MyInsul.in: Decision Support for Inpatient Physicians Managing Hyperglycemia

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PROBLEM – Inpatient physicians need a quick, reliable, and accurate tool to navigate complex guidelines for managing hyperglycemia.

SOLUTION – We created a HIPPA-exempt web application called MyInsul.in. Our tool provides physicians with immediate access to standard clinical insulin dose guidelines related to patient's mass, BMI, disease state, and drug use.
Objectives: Engineer, revise, and validate the use and effectiveness of our tool.

METHODS – MyInsul.in is available in mobile and full-sized versions for initiating and managing basal-bolus regimens in accordance with guidelines provided by the teaching hospital. Physicians were encouraged to actively use MyInsul.in starting December 1st. Data was aligned with stakeholders: web analytics (engineers), perceptions (physicians), glycemic compliance (hospital quality committee), and case studies (patients).

RESULTS – Web analytic data confirms that our tool was used, but less than would be expected given the number of patients on the ward. Physicians attributed fewer barriers to management of hyperglycemia after the introduction of our tool. The overall unit's glycemic control was not significantly different from historical data. The case studies suggest that physicians who used MyInsul.in had patients with better control than physicians who relied on sliding scale.

CONCLUSION – MyInsul.in was effective in reducing barriers to managing hyperglycemia when used. MyInsul.in improved residents' knowledge about hyperglycemia, and initiated discussion about clinically relevant quality measures to assess glycemic compliance. However, MyInsul.in is in the early stages of adoption suggesting that further intervention and education is necessary to improve hospital glycemic control.

Our bodies regulate many biological systems. When biological systems are well regulated, resources meet demands and homeostasis is achieved. When homeostasis is disrupted in the regulatory and counter-regulatory parts of the endocrine system, hyper- or hypo- glycemia occurs.

Approximately one in three hospitalized patients requires management of hyperglycemia (39). In the hospital, hyperglycemia is defined as random blood glucose levels greater than 180 mg/dL (10.0 mmol/L) (10, 16, 18-26). Stress, surgery, steroids or endocrine conditions like diabetes mellitus contribute to hyperglycemia in the hospital (45). Hypoglycemia occurs when blood glucose levels are below 70 mg/dL (3.9 mmol/L). Hypoglycemia causes confusion, irritability, seizures, and may lead to coma and death following extended periods of hypoglycemia. Good control in the hospital is defined as pre-meal blood glucose levels between 100 – 140 mg/dL (5.5 – 7.8 mmol/L) with an acceptable control range from 80 – 180 mg/dL (4.4 – 10.0 mmol/L).

Hyperglycemia is a large and growing problem in the hospital environment (35, 39) associated with the obesity epidemic. There are about 1.6 million newly reported cases of type 2 diabetes per year (36). Failure to properly manage hyperglycemia increases morbidity, such as surgical side infection and volume depletion (37). While proper treatment can help patients recover, incorrect treatment can be detrimental to the patient's wellbeing. Hyperglycemia is independently is associated with higher death rates (47).

Insulin and Insulin Therapy

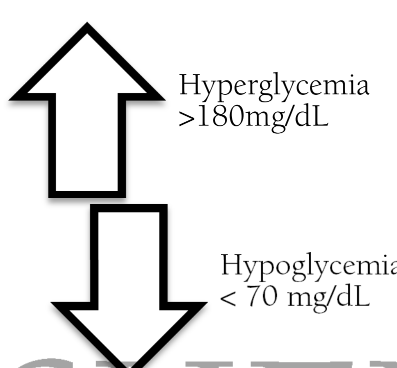
Currently, the most effective treatment for hyperglycemia is insulin therapy (56). Insulin is a hormone produced in the pancreas by beta cells enabling cellular consumption of glucose in the bloodstream, which regulates and controls blood glucose levels (45). Insulin requirements are determined in relationship to different disease states in the regulatory and counter regulatory systems. A patient's total daily dose of exogenous insulin is dependent on weight, disease states and resistances. Physicians must estimate patients' total daily dose based on these factors which is equal to weight (kg) times the units $\cdot \text{kg}^{-1} \cdot \text{day}^{-1}$ ratio.

Exogenous insulin exists in many different types and mixes of synthetic and natural analogues (41). Insulin is classified as acting over rapid, short, long and intermediate periods of time. Insulin is typically injected subcutaneously or intravenously into the body at specific times and distributions.

Two commonly prescribed regimens include sliding scale and basal-bolus regimens (35-37). The sliding scale regimen is common in hospitals due to it being easy to calculate on the ward. The sliding scale regimen was designed to react to immediate rises in blood glucose levels. The basal-bolus regimen is a newer plan that is designed to anticipate blood glucose levels by mimicking natural insulin secretion (39, 41, 45). However, unlike sliding scale, basal-bolus regimens require rigid injection schedules, more insulin injections, and active monitoring of blood glucose to accurately titrate insulin. Additionally, basal-bolus regimens have an additional supplemental insulin scale which works like sliding-scale in conjunction with basal and bolus components to offset temporary increases in blood glucose levels. It is given with nutritional doses (matching the nutritional insulin type). A prospective, multicenter, randomized trial determined that basal-bolus regimens produced significant improvement in glycemic control compared to normal medical wards (37).

Insulin distribution is usually given as a 50:50 proportion between basal and bolus insulin components, respectively. Continuous tube feeds give less basal insulin and more bolus insulin in a 40:60 distribution. Patients receiving steroids (specifically corticosteroids) also require a 40:60 distribution. Renal and hepatic failure require even less basal insulin as insulin is not removed from the bloodstream, instead with a 33:67 distribution.

Complications can be prevented through the use of modern work practices, specifically basal-bolus regimens. However, modern work practices require



patient weight, estimated total daily dose, and resistance. The access to these components of care are difficult to calculate, and are infrequently used in teaching hospitals. Other perceived barriers to adequate glycemic management in hospitals include uncertainty about diet, access to formulas and conversion charts, and clinical knowledge (e.g., patient resistance to insulin, and distribution of total daily dose).

Human-Technology Decision Support

Research conducted by other organizations proposed potential barriers to adequate glycemic management. There are many barriers to glycemic management including physician education, access and familiarity to insulin protocols, and system inefficiencies. Physicians, patients, informatics engineers, and hospital administrators are all invested in improving glycemic management among patients for a variety of different reasons.

Technology is increasingly prevalent in the hospital. Patient management systems streamline processes (i.e., charting, prescriptions, and communication) between all parties. However, protocols do not take advantage of electronic calculations and their interactivity in general. Many scientific studies have suggested a need for electronic protocols to replace paper counterparts to encourage improved management.

