The Effects of Redesigning the IDEATel Architecture on Glucose Uploads

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Abstract

The objective of this evaluation was to determine the effect of redesigning the Informatics for Diabetes Education and Telemedicine (IDEATel) telemedicine architecture on the average upload delay and on the average number of glucose uploads to a central database. These two measures positively influence our ability to deliver timely and accurate patient care to the study population. The redesign was also undertaken to improve the patients' experience in using the system and thereby increase the frequency and timeliness of their self-monitoring behavior. Using the total number of glucose uploads, we compared the delay in glucose upload times according to the type of home telemedicine unit the study participants used and the region where the participants lived. The participants were Medicare beneficiaries with diabetes living in medically underserved neighborhoods in New York City and rural Upstate New York. The populations in these two regions differed considerably in terms of ethnicity, language spoken (Spanish, English), and education level. Participants who had Generation 2 (Gen 2) (mean = 10.75, SD $\pm$ 7.96) home telemedicine units had significantly shorter upload delay times ($p < 0.001$) as measured in days than those participants with Generation 1 (Gen 1) (mean = 22.44, SD $\pm$ 11.18) and those who were upgraded from Gen 1

(mean = 20.67, SD $\pm$ 8.85) to Gen 2 (mean = 14.93, SD $\pm$ 9.37). Additionally, the delay was significantly shorter for participants living upstate (mean = 24.14 days, SD $\pm$ 11.95 days) than downstate (mean = 15.30 days, SD $\pm$ 7.87 days), $t(975) = 13.98$, $p < 0.01$. The system redesign made a significant impact in reducing glucose upload delays of IDEATel participants. However, upload delays were significantly impacted by the region where the participants resided.

Key words: telemedicine evaluation, technical architecture, diabetes telemedicine

Introduction

The use of telemedicine technology for home care in patients with chronic disease has a long history, particularly as it relates to diabetes mellitus. Various systems, employing a variety of technical solutions, have been developed over the past two decades that allow patients to collect blood glucose and other data at home, transmit them to central databases, and provide the data to clinicians who, in turn, communicate remotely with the patients to adjust their therapy. A number of systematic reviews have been conducted to summarize the experience to date.^{1–6} The recurring findings in these reviews have been that (1) telemonitoring of patients with diabetes is technically feasible; (2) small pilot projects are generally successful; (3) although some programs like the Informatics for Diabetes Education and Telemedicine (IDEATel) project have demonstrated significant changes in clinical outcome measures in the intervention group,⁷ most projects generally have not shown substantial improvements in outcome measures such as HbA_{1c} or cost; and (4) specific technical characteristics are readily identified as adversely affecting acceptability and adherence to protocols. While most systems do not get beyond the prototype or pilot phase, some have succeeded in expanding to involve substantial numbers of patients and are beginning to show improved outcomes and cost-effectiveness for some patient populations. For example, Bellazzi et

al.'s M2DM system in Italy monitors home glucose results entered remotely by patients and issues alarms and reminders by e-mail. In one 7-month study of 23 patients, they showed a statistically significant decrease in the percentage of badly controlled values from 33% to 27%.⁸ In a second, 56-month study comparing 28 intervention subjects to 26 controls, they found significant improvement in HbA1c (an initial average of 8.40% in one clinic dropped to an average of 7.75%) and a reduction in the percent of patients with markedly elevated blood glucoses (decreased from 30.14% to 21.85%).⁹ On a larger scale, the U.S. Veterans Health Administration conducted a study of their Veteran Affairs Care Coordination Home Telehealth program, following 445 veterans with diabetes for 2 years, and found that after a year of intervention, subjects had a 50% decrease in hospitalizations, an 11% decrease in emergency room visits, and a significant improvement in three of eight SF-36V (Short Form 36 specific for veteran population) subscales (Physical, Bodily Pain, and Social Functioning).¹⁰

Studies of diabetic patients using telemonitoring technology have shown that factors such as user interface design and system complexity can affect use and outcomes. The contribution of these factors is particularly evident when observational studies are conducted.¹¹ Observational studies of our IDEATel system identified a number of aspects of architectural design that affected use.^{12,13} We redesigned the system to enhance the patients' experience in using the system, thereby increasing the quality and frequency of their interaction with the system. In this paper, we describe the methods by which the system's capabilities were iteratively refined, report the changes in patients' understanding, compliance, and use of the IDEATel technologies, and discuss the lessons learned from this experience.

