A Preliminary Study of a Cloud-Computing Model for Chronic Illness Self-Care Support in an Underdeveloped Country

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Background: Although interactive voice response (IVR) calls can be an effective tool for chronic disease management, many regions of the world lack the infrastructure to provide these services.

Purpose: This study evaluated the feasibility and potential impact of an IVR program using a cloud-computing model to improve diabetes management in Honduras.

Methods: A single-group, pre–post study was conducted between June and August 2010. The telecommunications infrastructure was maintained on a U.S. server, and calls were directed to patients' cell phones using VoIP. Eighty-five diabetes patients in Honduras received weekly IVR disease management calls for 6 weeks, with automated follow-up e-mails to clinicians, and voicemail reports to family caregivers. Patients completed interviews at enrollment and a 6-week follow-up. Other measures included patients' glycemic control (HbA1c) and data from the IVR calling system.

Results: A total of 53% of participants completed at least half of their IVR calls and 23% of participants completed 80% or more. Higher baseline blood pressures, greater diabetes burden, greater distance from the clinic, and better medication adherence were related to higher call completion rates. Nearly all participants (98%) reported that because of the program, they improved in aspects of diabetes management such as glycemic control (56%) or foot care (89%). Mean HbA1c's decreased from 10.0% at baseline to 8.9% at follow-up ($p<0.01$). Most participants (92%) said that if the service were available in their clinic they would use it again.

Conclusions: Cloud computing is a feasible strategy for providing IVR services globally. IVR self-care support may improve self-care and glycemic control for patients in underdeveloped countries.

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Introduction

Mobile phones are ubiquitous in developing countries of Latin America, and few residents have a landline but not a cellular phone.[1–5] As in more industrialized regions,[6,7] telephone disease management is feasible and beneficial in that part of the world.[8–10] Interactive voice response (IVR) calls are acceptable to non-English speakers, and may improve chronically ill patients' outcomes.[5,11–22] However, most underdeveloped areas lack the infrastructure to provide those services.

Cloud computing is an approach to the design of technologic resources in which end users access the computing infrastructure remotely over the Internet. For IVR-supported disease management programs, a cloud-computing model means that clinics could access the program from almost anywhere in the world, with IVR calls generated from the central server to patients' cell phones using the low-cost technology for Voice over IP (VoIP). The present study examined the feasibility and potential impact of a cloud-computing approach to IVR-supported chronic illness care within a very low–income community located in an underdeveloped area of Honduras.

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Methods

Monolingual, Spanish-speaking adult diabetes patients with access to a cellular phone were identified between June and August 2010 at the time of primary care visits to a private clinic in a semirural region of Honduras. A prior survey found that the majority of Hondurans have cellular phones,[5] and patients used their own cell phones for the study. The study was approved by appropriate Human Subjects Committees.

Using VoIP, the system generated multiple IVR calling attempts to each patient's cell phone per calling week at times that the patient suggested were convenient. IVR calls were paid for by the study and (as is typical in Honduras and many other developing countries) patients paid no minute charges or calling-plan charges to receive the calls. Patients received recorded information in Spanish during IVR calls about how to manage their diabetes, and clinical teams received updates via structured e-mails based on concerning patient reports. Call content and information flow was developed based on integrative theories of health behavior.[23,24] Patients had the option of enrolling in the program with an informal caregiver or "CarePartner," who received structured IVR calls to his or her cell phone after each patient assessment including suggestions for what the caregiver could do to support the patient's diabetes self-care.

Patients completed in-person interviews at baseline and a 6-week follow-up. Depressive symptoms, diabetes distress, medication adherence, and diabetes self-efficacy were measured using validated scales.[25–29] Three items asked about the priority of diabetes relative to other issues (e.g., "I have other health problems more important than diabetes"). Patients were asked how long they had to travel to reach their source of primary care. Illiteracy was self-reported. Questions about perceived intervention impact included the question stems *How much would you say that you've improved in each of the following areas as a result of the CarePartner Program?* and *Due to the information you received during the automated calls since you have been in the CarePartner Program, have you ever done any of the following?* Items focused on self-care behaviors including medication adherence, dietary changes, and foot care.

Blood pressure was measured at baseline using standard procedures. As part of the study, patients' glycemic control was measured at baseline and follow-up using a point-of-care HbA1c analyzer.[30] The IVR calling system recorded the outcome of each call attempt (e.g., completed assessment, patient not reached) and patient's responses.

Analyses

Variation in assessment completion rates was examined across groups defined by patients' baseline characteristics. Stepwise logistic regression with backwards elimination and a p-value >0.20 for exclusion was used to identify baseline characteristics of patients who completed calls more frequently. Changes between baseline and the 6-week follow-up in patients' HbA1c levels were examined as well as perceived intervention-related changes in diabetes self-care.

Results

Of the 94 patients screened, one had no cellular phone, three were lost to follow-up before completing enrollment, five were excluded because of problems completing their initial IVR calls, and 85 were enrolled. On average, participants had 5 years of formal education and annual household incomes of $2591 (Table 1).

On average, 4.5 call attempts were made per patient per week, yielding 250 successful contacts. Overall 16 participants (19%) completed none of their IVR monitoring and behavior-change calls; 23 (27%) completed one to two calls; 26 (30%) completed three to four calls; and 20 (23%) completed five or more calls. In multivariate analyses (Table 2), patients traveling more than 1 hour to reach their clinic had nearly twice the odds of completing the majority of their IVR calls, and patients reporting at baseline that diabetes was their most important health problem had nearly 12 times the odds of completing half or more of their IVR assessments. Patients reporting more diabetes-related distress also had a greater likelihood of completing most of their assessments.