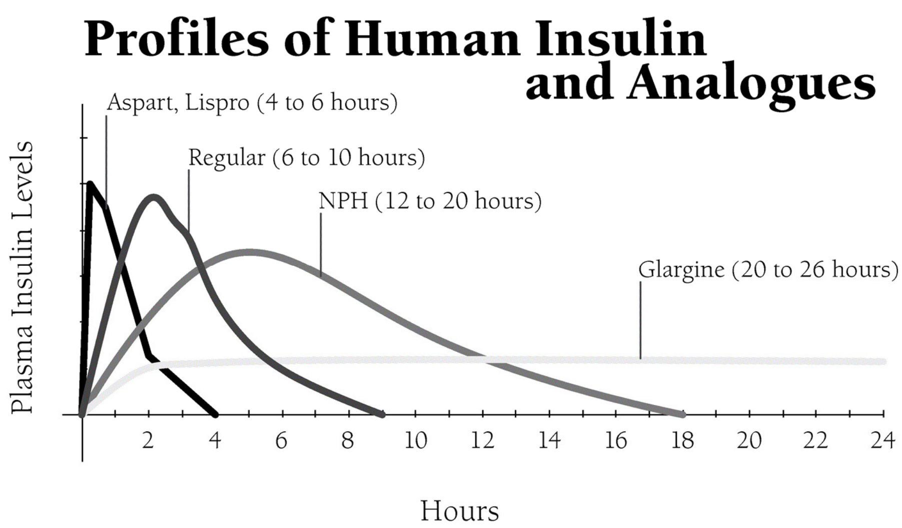
Research conducted by other group's proposed potential barriers to adequate glycemic management.

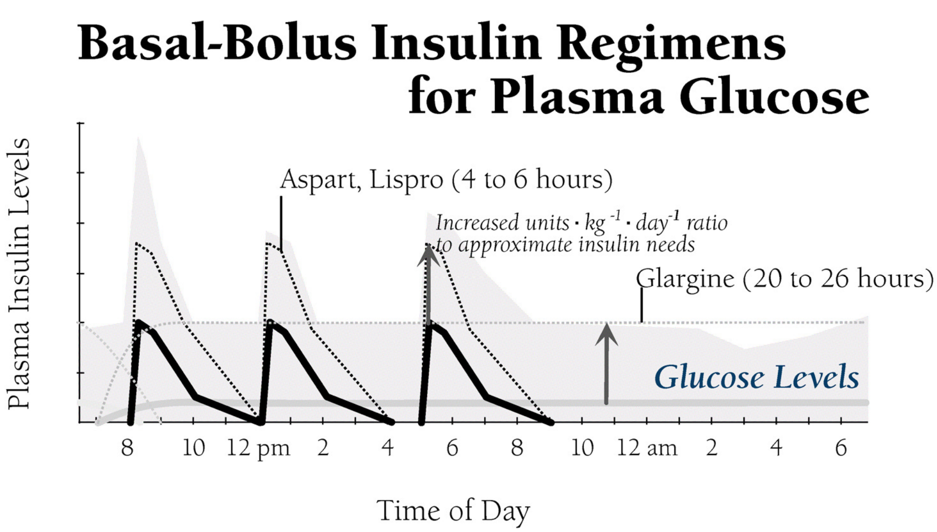
Few studies have investigated how to best utilize technology in insulin regimen management in a hospital environment. Those studies that have introduced electronic order forms have not publicly released versions of their electronic order forms and do not take advantage of electronic order form interactivity and flexibility.

Technology's place within hospitals is rapidly changing. With the introduction of electronic patient management systems within the hospital, paper checklists and forms are being phased out in the hospital environment.

Currently, no tools publicly exist for physicians managing hyperglycemia. The introduction of an electronic tool within the hospital is both a logical and important step to take in glycemic management given strides in patient glucose monitoring systems and the increase of complexity of guidelines to achieve better compliance. Such a tool would promote consistent dosing suggestions and use of the basal-bolus regimen.

Inpatient physicians need a reliable, accurate way to navigate complicated, personalized, modern insulin regimens.





A Solution: MyInsul.in

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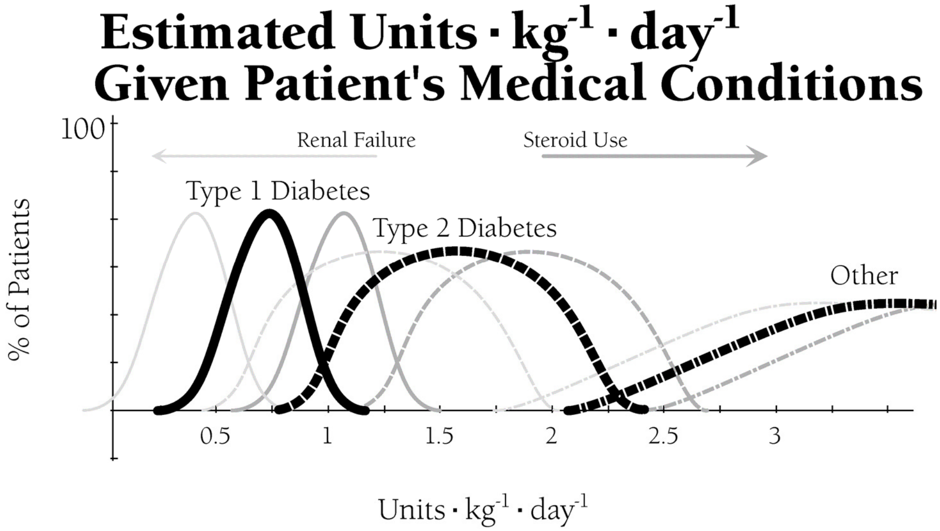
The solution to the can be addressed in multiple ways. For the purposes of this investigation, a tool will be created and tested using a naturalistic experimental design to eliminate barriers and increase proper management of hyperglycemia in the hospital. This process can be broken down into three objective points.

1) Engineer a tool that will support physicians' decisions with standard clinical practices related to personalized insulin doses in order to reduce perceived barriers to managing hyperglycemia, and increase normoglycemia.
2) Revise the program based on physician feedback in order to further increase compliance in the hospital.
3) Validate the use and effectiveness of the tool by introducing the tool to inpatient physicians.
4) Further revise the program based on physician feedback in order to further increase compliance in the hospital.

As established in scientific research, the problem of managing hyperglycemia can be addressed by educating the physicians, residents and nurses on proper dosing strategies, providing dosing tools such as electronic checklists integrated into the hospital and calculators that calculate



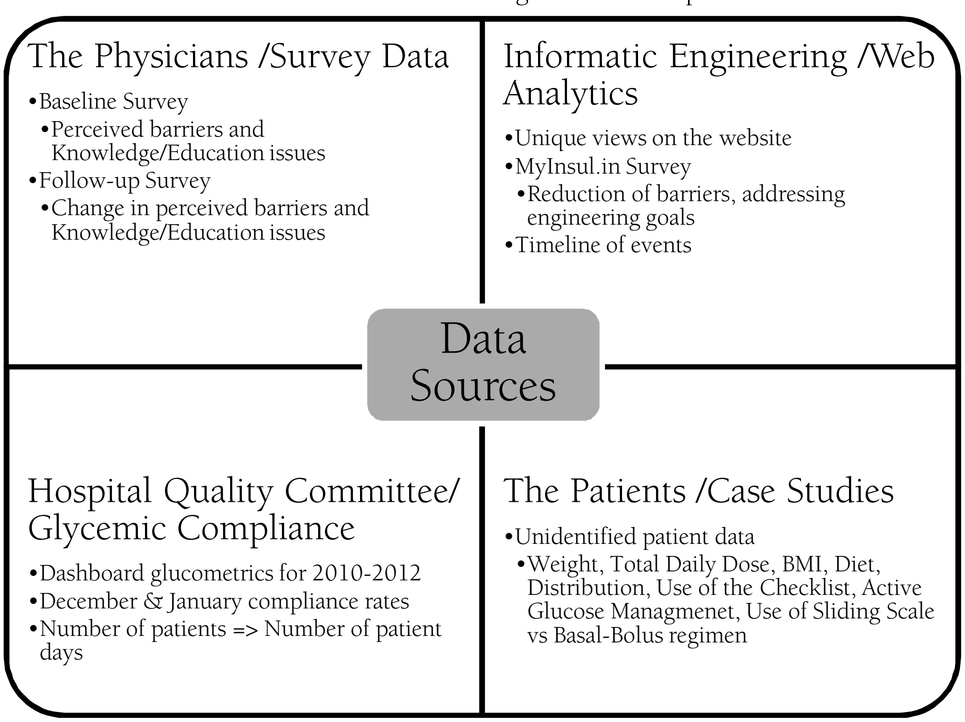
insulin regimens based on predetermined factors, and removing barriers to proper glycemic management.