Background

The IDEATel study seeks to demonstrate the technical feasibility, acceptability, clinical efficacy, and cost-effectiveness of telemedicine for management of elderly patients diagnosed with diabetes mellitus.¹⁴ Phase I of the IDEATel project was funded by the Health Care Financing Administration in 2000 for 4 years; in 2004, phase II of IDEATel was funded for an additional 4 years by the Centers for Medicare and Medicaid Services. The renewal of the project offered the opportunity to review the lessons learned during phase I and to take advantage of advancements in hardware, software, and telecommunications during that period to re-examine and redesign the technology used in the project.

In phase I of the IDEATel study, a total of 1,665 elderly patients with a diagnosis of diabetes mellitus were randomized to the telemedicine intervention or usual care. Approximately half of the

study population resided in New York City and the remainder in other, mostly rural areas of New York State.¹⁴ Subjects were randomized to receive usual care or the telemedicine intervention. Subjects in the intervention group were provided with PC-based home telemedicine units (HTUs; *Fig. 1*) that allowed them to have videoconferencing capabilities utilizing "plain old telephone service" to permit communication with their case managers. They were also provided with Internet access using an Internet service provider (ISP) in order to access the study-related Web site, a glucose meter for home fingerstick glucose monitoring, and a blood pressure meter. Measurements from the meters were automatically uploaded to the HTU, which then transmitted the results to a central database. These results were then immediately available to nurse case managers and/or physicians, using the project case management system. The patients also had access to these data via a Web-based case management site (*Fig. 2*), customized to allow them to review their results and trends.¹⁵

In conjunction with American Telecare (ATI), to simplify the patients' navigation of the IDEATel system, a customized patient launch pad was designed (*Fig. 3*). The launch pad was organized using different colors to depict various functions.¹⁵ A green button,

Fig. 1. Gen 1 IDEATel home telemedicine unit.

labeled “Video,” was used to allow the patients to answer a video call. This was the most basic goal/function for patient use of the HTU. A yellow button labeled “Send” was used to transmit glucose and blood pressure readings. This function represented the secondary goal of the system to allow patients to manually upload their results

Fig. 2. IDEATel Web-based case management system (Gen 1).

Fig. 3. Gen 1 IDEATel launch pad.

to the IDEATel databases. A blue button labeled “Web” automatically dialed the ISP and connected the patient to the project Web site. This represented the highest level of adoption of the system. Patients who used this function were typically the power users who engaged the system early.¹² The red button, called “Restart,” caused the system to reboot. This could be used whenever the system was not operating properly. Differences between the Gen 1 and Gen 2 architecture can be seen in Table 1.

As part of the evaluation of the IDEATel study, phase I, Kaufman and colleagues¹² conducted a usability study using cognitive task analysis and field usability testing methodologies. The analysis included a video-analytic approach to human-computer interaction in which the subjects were videotaped in their homes in order to evaluate the usability of the IDEATel HTU.¹² The investigators identified a series of tasks and goals that each participant should be able to accomplish in order to effectively use the HTUs.

During the analysis of the videotapes, tasks were identified in which suboptimal performance by the users warranted a reassessment of the system architecture, prompting the comprehensive redesign and evaluation of the framework used for enabling effective participation by the participants in the study. For example, Kaufman et al. found that the system was not optimally matched with the computer skills of older adults. The system demanded heavy use of a mouse, which proved difficult for many of the older adults. Productive use of the Web site necessitated levels of dexterity and visual acuity that exceeded the skills of many of the patients. There were many features of the standard graphical user interface (e.g., font size, scroll bars, spacing of content) that presented challenges to this population. The materials and their presentation also necessitated high levels of literacy and numeracy that reduced comprehension.