Patients with high blood pressures at baseline (>120/80 mmHg)[31] were more likely to complete the majority of their assessments, and these patients were nine times as likely as other patients to complete 80% or more calls. In contrast, patients with poorer medication adherence problems (as defined by a score of 2 or more on the Morisky Index[27]) at baseline were less likely to complete IVR assessments, and both poor perceived health

Table 1. Baseline characteristics of the sample

	All patients	With care partner	Without care partner
n	85	62	23
Female[a]	70.1	**68.9**	**76.9**
Age (years)	55.7 (11.0)	52.2 (11.6)	59.5 (11.2)
Years of education	4.7 (4.1)	4.9 (4.0)	4.1 (4.2)
Annual household income ($)	2591 (2521)	2639 (2467)	2469 (2705)
No. of family members in household	4.0 (2.5)	4.0 (2.5)	4.0 (2.6)
Insulin use	12.6	11.5	15.4
BMI	29.3 (6.7)	29.8 (7.1)	28.1 (6.7)
Depressed[b]	53.3	55.6	48.2
HbA1c	10.2 (3.0)	10.3 (2.9)	9.9 (3.3)
Blood pressure >120/80 mmHg	21.1	19.1	25.9

Note: Values are % or M (SD). Patients enrolling with a care partner chose to participate with a family member or other informal caregiver who received automated updates and suggestions via their cell phone after each patient IVR call. Boldface indicates significance.

[a]p=0.04. No other differences between patients with and without a care partner were observed.

[b]CESD-10 scores >4

CESD, Center for Epidemiological Studies Depression Scale; IVR, interactive voice response (or automated assessment and behavior change)

Table 2. AORs for patient characteristics associated with completing a greater percentage of IVR calls

	Completing ≥50% of calls		Completing ≥80% of calls	
	AOR (95% CI)	*p*-value	AOR (95% CI)	*p*-value
Traveling ≥1 hours to clinic	**1.9** (1.0, 3.4)	0.04	—	—
DM is most important health problem	**11.9** (2.6, 49.0)	0.001	**8.4** (1.7, 42.2)	0.01
Poor perceived health	0.2 (0.05, 1.1)	0.06	0.2 (0.3, 1.1)	0.07
Illiteracy	0.2 (0.05, 1.1)	0.07	—	—
Greater Rx adherence problems	**0.6** (0.3, 0.9)	0.03	0.6 (0.3, 1.1)	0.7
Greater diabetes distress[a]	**1.2** (1.1, 1.4)	0.005	**1.2** (1.1, 1.4)	0.01
Blood pressure >120/80 mmHg	**1.2** (1.1, 1.4)	0.005	**9.4** (1.9, 46.9)	0.006
Greater diabetes-related support[b]	—	—	1.3 (0.9, 42.2)	0.13

Note: AORs with $p<0.05$ are bolded. Results were derived from a stepwise logistic regression with backwards selection and a $p>0.20$ criterion for exclusion. Factors found not to be associated with call completion rates included age, gender, educational attainment, baseline HbA1c, diabetes-specific social support, depression, diabetes self-efficacy, and participation with an informal caregiver (care partner).
[a]Scores from the Problem Areas in Diabetes Scale.[26]
[b]Subscale scores from the Diabetes Care Profile.[29]
DM, diabetes mellitus; IVR, interactive voice response (or automated assessment and behavior change); Rx, prescription

and illiteracy were marginally associated with lower completion rates.

Sixty-four participants (75%) completed endpoint surveys. Of those respondents, 83% agreed that the IVR system was easy to use, and 89% agreed that it provided useful suggestions for managing their diabetes. Ninety-two percent said that if the program were available, they would use it again, and 100% said that they were very satisfied or generally satisfied with the program.

All but one respondent (98%) completing the follow-up survey reported that they had improved in some aspect of their health and self-care as a result of the program. More than half (56%) reported that they improved in their blood sugar control, 66% reported that their diet improved, 64% said they improved in their medication adherence, and 89% reported that because of the information they received during the automated calls their foot care improved. HbA1c levels improved from an average of 10.0% at baseline to 8.9% at follow-up ($p<0.01$). Participants who completed more than half of their IVR assessments had significantly larger average decreases in their HbA1c levels than other patients (mean change of 1.1% vs 0.34%; $p=0.04$).

Discussion

This study suggests that mobile health tools for chronic disease management using a cloud-computing model and standard phone lines are technically feasible, acceptable, and potentially useful in resource-poor areas of underdeveloped countries. Patient satisfaction was high. Most participants reported positive changes in their self-management, and pre–post changes in patients' HbA1c were clinically relevant, despite the study's short duration.

Factors associated with a greater need for self-management support (e.g., greater travel times, higher levels of diabetes distress, and higher blood pressures) were associated with higher levels of call completion. In contrast, illiteracy and medication adherence were associated with lower levels of call completion. These findings suggest that careful targeting and training will be important to ensure that patients who need additional motivation and ongoing support are appropriately served.

The current sample was too small to identify subgroups of patients who would or would not be especially likely to benefit from this service. The majority of participants were women and patients participated in the study for only 6 weeks, limiting the ability to examine temporal trends in call completion rates. The sample may not be representative of other areas; however, the educational attainment and income levels for participants were quite low, suggesting that this service is accessible to patients facing substantial socioeconomic barriers to access. Because the study did not include a control group, changes in patients' health or self-care cannot be attributed definitively to the intervention. Finally, 25% of patients were lost to follow-up, and those patients may have been less satisfied with their experience.

These results indicate that a cloud-computing model for IVR-supported diabetes management is feasible for patients in a remote area of Honduras, and that the service may improve patients' disease outcomes. Controlled studies with larger samples, longer follow-up, and pa-

tients from other areas are warranted to determine whether this approach is sustainable and has impacts on patients' health.

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