By creating a web application and providing attending physicians and residents with reliable insulin suggestions, compliance rate should increase, use of basal bolus regimens should increase in the hospital, knowledge among physicians and resident should increase and many of the barriers preventing inpatient physicians from managing hyperglycemia should be eliminated. The web application was also designed to encourage physicians to communicate blood glucose and insulin in terms of total daily dose, units $\cdot$ kg^{-1} $\cdot$ day^{-1} ratio, and insulin basal-bolus distribution.

Methods

This study was conducted at Legacy Emanuel, part of Legacy Health Systems, a teaching hospital in Portland, Oregon, on an adult general medicine inpatient unit with 34 beds. On any given day, the unit has, on average, four medicine attending physicians and six residents.

Initial introduction of MyInsul.in, the computerized insulin dosing application, took place on December 1st 2011 and continued until January 31st 2012. Baseline and follow-up data was collected to determine the success of introducing MyInsul.in to support physician decisions and eliminate barriers to glycemic management in a hospital.



Experimental Design

A natural experimental design was used in order to analyze the effects of implementing MyInsul.in in a dynamic hospital system. This design enables analysis of physician adoption to using MyInsul.in. A natural experiment further allows an observational outlook of the hospital system in recognizing the success or failure of implementation of interventions. Finally, a natural experiment allows for the ethicality of letting physicians have complete control and discretion of whether or not to use MyInsul.in.

Intervention

The tool was introduced to the faculty physicians and residents in three ways: in-person meetings with a Microsoft PowerPoint presentation and demonstration of the tool, an email list, and constant advocacy by a committed inpatient physician and other dedicated and enthusiastic about MyInsul.in parties on the ward. Additionally, bookmarks were placed on every browser on each computer on the ward and a link was implanted into a checklist in the charting system, EPIC, to increase the number of times physicians come in contact with the tool and ease of accessibility.

Data Collection

Data was collected to address the groups involved in this problem: the physicians, the informatics-engineering group, hospital quality committee, and the patients. Sources of data are listed below:

Informatics Engineering/Website Analytics (Use of the Tool in the Hospital)

To ensure that physicians are using MyInsul.in during the months of implementation, the numbers of unique views on the full-sized site (and other website Analytics) per day, sorted by request hostname, were tallied. Google Analytics provided these raw analytics. Correlation to the number of patients on the unit each day was then completed. Further properties of visits were recorded (e.g., duration of visits).

The Physicians/Survey Data

The Inpatient Diabetes Management Survey (53, 54) was distributed to inpatient physicians as a way to access the social environment in which physicians are interacting. To increase the number of people taking the survey, the survey was distributed in person and by an emailing list. The Inpatient Diabetes Management Survey consists of questions regarding: protocols in the hospital, confidence with insulin prescriptions, and barriers to providing care.

The survey was provided before and after the two-month intervention and the results from the two surveys were used as validation that the physicians believed MyInsul.in was there to support their decisions. With the follow up Inpatient Diabetes Management Survey, a set of questions about MyInsul.in was included. These questions addressed the engineering goals as were designed to determine of physicians agreed that the goals were met.

We created mobile and full-sized web application layouts for correctly formatting MyInsul.in on almost all electronic platforms.

Hospital Quality Committee/Glycemic Compliance

When new protocols or tools are implemented into the teaching hospital, physicians determine the impact by looking at hospital data for monthly compliance days. This data source goes back until early 2009 allowing for further baseline-follow up analysis possible. A practicing physician agreed to provide this data for this study. The practicing physician also agreed to provide information about the number of individual patients on the ward each day. This data will determine if there was an impact on the ward following introduction.

The Patients/Case Study Information

A practicing physician at the hospital agreed to provide unidentified patient data. This data was gathered to further describe the effectiveness of the tool when it was used in the hospital.

DEVELOPMENT

MyInsul.in is a web application that was designed for initiating and managing basal-bolus regimens in accordance with guidelines provided by the teaching hospital. MyInsul.in was created to make calculations for a basal-bolus regimen fast and reliable and discourage sliding scale usage in the hospital. MyInsul.in was developed in November 2011, with its first stable release on December 1st 2011. Physicians were encouraged to actively use the tool through December 1st 2011 and January 31st 2012, although use after this period is acceptable and encouraged, especially for future analysis. MyInsul.in exists in a full-size and mobile version for increased accessibility on all potential platforms.

MyInsul.in is publicly accessible online at http://myinsul.in. To avoid any liabilities, there is a disclaimer section in the application. MyInsul.in strives to make accurate dosing recommendations. Since no dosing/patient data is recorded by MyInsul.in, the program is exempt by The Health Insurance Portability and Accountability Act of 1996 (HIPAA).

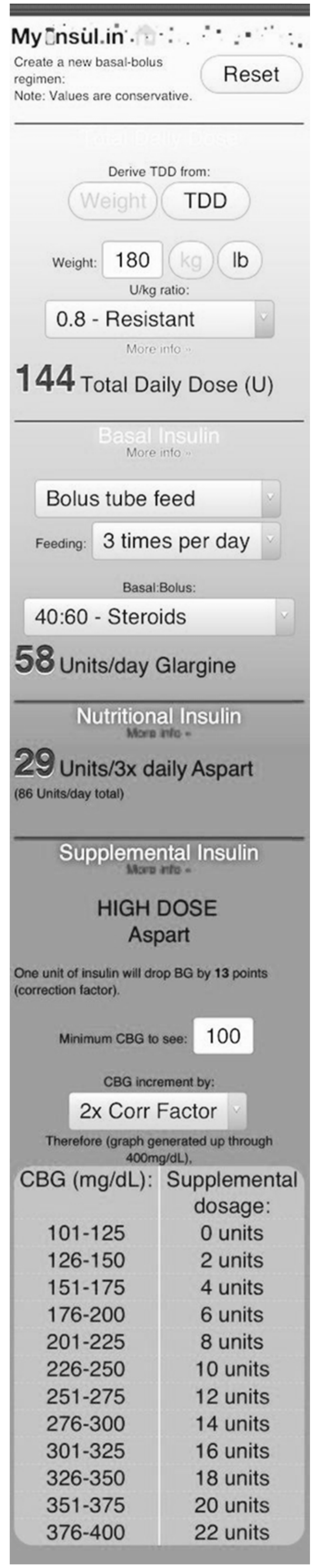
Before designing MyInsul.in, engineering goals were suggested. These engineering goals were addressed by the tool and became reference points and questions for asking the physicians in the final follow up survey. Because of the natural experiment nature of this study, making the program appealing for use by physicians is a critical aspect of success. The desired goals were outlined and addressed as follows:

Short, Easy to Remember Domain Name

In order to make the tool easy to remember (and there by accessible) we registered a domain name that is simple and short. We decided to register MyInsul.in rather than myinsulin.com or other alternatives. This extension of the name into the domain of the domain name shortens the domain name by three letters making it easier to remember and faster to type into a browser URL bar, taking advantage of the Internet country code top-level domain (ccTLD) for India: '.in'.