Table 1. Gen 1/Gen 2 Feature Differences

FEATURES	GEN 1	GEN 2
Hardware	Conventional CPU and monitor	Custom designed Integrated Hardware
Input devices	Mouse, keyboard, launch pad	Touch-screen, keyboard, and optional mouse
Required skill level	Moderate	Basic
Method of data upload	Manual and remote	Automated, manual, and remote
Patient portal	Designed for adult users with diabetes	Modified for older adults with diabetes

Methods

Based on the results from the 2003 Kaufman et al. study and recommendations of field trainers and nurse case managers, the IDEATel project embarked on a system redesign for phase II of the study. Some of the recommendations required the increase of font and button sizes on the IDEATel case management Web site, prompting the developers to redesign most of the Web site's widgets (e.g., scrollbars, buttons, the calendar, etc). Complex user tasks, such as sending secure messages to the case managers, were also simplified. The HTU device itself (Fig. 4) was also redesigned, in collaboration with ATI and the IDEATel researchers, to increase usability and decrease the complexities of many tasks (e.g., a reduction in the number of steps needed to access the Web). To accomplish these goals, we dispensed with the standard windows, icon, mouse-based PC and employed a touch-screen computer. This device was a single, compact unit, about the size of a standard liquid-crystal monitor. The new design also included automated uploads of patient-collected blood pressure and glucose readings to the central database for examination by the clinical team. At regular time intervals, the central system would query both the blood pressure and glucose devices to determine if there were any new readings and then would proceed to upload the new values to a central database. The redesign process took 9 months to complete.

As mentioned, the introduction of the Gen 2 technology corresponded with the introduction of phase II of IDEATel. There were 341 participants enrolled in phase I who did not participate in phase

II. During phase II, an additional 249 participants were enrolled. However, due to limited availability of the Gen 2 system, at that time, not all phase II participants received a Gen 2 device. Thus, 445 intervention participants used the new Gen 2 system and 307 intervention participants used the Gen 1 technology during phase II of the IDEATel project.

EVALUATION OF AUTOMATED UPLOAD FEATURE

To assess the effectiveness of the automatic upload feature, we examined the number of glucose readings uploaded by each intervention patient in the study. We divided the study population by region (upstate/rural component and downstate/urban component) and then categorized each patient by the type of unit they received from the project: "Gen 1 ONLY" (patients who had the first-generation HTU throughout their entire time in the study), "Gen 1 to Gen 2" (patients who had the first-generation HTU and later converted to a second-generation unit), and "Gen 2 ONLY" (patients given the second-generation unit upon entry into the study and never used the first-generation unit).

We normalized patient time for IDEATel intervention patients by number of months in the study, irrespective of the patient's calendar date of enrollment and/or HTU installation date. Using the normalized month procedure, we determined the ratio of uploaded data by the number of study participants who uploaded data within each month and then compared the total number of uploaded home glucose readings for each patient.

UPLOAD DELAY

We also analyzed the upload delay, defined as the number of days between the patient's actual reading and the time of upload to the IDEATel database. We categorized the methods of upload as self-upload (initiated by the patient), automatic upload (initiated by the Gen 2 units every morning), or case manager initiated upload (initiated during a video visit). We examined the effect of patient location, gender, unit type (Gen 1 vs. Gen 2), and language (English vs. Spanish). Although the patients also recorded and transmitted blood pressure data, these activities typically occurred simultaneously with the primary activity of glucose monitoring; a separate analysis did not provide any additional insights and therefore we do not report these data.

Prior to analyzing the upload data for glucose, we conducted a two-step data cleaning procedure. Step 1 identified extreme values for glucose upload times. In step 2, we eliminated glucose upload delay times from the analysis that were less than zero or greater than 100 days. Upload delay times that were less than zero were caused by a meter date error or a database error. Meter date errors occurred when

Fig. 4. Gen 2 IDEATel home telemedicine unit.

Table 2. Average Number of Months of Intervention per Participant

UNIT TYPE	UPSTATE PARTICIPANTS		DOWNSTATE PARTICIPANTS		ALL PARTICIPANTS	
	TOTAL UPSTATE	AVG MONTHS PER PATIENT (SD)	TOTAL DOWNSTATE	AVG MONTHS PER PATIENT (SD)	TOTAL	AVG MONTHS PER PATIENT (SD)
Gen1	305	30.38 (21.11)	227	38.41 (26.17)	532	33.81 (23.74)
Gen2	134	18.99 (5.90)	80	18.45 (6.56)	214	18.79 (6.16)
Gen1 to Gen2 ^a	120	58.09 (14.34)	111	63.30 (8.63)	231	60.59 (12.22)
Gen1 ^b	118	42.10 (13.79)	110	42.98 (7.82)	228	42.53 (11.33)
Gen2 ^c	120	17.11 (6.73)	111	18.51 (6.67)	231	17.78 (6.73)
AllGen1	423	33.64 (20.07)	337	39.90 (22.05)	760	36.42 (21.20)
AllGen2	254	18.10 (6.37)	191	18.48 (6.62)	445	18.27 (6.48)
Total	559	33.59 (21.93)	418	41.20 (25.16)	977	36.85 (23.67)

