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ORIGINAL ARTICLE

Using Digital Health Technology to Prevent and Treat Diabetes

Neal Kaufman[1,2] and Irina Khurana[3]

Introduction

THIS YEAR'S ARTICLE on health information technology (HIT) illustrates the use of digital technology to prevent and treat diabetes by enabling consumer engagement, behavior change, and impact analytics. It provides a snapshot of current thinking about digital technology's capabilities and capacity to deliver personalized interventions at scale.

Early results are promising. A growing number of digital programs are clinically proven to improve health and lower the cost of care. And pioneering health-care organizations are offering these programs to members and patients as part of their new models for value-based care. Their success will drive other organizations—payers, providers, and employers—to make similar investments in health.

In the modern health-care world, experts agree that ''value'' will be created by enabling health, not just delivering care. With today's epidemic of diabetes, patients who use digital health technologies can benefit greatly from both short-term health improvements and long-term health self-management. The foundations have been laid with evidence-based programs. Now, more health-care organizations must embrace this population management strategy for health.

As adoption increases, the next technology challenge will arise: consumer engagement at scale. This engagement will be digital: content-rich programs filled with social support to activate, educate, and engage consumers.

Most of the articles included in this and prior ATTD *Yearbook* articles address the specifics of digital interventions once the person enrolls. But before enrollment, consumers must engage. And to engage consumers, one must understand their reasons for engaging and their expectations for results. These insights fall into the realm of digital marketing, rather than the domain of clinical programs. Using a multidisciplinary approach, digital engagement will be the next variable to solve in the equation for scalable digital health.

Not for a lack of trying, we have been unable to find noteworthy articles presenting best practices for consumer engagement from outreach to enrollment. But the future looks quite bright for the science of marketing digital health interventions. Increasingly, ''big data'' is providing scientists, innovators, entrepreneurs, educators, health-care providers, and administrators with the insights they need to predict consumer interests and personalize experiences throughout the entire behavior change process—from outreach to outcomes.

Over the coming year, we will continue to search the health-care landscape to bring more innovations in digital health and diabetes prevention, from consumer engagement to population impact.

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Key Articles Reviewed for this Article

A mobile health intervention for self-management and lifestyle change for persons with type 2 diabetes, part 2: one-year results from the Norwegian randomized controlled trial RENEWING HEALTH

Holmen H[1], Torbjørnsen A[1], Wahl AK[2], Jenum AK[3], Småstuen MC[1], Årsand E[4], Ribu L[1]

*JMIR Mhealth Uhealth 2014; **2**: e57*

Are patients with diabetes mellitus satisfied with technologies used to assist with diabetes management and coping?: a structured review

Harrison S[1], Stadler M[2], Ismail K[3], Amiel S[2], Herrmann-Werner A[3]

*Diabetes Technology & Therapeutics 2014; **16**: 771–83*

Management of endocrine disease. Effects of telecare intervention on glycemic control in type 2 diabetes: a systematic review and meta-analysis of randomized controlled trials

Huang Z[1], Tao H[1], Meng Q[1], Jing L[2]

*Eur J Endocrinol 2015; **172**: R93–R101*

Efficacy of a web-based intervention with mobile phone support in treating depressive symptoms in adults with type 1 and type 2 diabetes: a randomized controlled trial

Nobis S[1], Lehr D[1], Ebert DD[1,2,3], Baumeister H[4], Snoek F[5,6], Riper H[1,5,7,8], Berking M[1,3]

*Diabetes Care 2015; **38**: 776–83*

Evaluation of a chronic disease management system for the treatment and management of diabetes in primary health care practices in Ontario: an observational study

O'Reilly DJ[1,2], Bowen JM[1,2], Sebaldt RJ[1,3], Petrie A[3], Hopkins RB[1,2], Assasi N[1,2], MacDougald C[1,2], Nunes E[1,2], Goeree R[1,2]

*Ont Health Technol Assess Ser [Internet] 2014; **14**: 1–37*

Multifactorial intervention in diabetes care using real-time monitoring and tailored feedback in type 2 diabetes

Lim S[1,2], Kang SM[1,2], Kim KM[1,2], Moon JH[1,2], Choi SH[1,2], Hwang H[1,2], Jung HS[3], Park KS[3], Ryu JO[4], Jang HC[1,2]