Fast Hosting and Server Response Time

A secure, professional, stable hosting environment provides MyInsul.in with business-grade hosting throughout the day. Hawk Host, a web-hosting provider, utilizes LiteSpeed's web server technology that is faster than Apache and owns servers in multiple locations on the west coast including Seattle, Washington (where MyInsul.in runs through). All JavaScript coding is optimized using Google's Closure Compiler Service. Additionally, a cache manifest in the mobile version is used to allow use of the application without an Internet connection.



Shows a screenshot of the mobile version of MyInsul.in's "calculate new regimen" page.

Instant Calculations

We created similar mobile and full-sized web application layouts for correctly formatting MyInsul.in for almost all electronic platforms. MyInsul.in utilizes the HTML (HyperText Markup Language) 4.01 strict (full-sized) and HTML 5 (mobile) for page layout with CSS 3 (Cascading Style Sheet) that is CSS 2 backward-compatible. The full-sized version fully complies with World Wide Web Consortium (W3C) markup standards for best compatibility across browsers, including Internet Explorer 6. A JavaScript backend will provide instant calculation updates for both versions, as well the backend of popup screens for further information. Absolutely no server site processing, for example, with PHP (HyperText Preprocessor), is used.

Accurate and Consistent Guidelines

MyInsul.in used guidelines provided by a local teaching hospital as core functionality and re commendations for design of MyInsul.in. The local teaching hospital agreed to use the first stable version of the tool in their clinical practices. The hospital had guidelines for: creating and managing a basal-bolus regimen, conversion from intravenous insulin, titration, and discharge. Furthermore, other guidelines and suggestions (10-26) were considered and added for added functionality.

Efficient Layout

Each page can be accessed by each other in only one click to minimize time spent in navigation. To get to any part of the website, at most two page loads are required: one to access the index, and another to access the specific page of interest.

Each page of the web application was also designed to be functional and user-friendly in an interface that is welcoming and yet professional and straightforward. Advantages of the mobile version include a touch interface that was exploited in big buttons and a scrolling interface, while advantages of the full-size site include a larger screen resolution to condense information to fit on the screen at once. However, in general, both versions were designed to look and function similarly for end product familiarity to patients.

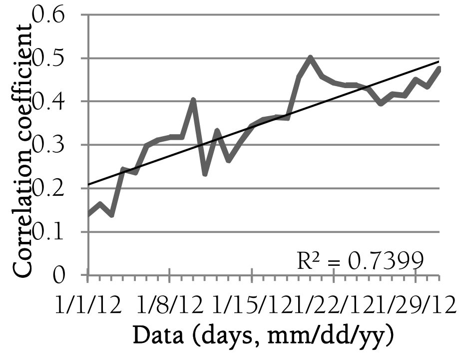
Accessible at the Point of Physician's Decisions

Both versions of MyInsul.in have many similar components available to physicians. These pages include: "New plan", "Tit rate", "Convert", "Discharge", "Manual conversions" (only full-size), and "More". The purpose of each is to address all parts of a basal-bolus plan, and allow the user to easily access the part of the basal-bolus regimen they are interested in modifying. The "Manual conversions" page on only the full-size layout shows the guidelines that MyInsul.in uses in order to give physicians further information if needed. Additionally, index, "Contact", "Disclaimer", and "About" (only full-size) pages are available for further information that do not have to do strictly with basal-bolus dosing, but general MyInsul.in information.

Results

Informatics Engineering & Web Analytics

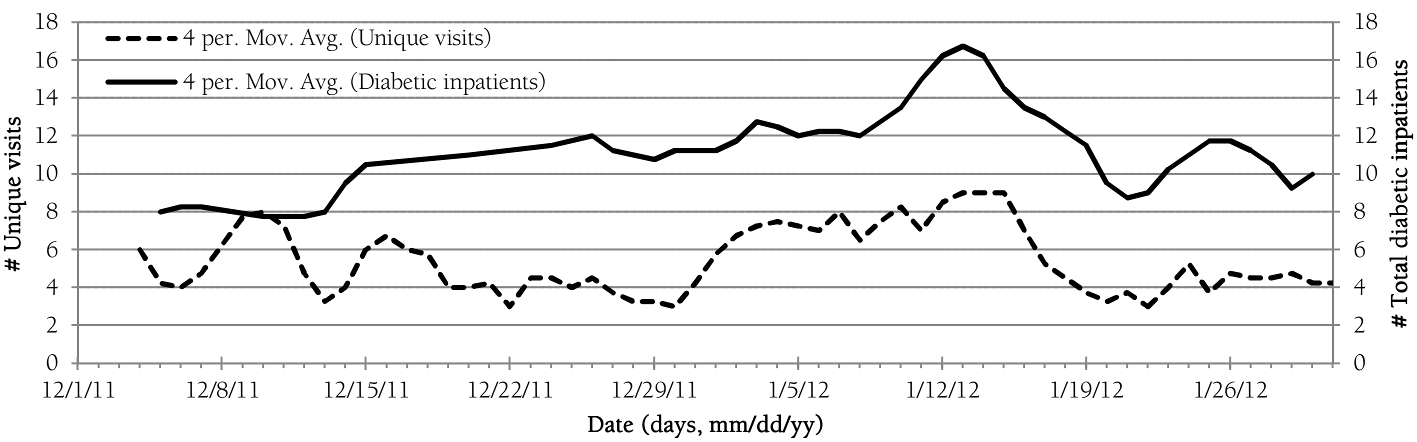
Google Analytics, a tool used to log website analytics, resolves Internet Protocol (IP) addresses to their host names. This can separate our own views of MyInsul.in during development, as well as any other views from additional locations, from the hospital system's usage. Furthermore, the hospital system has Internet requests both from the patient manage-



Analytically demonstrates the relationship between the number of unique views on Myinsul.in's full-sized version and total number of diabetic inpatients in the medical ward. A month long moving correlation was used to describe this relationship.

ment portal and direct views from the workstations' Internet browsers in the hospital. These requests have differing host names, which Google Analytics recognizes. This enables analyzing each of the two locations of views differently. We only analyzed full-size version analytics because of certain limitations in gathering analytics for the mobile version.