^aParticipants who were upgraded from a Gen 1 to Gen 2 device. ^bUpgraded participants while using a Gen 1 device. ^cUpgraded participants while using a Gen 2 device.

patients inadvertently advanced the meter dates ahead of the actual date and time. Although the meter dates were corrected once the meters communicated with the HTUs and erroneous HTU dates were corrected when the HTUs connected with the server, this did not correct the dates and times of previously measured readings. Efforts to correct these data manually were part of the standard operating procedures once the data were uploaded to the database. However, this was not always easy or successful. To that end, glucose readings where the reported reading time was later than the actual registered upload time (referred to as “future dates”) were removed prior to statistical analyses. Glucose upload times that were greater than 100 days were primarily the result of a patient being hospitalized or entering a nursing home, “snow birds” who traveled to warmer climates during the colder months, or HTUs that for either technical issues or loss of communication were out of commission for over 100 days.

The mean number of upload delay days taken from the sample of glucose readings was 21.95 days (standard deviation [SD] of 33.15 days); thus, 2 SDs above the mean was 88.25 days, which validated our choice of 100 days as the cutoff for a reasonable number of days of inactivity. We concluded that only 0.14% (1,382 readings) of the glucose upload times represented future dates and 2.99% (29,638 readings) represented glucose upload times that were greater than 100 days. Thus, we used 96.87% of the glucose data or 955,753 total readings.

Results

Tables 2, 3, and 4 display the average number of months of intervention, the average number of glucose uploads per month, and the average upload delay in days between the time the partici-

Table 3. Average Number of Glucose Uploads per Month

UNIT TYPE	UPSTATE PARTICIPANTS	DOWNSTATE PARTICIPANTS	ALL PARTICIPANTS
Gen1	30.56 (20.07)	15.10 (10.33)	23.96 (18.30)
Gen2	29.09 (26.25)	17.39 (13.77)	24.71 (23.12)
Gen1/2 on Gen 1 ^a	33.45 (22.75)	20.07 (12.98)	27.02 (19.91)
Gen1/2 on Gen 2 ^b	35.07 (27.44)	22.17 (16.51)	28.88 (23.74)
AllGen1	31.53 (20.90)	16.78 (11.52)	24.99 (18.86)
AllGen2	31.91 (26.99)	20.17 (15.60)	26.87 (23.54)
Total	31.25 (22.40)	16.97 (12.07)	25.14 (19.99)

^aParticipants upgraded from Gen 1 to Gen 2 data while on a Gen 1 device.

^bParticipants upgraded from Gen 1 to Gen 2 data while on a Gen 2 device.

Table 4. Average Upload Delay in Days

UNIT TYPE	UPSTATE PARTICIPANTS	DOWNSTATE PARTICIPANTS	ALL PARTICIPANTS
Gen1	19.20 (7.83)	28.13 (12.42)	22.44 (11.18)
Gen2	9.15 (6.17)	13.43 (9.70)	10.75 (7.96)
Gen1/2 on Gen 1 ^a	14.67 (5.51)	27.15 (7.10)	20.67 (8.85)
Gen1/2 on Gen 2 ^b	13.55 (8.90)	16.43 (9.63)	14.93 (9.37)
AllGen1	17.28 (7.41)	27.89 (14.58)	21.99 (10.57)
AllGen2	11.23 (7.89)	15.17 (9.77)	12.92 (8.96)
Total	15.30 (7.87)	24.18 (11.94)	19.10 (10.76)

^aParticipants upgraded from Gen 1 to Gen 2 data while on a Gen 1 device.

