factor criteria are presented.

DISCUSSION

We evaluated diabetes decision support systems based on design criteria, type and purpose of decision support systems. In this study, for the design criteria from classification of Miller et al. [9] is used for interface, interaction and information factors. Overall, study mentioned was provided aims to compiling and report CDSS design recommendations to support efficient, effective and timely delivery of high quality care.

According to the reviewed articles, decision support

systems for diabetic patients are further advised on aspects of blood glucose control and reminders for lifestyle changes (diet and physical activity), physician alert for drug administration (insulin dose adjustment) and warning was emphasized for abnormal laboratory results.

The classification of type of diabetes decision support systems is more in the type of consultation (type 2) because the primary purpose of diabetes decision support systems is to control blood glucose which can be in the context of specific patient counseling, status alerts, and reminders. Or other recommendations. Info button decision support systems and information presentation are less common, though they are probably simpler to design than other types of decision support systems. Info buttons, provides context-specific methods of informing a retrieval engine of the kind of information needed in a particular context, e.g., when reviewing of a laboratory test result. This methodology does not tailor advice but rather selects it based on context [49].

Patient-based reminders provide various warnings, the most notable being warnings indicating abnormal levels (abnormal laboratory results and drug overdose) and abnormal changes (hypoglycemia management). Reminding the user is to perform a task, or to alert them about the potential consequences of not performing a task [50], and the intention behind putting a reminder system in place provides not only an avenue for continuity of care, but also a continuum of awareness of the risk for development of diabetes [51]. Reminders and alerts need to be integrated into the workflow in order to be maximally useful, nonirritating, and less likely to require extra time and effort from a user. However, that requires considerable effort in editing a basic rule, to incorporate such factors as how it should be triggered, when it should be run (e.g. firing a reminder when a due date for a screening test is about to occur, or only afterwards if the provider neglected to order the screening test), who should be notified, and how to do the notification. Managing alerts about reminders is an important issue not addressed in the reviewed articles. Unsystematic alert management can lead to no adherence, high override rates, and "alert fatigue," in which clinicians neglect CDSS and other alerts, thereby diminishing their effectiveness and potential benefits. As a result, CDSS developers and users aspire to improve alert management to achieve better acceptance rates and improved care delivery [9].

When interface not well designed, the use of the system for the user is vague and not easy for everyone to use, so simplicity and ease of use are important. And the correct application of colors and graphic elements and the correct presentation of

textual content plays an important role in the patient's absorption and use of the system. So a good and efficient user interface makes the system easy and enjoy for the user.

In the reviewed articles, most decision support

systems focused on ease of use and reduced cognitive load and possible user error. Because the system with automatic information interaction, feedback, flexibility reduces possible cognitive and error loads and facilitates workflow.

Table 1: The interface, interaction, information factor criteria

INTERFACE (presentation)	INTERACTION (Function)	INFORMATION (Content)
Interface features categorized as presentation, placement, positioning, and provision of multiple presentation layers	Interaction features categorized as fast, fit, feedback, forgiveness, and flexible design	Information features categorized as clean and concise, content guidance, and consistency
Presentation Make it simple Use appropriate font sizes Use meaningful colors Keep presentation consistent Deploy space-filling techniques Make icons bold or bigger in size Placement and positioning Display information in prominent positions to ensure that it is seen Allow for reading left to right Localize information Avoid using only text	Provide timely feedback Reduce the amount of time the user is required to interact with the CDSS Fit Minimize cognitive load Minimize cognitive load Automatically pull data from the EHR/integrate into the charting system Navigate to appropriate locations Initiate intervention and take Provide a route to get to provider-specific info Adapt its behavior according to a subset of relevant actions taken by clinicians Incorporate functions supporting the dialog between the CDSS and the clinician Feedback Provide decision support automatically as part of clinician workflow Automate alerting Request documentation of reasons for not following system recommendations Allow the user to be able to modify orders Integrate a reset button Flexible design	Clean and concise Standardize terminology Use concise and effective language Content guidance Provide a recommendation, not an assessment Justify recommendations Suggest alternative recommendations Provide additional resources Make evidence-based recommendations the default Keep recommendations up to date Consistency Recommendations should come from the same place Have the same display of basic CDSS for all members of the health care team

In the information section, the focus of the articles studied was on the content guide and clinical practice guidelines and the evidence-based recommendations, because; clinicians want to give their patients the best possible care. To do this, they need to keep up to date with the evolving body of scientific research, and combine this scientific knowledge with their own clinical experience and each individual patient's circumstances and preferences [52]. This is evidence-based practice. One way of supporting implementation of evidence is through evidence-based clinical practice guidelines [52]. CPGs outline a plan of expected care, providing a guide to recommended practice and outlining the likely outcomes of care [52]. Evidence-based clinical practice guidelines represent a systematic approach to translating the best available research evidence into clear statements regarding

treatments for people with various health conditions [53]. Guidelines have a range of purposes, intended to improve effectiveness and quality of care, to decrease variations in clinical practice and to decrease costly and preventable mistakes and adverse events [54]. Quality CPGs based on comprehensive reviews of the research evidence can help patients, practitioners, policy makers, and administrators make better decisions about how to proceed with care [53]. High-quality guidelines, used appropriately, can facilitate shared decision making and identify gaps in knowledge [53].

One of the key points for the success of a clinical decision support systems (CDSS) is its capability of being integrated in a health information systems (HIS). An integrated CDSS is able to provide their predictions or recommendations based on patients'

electronic health record (EHR). Non-integrated CDSS may require an additional data entry, a workflow issue that can lead to failure the acceptance and effectiveness of a CDSS [20]. Widespread adoption of sophisticated EMR-based CDS has the potential to modestly improve the quality of care for patients with chronic conditions without substantially increasing costs to the health care system [47]. Nine articles From the 35 articles reviewed in this study, diabetes decision support systems used the information in electronic health records and electronic medical records [14, 20, 22, 26, 28-30, 35, 37].

However a successful integration of a CDSS results by adapting solutions to particular systems, e.g. by building ad hoc accesses to local relational databases or EHR. This solution, however, may remain unscalable in the sense that it would require the effort of performing a specific integration for each different HIS [20]. In addition to Integrated reminders within clinical systems have become more prevalent due to the use of electronic health records and evidence demonstrating an increase in compliance within practice. The growing number of prompts may be counterproductive as healthcare professionals are increasingly suffering from “reminder fatigue” meaning many reminders are ignored [50].

CONCLUSION

Clinical decision support systems are being promoted as a promising approach aimed at healthy

and effective management of diabetes. The purpose of most of these systems is to adjustment insulin dosing. Most decision support systems consider some number of factors listed above. System designers in each system only considered a few design criteria, so they could focus more on design aspects to improve performance. Decision support system evaluation models can also be added to the factors under consideration. Due to the decrease in infectious diseases and increased life expectancy in developed and developing societies and since chronic diseases are one of the challenges of increasing life expectancy, this study is recommended for other diseases. To achieve more accurate results and enhance future research, use chronic databases such as Scopus and Med Line.

AUTHOR'S CONTRIBUTION

The authors agree on this final form of the manuscript, and attested that all authors contributed in the final draft of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this study.

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No financial interests related to the material of this manuscript have been declared.

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