In this two-month long study from December 1, 2011 to January 31, 2012, analytics data was collected only for the full-sized version. In this, 979 total unique visits were logged in which 225 (3.63 average) were from the patient management portal and 113 (1.82 average) were from the workstations' Internet browsers for a total of 338 unique visits (5.45 average) from the medical system's network, which are assumed to be almost completely from the medical ward. Almost exactly 2/3 of unique views from the medical system's network were from the patient management portal and 1/3 from the workstations' Internet browsers.



Represents total unique visits from the hospital system's network against total diabetic inpatients in the medical ward. A 4 day moving average was used to best allow easier visualization of both data series, removing short-term fluctuations in values and highlighting long-term changes.

December 12th 2011 was the only day to receive no visits from the hospital system's network. On December 10th 2011, MyInsul.in was manually placed on all the browsers on the ward to increase availability. As a result, this date was excluded from analysis.

Almost all unique visits from the hospital system's network were from Internet Explorer 7 (90 .7%), with hits using Google Chrome had 5.2% and Firefox had 4.1%. The average time on the site from the hospital system's network, as interpreted by Google Analytics, was 1 minute and 43 seconds.

The data collected to describe the use of MyInsul.in underestimates of total MyInsul.in use as it was only from the full-sized site (see limitations section).

THE PHYSICIANS/SURVEY DATA

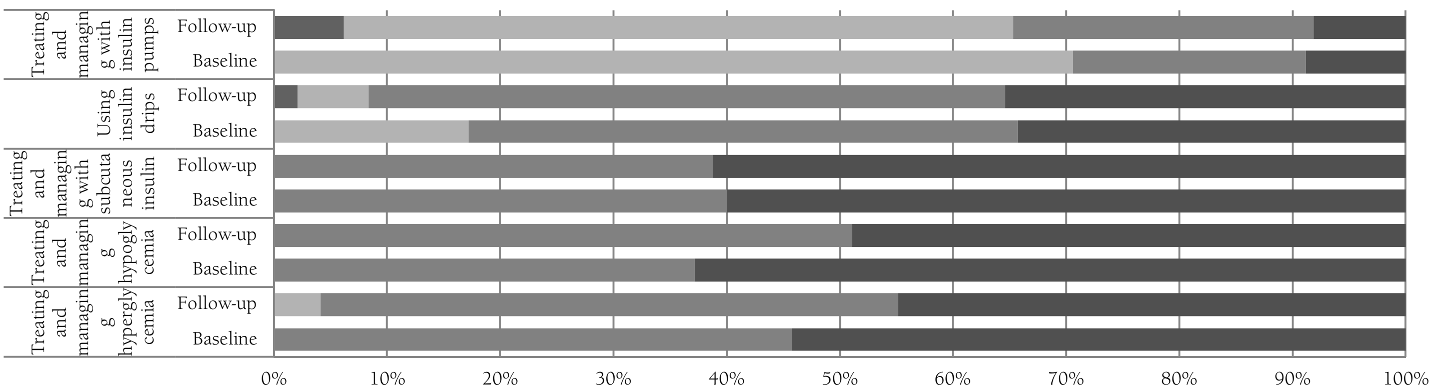
Baseline & Follow-Up Survives

To understand changes within the social environment at the hospital, a baseline survey (n=49) was distributed among physicians prior to introduction of the application. A follow-up survey (n=35) was conducted that was very similar to the baseline survey. A few questions were added with a MyInsul.in section attached at the end. The surveys reported on: confidence with different protocols, familiarity with protocols, and barriers preventing proper management of hyperglycemia.

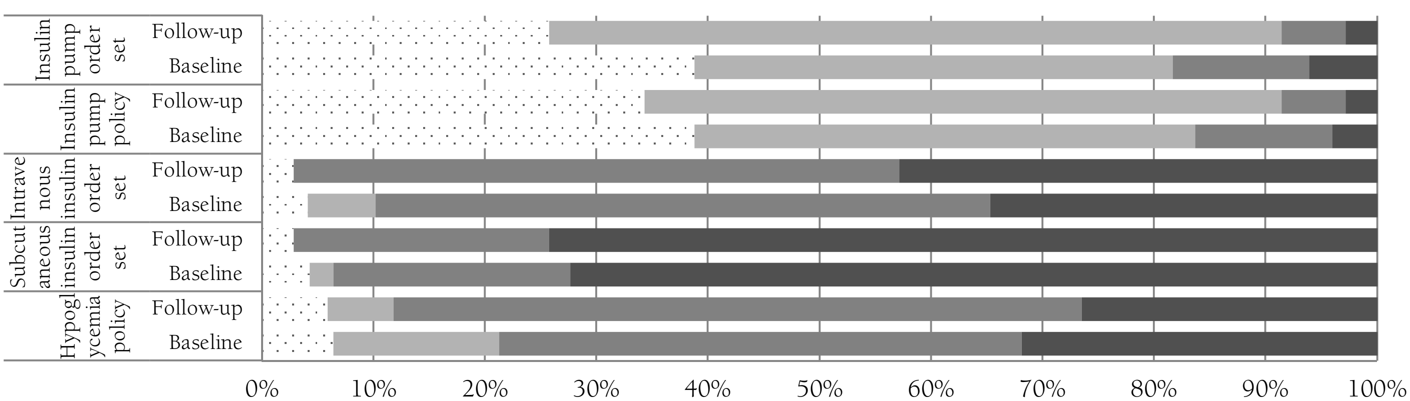
MyInsul.in uses policies from the teaching hospital regarding intravenous insulin, subcutaneous insulin, and hyper/hypoglycemia protocols.

Approximately 4.08% and 6.12% of physicians were initially familiar with the insulin pump policy and insulin pump order set. Similarly, during the follow-up survey, approximately 2.86% reported that they were very familiar with the insulin pump policy while and 2.86% were familiar with the insulin pump order set. At this teaching hospital, there is no insulin pump policy or order set. This suggests that a large portion of our sample was providing us with, what they perceived, to be the desired response rather than reflecting the reality within the hospital. In phycology this type of response is referred to a conformation bias.

About two thirds of inpatient physicians were very familiar with subcutaneous insulin order sets but are not familiar



	Treating and managing hyperglycemia		Treating and managing hypoglycemia		Treating and managing with subcutaneous insulin		Using insulin drips		Treating and managing with insulin pumps	
	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
■ Don't Know/NA	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.04%	0.00%	6.12%
■ Not at all comfortable	0.00%	4.08%	0.00%	0.00%	0.00%	0.00%	17.14%	6.12%	70.59%	59.18%
■ Somewhat comfortable	45.71%	51.02%	37.14%	51.02%	40.00%	38.78%	48.57%	55.10%	20.59%	26.53%
■ Very comfortable	54.29%	44.90%	62.86%	48.98%	60.00%	61.22%	34.29%	34.69%	8.82%	8.16%



	Hypoglycemia policy		Subcutaneous insulin order set		Intravenous insulin order set		Insulin pump policy		Insulin pump order set	
	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
· unaware of policy	6.38%	5.88%	4.26%	2.86%	4.08%	2.86%	38.78%	34.29%	38.78%	25.71%
■ Not at all familiar	14.89%	5.88%	2.13%	0.00%	6.12%	0.00%	44.90%	57.14%	42.86%	65.71%
■ Somewhat familiar	46.81%	61.76%	21.28%	22.86%	55.10%	54.29%	12.24%	5.71%	12.24%	5.71%
■ Very Familiar	31.91%	26.47%	72.34%	74.29%	34.69%	42.86%	4.08%	2.86%	6.12%	2.86%

in intravenous insulin or the hypoglycemia policy. During the follow-up survey, the number of physicians unaware of the guidelines, policies, and order sets decreased.