^bParticipants Upgraded from Gen 1 to Gen 2 data while on a Gen 2 device.

pants took their readings and subsequently uploaded the data to the IDEATel database. Each table displays data by region and unit type. The unit types are categorized into Gen 1 and Gen 2; participants who upgraded from Gen 1 to Gen 2; the period of time the participants had a Gen 1 unit and the period of time the participants had a Gen 2 unit; and finally the total number of Gen 1 and Gen 2 units in the study.

We conducted an analysis of variance, using SPSS (version 15.0) to determine whether there were group differences based on unit type. We found significant differences between the groups in average number of glucose uploads per month, $F(2, 974) = 110.12, p < 0.001$. There was also a significant difference between the groups in average upload delays in days, $F(2, 974) = 3.77, p = 0.023, F(2, 974) = 110.12, p < 0.001$ with Gen 2 units exhibiting significantly shorter delay times as measured in days (mean = 10.75, SD $\pm$ 7.96) than Gen 1 (mean = 22.44, SD $\pm$ 11.18) and those who were upgraded from Gen 1 (mean = 20.67, SD $\pm$ 8.85) to Gen 2 (mean = 14.93, SD $\pm$ 9.37).

We conducted further analysis to determine other factors that contributed to significant differences in the average upload delay. We found that the participant's region had a significant association with average upload delay. The delay was significantly shorter upstate (mean = 24.14 days, SD $\pm$ 11.95 days) than downstate (mean = 15.30 days, SD $\pm$ 7.87 days), $t(975) = 13.98, p < 0.01$. Likewise, there was significantly more data uploaded upstate (mean = 31.24 uploads per month, SD $\pm$ 22.42 uploads) than downstate (mean = 16.97, uploads per month SD $\pm$ 12.08 uploads), $t(975) = 11.79, p < 0.01$.

Discussion

The system redesign of the IDEATEL architecture demonstrated significant reductions of the interval between when glucose readings were taken and subsequently uploaded to the IDEATEL database for participants who had the second-generation architecture (Gen 2). This difference was also apparent in downstate participants who were upgraded from Gen 1 to Gen 2. Despite the significant differences in the aforementioned analyses in the reduction in upload delay times, the group that was upgraded to Gen 2 still took significantly longer to upload their readings than the group who had Gen 2 the entire time they were in the study. We suspect that the architecture upgrade by itself was not enough to change behavioral patterns that already existed in this upgraded group. The upgraded group, for the most part, was accustomed to having their results uploaded by their case managers during the scheduled monthly video visits. Despite the reminders from the IDEATEL staff and follow-up training on the new technology, we suspect that they never fully made the transition to this new data upload model.

An even greater difference in the number of monthly glucose uploads, and the timeliness of those uploads, was related to region status. The upstate participants uploaded more data during a shorter period of time than the downstate participants. We believe the regional differences can be attributed to several factors. The first is the difference in education level. The majority of the downstate population had between 1 and 11 years of education, while the majority of the upstate population had more than 12 years of education.⁷ Secondly, the downstate population was predominantly non-English speakers, with 25.7% speaking English compared to 95.5% upstate.⁷ Although the downstate case managers were Spanish-speaking for the most part, there was a period of time when the video visit intervention was delivered downstate by an English-speaking nurse using a translator. A third factor was the role of child caregiver that many of the downstate grandparents had to fill. Based on anecdotal evidence relayed by the case managers, many of the downstate participants were responsible for young children during the day, which contributed to missed appointments and fewer data uploads. In general, the social support systems available to the downstate participants seemed more limited and played a role in the consistency of intervention use.¹² A fourth possible factor may have been the greater continuity of the intervention upstate. During the transition period between Gen 1 and Gen 2, the upstate region was able to maintain consistent intervention while the downstate region experienced a turnover in personnel. During this transition period, downstate participants were less involved in the intervention and consequently may have experienced a greater learning curve during the second phase of IDEATEL when the new technology was introduced.

The redesign of the IDEATEL system provided significant improvements in patient utilization of the system, as shown by the reduced delays in upload times. Usability analysis was a key component in identifying areas where system redesign would improve the experience of the intervention participants in the IDEATEL study. This analysis demonstrated the effectiveness of the redesign and improvements in participant compliance. Future studies that evaluate the effectiveness of telemedicine studies should also assess the usability of their systems as part of the overall system evaluation. The IDEATEL project demonstrated the utility of applying quantitative and qualitative analysis in evaluating system effectiveness and incorporating the recommendations of the qualitative analysis in system redesign. This reduction in delay has the ability to improve the usefulness of the data collected, which can be important for decision making in chronic disease management.