Acta Diabetol 2015. [Epub ahead of print]; DOI 10.1007/s00592-015-0754-8

Mobile applications for diabetics: a systematic review and expert-based usability evaluation considering the special requirements of diabetes patients age 50 years or older

Arnhold M, Quade M, Kirch W

*J Med Internet Res 2014; **16**: e104*

Automated telephone self-management support for diabetes in a low-income health plan: a health care utilization and cost analysis

Quan J[1,2], Lee AK[2], Handley MA[1,2,3], Ratanawongsa N[1,2], Sarkar U[1,2], Tseng S[4], Schillinger D[1,2]

Popul Health Manag 2015. [Epub ahead of print] DOI 10.1089/pop.2014.0154

Using mHealth tools to improve rural diabetes care guided by the chronic care model

Mallow JA[1], Theeke LA[1], Barnes ER[2], Whetsel T[1], Mallow BK[3]

*Online J Rural Nurs Health Care 2014; **14**: 43–65*

Internet delivered diabetes self-management education: a review

Pereira K, Phillips B, Johnson C, Vorderstrasse A

*Diabetes Technol Ther 2015; **17**: 55–63*

Technology and diabetes self-management: an integrative review

Hunt CW

*World J Diabetes 2015; **6**: 225–33*

The role of exergaming in improving physical activity: a review

Sween J[1], Wallington SF[1], Sheppard V[1], Taylor T[2], Llanos AA[1], Adams-Campbell LL[3]

*Phys Act Health 2014; **11**: 864–70*

The use of videogames, gamification, and virtual environments in the self-management of diabetes: a systematic review of evidence

Theng Y-L[1], Lee JWY[2], Patinadan PV[2], Foo SSB[2]

*Games Health J 2015; **4**: 352–61. [Epub ahead of print]; 10.1089/g4h.2014.0114*

The effect of active video games by ethnicity, sex and fitness: subgroup analysis from a randomised controlled trial

Foley L[1], Jiang Y[1], Mhurchu CN[1], Jull A[2], Prapavessis H[3], Rodgers A[4], Maddison R[1]

*Int J Behav Nutr Phys Act 2014; **11**: 46*

eHealth interventions for the prevention and treatment of overweight and obesity in adults: a systematic review with meta-analysis

Hutchesson MJ[1], Rollo ME[1], Krukowski R[2], Ells L[3], Harvey J[4], Morgan PJ[5], Callister R[6], Plotnikoff R[5], Collins CE[1]

*Obesity Reviews 2015; **16**: 376–92*

Social networking strategies that aim to reduce obesity have achieved significant although modest results

Ashrafian H[1], Toma T[1], Harling L[1], Kerr K[2], Athanasiou T[1], Darzi A[3]

*Health Affairs 2014; **33**: 1641–47*

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A mobile health intervention for self-management and lifestyle change for persons with type 2 diabetes, part 2: one-year results from the Norwegian randomized controlled trial RENEWING HEALTH

Holmen H[1], Torbjørnsen A[1], Wahl AK[2], Jenum AK[3], Småstuen MC[1], Årsand E[4], Ribu L[1]

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*JMIR Mhealth Uhealth 2014; **2**: e57*

Background

Interventions to treat and manage type 2 diabetes are often centered around self-management. With modern advances in technology, mHealth could play a significant role in improving self-management and clinical outcomes such as glycemic control, especially when combined with health counseling.

Methods

This study was designed as a three-arm prospective, randomized, controlled trial with two intervention groups and one control group. All patients were adults with type 2 diabetes as demonstrated by HbA1c levels. The two intervention groups received mobile phone-based intervention consisting of a diabetes diary app with records of blood glucose, diet, physical activity, and personal goals via the Few Touch Application (FTA) for one year, with one group additionally receiving health counseling for 4 months. Primary outcomes measured were HbA1c, with secondary outcomes being self-management and quality of life.