The graph above describes the percent comfort with different methods of treating and managing blood glucose. Most inpatient physicians reported feeling comfortable with treating with subcutaneous insulin

Above is a table showing the baseline responses to barriers preventing physicians from managing hyperglycemia. The far left column shows a list of barriers MyInsul.in was designed to address. Of the 20 barriers, MyInsul.in addresses 13 of them. Among those, physicians' fears of harming patients (54.2%), unpredictable changes in diet and meal times (47.9%), and fluctuating insulin demands related to stress and timing of food (41.7%) were among the top four barriers to physicians that MyInsul.in could address.

The Inpatient Diabetes Management Survey has been used in previous scientific articles as a tool to describe beliefs at other hospitals around the country. Specifically in articles conducted by Cook and colleagues, the Inpatient Diabetes Management Survey identified common barriers preventing physicians from a higher standard of care. The results from these articles are shown along with results as to initial perceptions at the locate teaching hospital.

MyInsul.in Survey

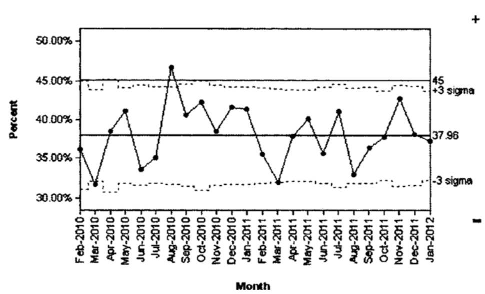
MyInsul.in was generally well received in the presentations and as reported by our designated scientist. Almost all physicians were excited to see change in revamping the current state of glycemic management in the hospital system on multiple fronts (i.e., MyInsul.in, surveys, education and realization of a problem). A second section of the follow-up survey was dedicated to determining MyInsul.in reception. Any question on the survey could be omitted. In the follow-up survey (n=35) of residents working in the hospital in general (not necessarily in our targeted ward) administered during an academic half-day and later online, 40% physicians (n=14) reported that they learned about MyInsul.in during the formal presentation by the supervising scientist. 42% of residents reported that they never used MyInsul.in in prescribing insulin (including never heard about it), 85% reported using the mobile device, with 43% solely using the mobile version. The majority of barriers addressed by MyInsul.in were perceived reduced, while barriers that MyInsul.in did not address became more apparent to physicians. Physicians also reported that MyInsul.in adequately addressed barriers addressable by MyInsul.in.

Hospital Quality Committee & Glycemic Compliance

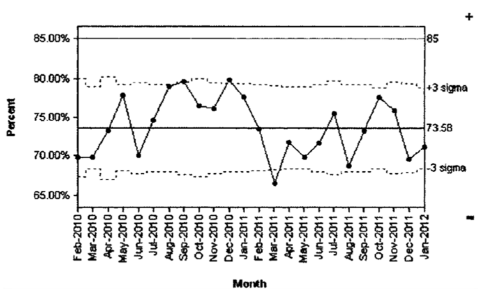
The medical ward's monthly glycemic compliance dashboard was provided for the months of February 2010 to January 2012. Results were automatically transformed from raw data as *p*-charts and summarized data tables, and generated on February 8, 2012. This data was calculated in terms of patient bed days in two different ways: by average or by all point of care blood glucose (CBG) levels measured by patient-days being between certain criterions.

Graphs describing average CBGs include data transformations and accompanying tables of good control (100-140 mg/dL), accept able control (80-180 mg/dL), hyperglycemia (> 180 mg/dL), and hypoglycemia (< 70 mg/dL). There were two transformations and tables for controlled CBGs: good control (100-14 0 mg/dL) and acceptable control (80-180 mg/dL).

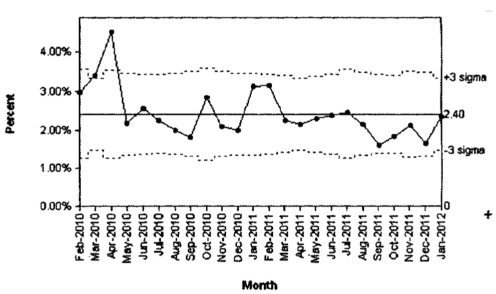
Each range is calculated by determining the number of patient days in compliance and the total number of patient days for that month. Shown as a *p*-chart, this percentage is graphed along with +/- 3 sigma ranges to describe months with significant changes in control.



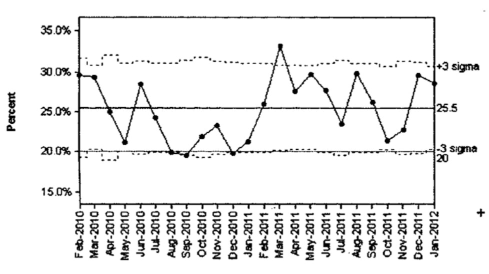
Percent Days Averaged Between 100-140 mg/dL.



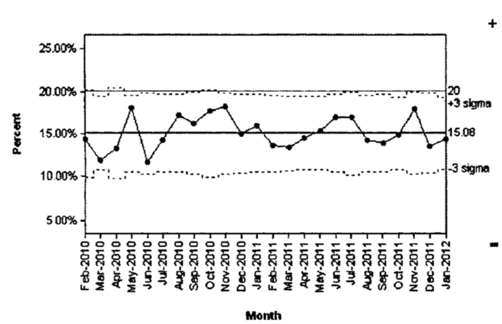
Percent Days Averaged Between 80-180 mg/dL.



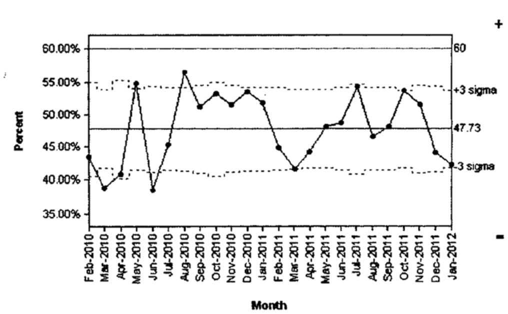
Percent Days Averaged < 70 mg/dL.