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Disclosure Statement

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REFERENCES

1. Hersh WR, Helfand M, Wallace J, Kraemer D, Patterson P, Shapiro S, Greenlick M. Clinical outcomes resulting from telemedicine interventions: A systematic review. *BMC Med Inform Decis Mak* **2001**;1:5.
2. Montori VM, Helgemoe PK, Guyatt GH, Dean DS, Leung TW, Smith SA, Kudva YC. Telecare for patients with type 1 diabetes and inadequate glycemic control: A randomized controlled trial and meta-analysis. *Diabetes Care* **2004**;27:1088–1094.
3. Farmer A, Gibson OJ, Tarassenko L, Neil A. A systematic review of telemedicine interventions to support blood glucose self-monitoring in diabetes. *Diabet Med* **2005**;22:1372–1378.
4. Barlow J, Singh D, Bayer S, Curry R. A systematic review of the benefits of home telecare for frail elderly people and those with long-term conditions. *J Telemed Telecare* **2007**;13:172–179.
5. García-Lizana F, Sarria-Santamera A. New technologies for chronic disease management and control: A systematic review. *J Telemed Telecare* **2007**;13:62–68.
6. Paré G, Jaana M, Sicotte C. Systematic review of home telemonitoring for chronic diseases: The evidence base. *J Am Med Inform Assoc* **2007**;14:269–277.
7. Shea S, Weinstock RS, Starren J, et al. A randomized trial comparing telemedicine case management with usual care in older, ethnically diverse, medically underserved patients with diabetes mellitus. *J Am Med Inform Assoc* **2006**;13:40–51.
8. Bellazzi R, Arcelloni M, Ferrari P, Decata P, Hernando ME, García A, Gazzaruso C, Gómez EJ, Larizza C, Fratino P, Stefanelli M. Management of patients with diabetes through information technology: Tools for monitoring and control of the patients' metabolic behavior. *Diabetes Technol Ther* **2004**;6:567–578.
9. Larizza C, Bellazzi R, Stefanelli M, Ferrari P, De Cata P, Gazzaruso C, Fratino P, D'Annunzio G, Hernando E, Gomez EJ. The M2DM Project—the experience of two Italian clinical sites with clinical evaluation of a multi-access service for the management of diabetes mellitus patients. *Methods Inf Med* **2006**;45:79–84.
10. Chumbler NR, Neugaard B, Kobb R, Ryan P, Qin H, Joo Y. Evaluation of a care coordination/home-telehealth program for veterans with diabetes: Health services utilization and health-related quality of life. *Eval Health Prof* **2005**;28:464–478.
11. Cytryn KN, Patel VL. Reasoning about diabetes and its relationship to the use of telecommunication technology by patients and physicians. *Int J Med Inform* **1998**;51:137–151.
12. Kaufman DR, Patel VL, Hilliman C, Morin PC, Pevzner J, Weinstock RS, Goland R, Shea S, Starren J. Usability in the real world: Assessing medical information technologies in patients' homes. *J Biomed Inform* **2003**;36:45–60.
13. Kaufman DR, Pevzner J, Hilliman C, Weinstock RS, Shea S, Starren J. Redesigning a telehealth diabetes management program for a digital divide seniors population. *Home Health Care Manage Pract* **2006**;18:223–234.
14. Shea S, Starren J, Weinstock RS, Knudson PE, Teresi J, Holmes D, Palmas W, Field L, Goland R, Tuck C, Hripsak G, Capps L, Liss D. Columbia University's Informatics for Diabetes Education and Telemedicine (IDEATel) Project: Rationale and design. *J Am Med Inform Assoc* **2002**;9:49–62.
15. Starren J, Hripsak G, Sengupta S, Abbruscato CR, Knudson PE, Weinstock RS, Shea S. Columbia University's Informatics for Diabetes Education and Telemedicine (IDEATel) project: Technical implementation. *J Am Med Inform Assoc* **2002**;9:25–36.

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