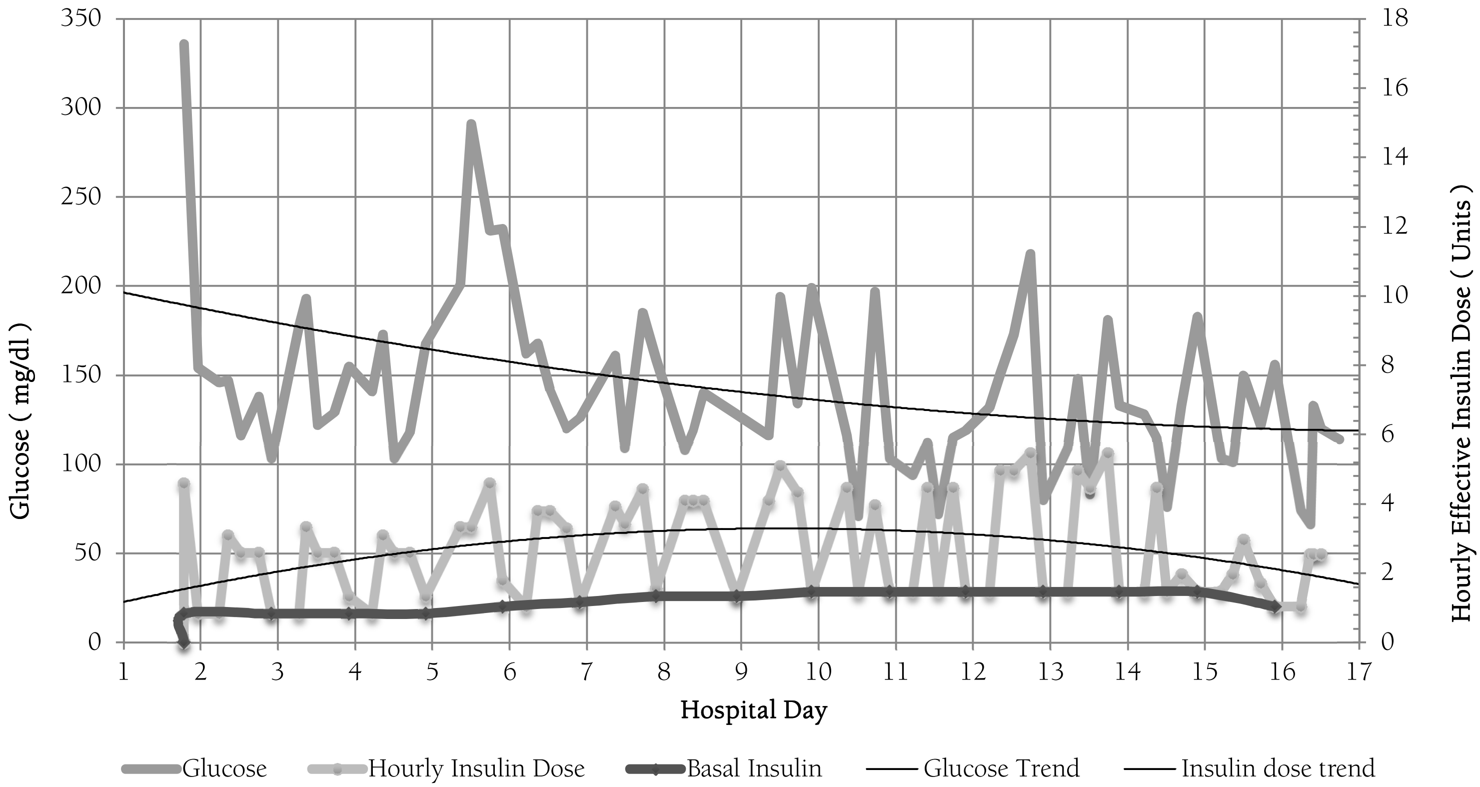
Percent Days Averaged > 180 mg/dL.



Percent Days Controlled Between 100-140 mg/dL.



Percent Patient Controlled Between 80-180 mg/dL.



Glucose vs Insulin Dosing with MyInsul.in by Hospital Day for Patient Admitted with Infection

On this medical ward, an average of 37.96% patient-days averaged good control and 73.58% averaging acceptable control. 25.0% patients-days averaged hyperglycemic and 2.40% averaged hypoglycemic. Rates of average compliance were much higher than rates of all (controlled) compliance as expected. 15.08% patient-days had controlled good control while 47.73% had acceptable control.

During December 2011 and January 2012 there was no significant change in glycemic compliance. Despite the goal of a significant (3 sigma) change in compliance, MyInsul.in was unable to show any significant changes in any direction.

For both December 2011 and January 2012, averaged CBGs of good control hovered around the mean with little change. For averaged CBGs of acceptable control, initially control shifted from above the mean to below it insignificantly, but in January 2012 control slightly improved.

The average CBGs interpretation could incorrectly label a patient-day as having good control if in reality the patient's CBGs were sporadically fluctuating between hypo- and hyper- glycemic incidences. However, the all (controlled) CBGs interpretation could not count a patient-day of mostly good control where only one CBG of hypoglycemia was measured and the patient was within good control for the rest of the day.

The Patients/Case Studies

Currently, a designated scientist is collecting data for an extensive case review. Future analysis will include characteristics of the patients stay such as: weight, age, body mass index (BMI), presence or absence of steroids, renal failure or kidney failure, who the attending physician was, and who whether or not a resident was working with the patient. This data will allow for predictive analysis of recommended dosing using MyInsul.in. This predictive analysis can then be used to determine the effectiveness of the tool by comparing the results calculated using MyInsul.in with the prescriptions prescribed at the hospital during the patients stay.

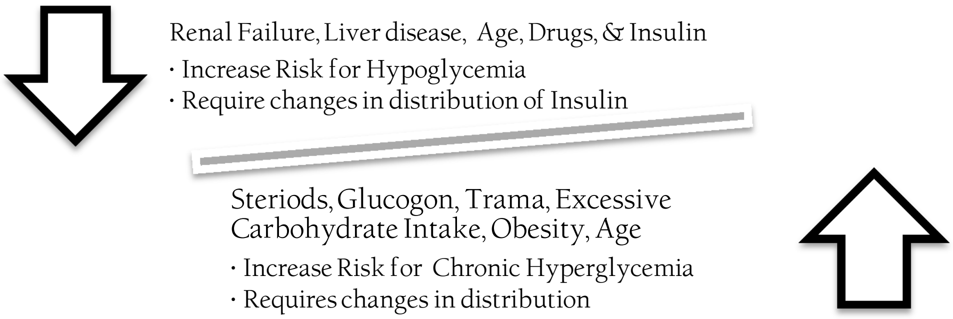
Right now, case studies are available to describe what happens to a patient when MyInsul.in is being used during their stay. The first patient was admitted with an infection and was requiring insulin for a total of seventeen days. This patient weighted 73 kg and had a BMI of 32. With an A1c of 7.9, she requires a large quantity of insulin to control her blood glucose. The illustration describes the control during her stay as the insulin prescription rose and her blood glucose levels decreased.

Discussion

Ineffective hyperglycemic management within the hospital environment is a consistent problem. Insulin prescription in a hospital is complex and has to take into account different variables that influence insulin requirements (e.g., insulin type and sensitivity). Many hospitals outsource glycemic management. However, hiring a diabetes specialist is not an option for all hospital wards and the presence of another physician may lead to a decline in communication among physicians and further confusion for hospitalized patients.

In the hospital, hyperglycemic events can occur in patients without a history of diabetes. Consistent insulin protocols across hospital systems are not established making glycemic management varied among different institutions.

Despite the complexity of insulin dosing, physicians either do not understand the basic causes of fluctuating blood glucose or do not have the time to analyze the causes that can be prevented. MyInsul.in was created to resolve the basic misunderstandings to insulin dosing and to make it a simple process to establish, titrate, convert, and discharge an insulin regimen.



MYINSUL.IN

Designing MyInsul.in

MyInsul.in was designed to be increase physicians' access to hospital guidelines by providing an interactive interface for basal-bolus calculations in the hospital. The tool was developed to assist physicians in prescribing a personalized regimen based on common individual characteristics. These characteristics include: weight, BMI, resistance (units/kg ratio). Age, steroid use, hemodialysis, and liver and renal dysfunction affect a patient's resistance, while the mode of nutrition, use of steroids, liver and renal dysfunction affects the distribution of insulin types. Physicians need to take into account these different components of a patient's health to effectively use MyInsul.in to treat patients in the hospital.

How successful was MyInsul.in at eliminating barriers?

Physicians thought that MyInsul.in reduced many of the barriers that it aimed to address. However, whether or not MyInsul.in fully eliminated barriers within the system has yet to be concluded as there was no significant change in glucometric data. MyInsul.in has the potential to address and eliminate the barriers within the system but further observation of the tool's effectiveness in the hospital is necessary.

How expansive was MyInsul.in's population outreach?

MyInsul.in was introduced into a single medical ward in a teaching hospital. However, many of the attending physicians and residents, who work on the medical ward, also work on different wards and in some cases different hospitals. This leads to communication between different groups in the larger hospital system. This complex system introduces the concept of "bleed though" where MyInsul.in becomes available and used by different parties outside of the medical ward in which MyInsul.in was original introduced. This "bleed though" became apparent when, on February 7th 2012, MyInsul.in was introduced at a conference by a physician. This change was confirmed after analytics showed views on the site occurring outside of Portland, Oregon. From this point on, the informatics information of hits became difficult to analyze as the data no long solely represented hits from the single ward.

UNEXPECTED COMPLICATIONS IN DATA COLLECTION

Informatics Engineering & Web Analytics

Technological barriers prevented accurate informatics data from being collected. Unfortunately, the mobile version could not be included in data analysis. The mobile version of MyInsul.in includes a cache manifest feature which enables using a downloaded offline version of MyInsul.in if an Internet connection does not exist or the website is offline. However, when the cache manifest is used, Google Analytics data cannot collect data for that visit leaving results regarding mobile site views inaccurate and an underrepresentation of the systems in place.

Additionally, by including mobile devices in analysis, it becomes extremely difficult to differentiate views from physicians, and views from people outside the system. Cellular devices connect to the Internet over EDGE or 3G, routing through the mobile service providers and their respective hostname(s). To ensure no mobile hits were counted in the informatics data, Google Analytics filtered mobile devices from the health center leaving the data for only the full-sized version.

The Physicians/Survey Data

Administering the surveys was difficult to coordinate with the physicians and residents. A practicing physician and supervising scientist had to find time in which all residents and many of the attending physicians were on grand rounds, a time period in which attending physicians are available to teach about different ways to manage patients. Grand rounds occur infrequently and as a result, the follow-up survey was administered a month after the planned cut-off date.

Hospital Quality Committee/Glycemic Compliance

Hospital compliance was received in the form of monthly dashboard glucometrics. During initial analysis of these glucometrics, it was determined that the data was not accurately representing the data. Patient-day counts were greater than expected, it was apparent that the day of admission was not excluded from the counts, and it was impossible to determine how many patients were on the ward at any given time. Drawing accurate conclusions from this data set is difficult and so further analysis in this category is necessary. The hospital quality committee group responsible for the glucometics data has agreed to provide us with individual patient's highs and lows on each day of admittance. The supervising scientist has agreed to unidentified the data to allow further analysis to draw more accurate conclusions about the use of MyInsul.in.

The Patients/Case studies

Initially there was a plan for a full case study review. This review would be used to address the issue of compliance rates and to see how often MyInsul.in was used in the notes. This proved to be time consuming, as patient data had to be collected by hand and unidentified before analysis could commence. Due to the complexity of the data and the limited available time, the planed case study review was put on hold until a later date. Instead, glucograms and case studies were analyzed to demonstrate the effectiveness of MyInsul.in for insulin dosing recommendations.

LIMITATIONS & FUTURE DIRECTIONS

Perceptions of MyInsul.in

The physicians may have perceived MyInsul.in as a third party infringing upon physicians' practices. Interactions were limited between the informatics engineers and the physicians. MyInsul.in contained a "contact us" button in which physicians could send emails with comments about improvements for the program. However, only one physician used this feature. Instead, the majority of comments regarding further availability came via second hand information provided by the supervising scientist.

Reactions to MyInsul.in in presentations were positive. Many physicians were thrilled to see a change in hyperglycemic management and MyInsul.in to make their work easier. However, while some physicians used MyInsul.in on patients, a sociopsychological phenomenon of diffusion of responsibility occurred in which physicians see a need for action to be taken in the system, but not necessarily on their part as an individual.

Duration of Implementation

Even though the initial introduction of MyInsul.in has been completed, MyInsul.in is still being used in the teaching hospital today. The duration of this project extremely short in terms of implementing a tool into a complex hospital system. Ultimately, two months is not enough time to see a shift in compliance. After consulting with a committee who works on implementing new protocols in the hospital, it was determined that six months was the proper amount of time necessary to determine the success of an intervention. In order to further determine the effectiveness of MyInsul.in, a continuation of this project (over six months to two years) and the continued implementation, education and revisions of the application would be opportune. This future study could also have the potential to be retrospective on our design, implementation, and overall intervention.

"We cannot solve our problems with the same thinking we used when we created them."

– Albert Einstein.

Rapid Adaption

Physicians in the hospital do not have enough time in the day to address all the problems a single patient has. Some physicians in the medical ward have to manage up to 13 patients at a time and physicians generally take over patients who have been in the hospital for extended periods of time. Physicians do not have the time built into their schedules to read new literature on medical practices and adjust their practices accordingly, especially on a more informal volunteer basis, even if it may make their work easier. While this prevented a quick adoption rate, one of the goals MyInsul.in was to make it easy and convenient to use as this study progresses.

Contrary to expectations, at the end of December, data regarding general monthly compliance rate went down. Research was then done into the inventor's adaption curve, a curve that describes the general adaption of new technologies into a large group. On this curve there is a place called "The Chasm". "The Chasm" is the term used to describe the point in which new technologies can either be used by everyone, or will fade into the background. During the month of December, MyInsul.in fell into "The Chasm". With an adaption rate lower than necessary, MyInsul.in made an impact, but wasn't going to go viral without a large base of dedicated users.

Extent of assisting

Even though physicians may be given a tool or a set of guidelines to assist them in prescribing insulin, they still need experience to accurately access all types of situations. However, without the tool, physicians require more time spent with prescribing insulin and the adverse effects of poor control than when guidelines are available as MyInsul.in. MyInsul.in provides an easy and flexible way to dose insulin that aims to not remove the physicians' end decision but to supplement their decisions with recommendations.

Conclusion

This study developed and assessed the use and effectiveness of an electronic insulin dosing guide to manage hyperglycemia in a teaching hospital. The data suggests that MyInsul.in was effective in reducing barriers to manage hyperglycemia when used. However, MyInsul.in is in the early stages of adoption suggesting that further intervention and education is necessary to improve hospital glycemic control.

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