Results

From an initial enrollment of 151 study participants, 51 were randomized to the mobile phone-only intervention group, 50 to the mobile phone plus health counseling intervention group, and 50 to the control group. There was a 79% retention rate after 1 year, with follow-up data available for 120 participants. In the mobile app-only group, 39% were

classified as substantial users, with 34% of the mobile app and health counseling group as substantial users. Participants over the age of 63 years used the app more than younger participants (OR 2.7; 95% CI 1.02–7.12; $P = 0.045$). All groups demonstrated a decreased HbA1c, with no significant difference between groups. After adjustment for age, education, and gender, self-management (measured by heiQ domain skills and technique acquisition) was significantly greater in the intervention group with mobile and health counseling, though other secondary outcomes did not differ.

Conclusions

Intervention with either a mobile app or a mobile app and health counseling did not result in any significant difference in the change in HbA1c after one year. About one third of intervention group participants were substantial users, with greater numbers of older participants using the app than younger users. The self-management domain of skill and technique acquisition increased in the mobile app plus health counseling group, though the other secondary outcomes did not differ among groups.

Comment

This randomized controlled trial was well designed and well implemented. The negative results, while disappointing, are not all that surprising. The baseline A1C values were a mean of 8.1 and a small number had A1C's above 9.0. With low starting A1C values it is hard to demonstrate impact on glycemic control. In addition, the technology support was used by a small proportion of the participants, further lessening the chances for success. This study does however highlight some important issues. Programs need to be designed and implemented so individuals are engaged and likely to use the program. Allowing participants to self-tailor their experience is one method that works. Providing interactions with others going through the same experiences can also help.

Are patients with diabetes mellitus satisfied with technologies used to assist with diabetes management and coping?: a structured review

Harrison S[1], Stadler M[2], Ismail K[3], Amiel S[2], Herrmann-Werner A[3]

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*Diabetes Technology & Therapeutics 2014; **16:** 771–83*

Background

While self-care has been proven to be important in the management of diabetes, it is often difficult for patients to engage in necessary self-care behaviors. Modern technology has enabled the use of devices and applications, such as SMS reminder systems, online educational programs, and electronic communication between physician and patient, to be used to help patients in self-management of their diabetes. This review examines patient perceptions and satisfaction regarding such technologies.

Methods

Four databases (Embase, Psychinfo, Medline, CINAHL) and gray literature databases were searched for articles that evaluated patient satisfaction of technology aimed to improve management in diabetes patients. Search terms used were ''diabetes mellitus,'' ''technical device,'' ''patient satisfaction,'' and synonyms. Every abstract and full-text was reviewed by two independent reviewers for inclusion, and jointly in the case of disagreement between the two reviewers.

Results

After searching and review, 26 studies met inclusion criteria: 8 on type 1 diabetes, 9 on type 2 diabetes, and 9 on both. Data on patient perceptions such as satisfaction, usability, diabetes management, support, and objective usage was extracted. Across the board, studies reported high satisfaction from patients regarding most devices, with little to no difference based on intervention type or outcome measured. Satisfaction appeared to strongly correlate to ease of use and improved management. Technical difficulties were barriers to both use and satisfaction, with web devices being the easiest to use and devices such as smartphones being slightly more difficult. Devices that encouraged or facilitated interaction between patients and either health-care professionals or peers were valued and produced higher patient satisfaction for increasing support.

Conclusions

In all, modern technology–enabled devices and applications for the treatment of diabetes are well received by patients as a supplement to usual therapy. Patients value easy-to-use devices and applications that facilitate support from health-care providers or peers. These results provide insight into strategies that health-care providers and developers of such technologies might use to further help patients with diabetes in self-care.

Comment

This article focused on a very important issue for technology-enabled interventions—patient satisfaction with the program. Satisfaction was principally associated with two factors: usability of the device and improvement in diabetes management. It was also encouraging to hear that interactions with clinicians and others made a difference. This demonstrates that people are not looking for stand-alone interventions but prefer those that are sponsored by and integrated into therapeutic relationships. This may differ a lot by patient characteristics, such as well-controlled patients with many years of diabetes might find the connection to a provider less important than newly diagnosed patients or those who are struggling to meet their goals.

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Management of endocrine disease. Effects of telecare intervention on glycemic control in type 2 diabetes: a systematic review and meta-analysis of randomized controlled trials

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*Eur J Endocrinol 2015; **172:** R93–R101*

Background

There is a relative lack on systematic reviews looking at the effectiveness of telecare in patients with type 2 diabetes. This review seeks to investigate randomized controlled trials on telecare in patients with type 2 diabetes to determine whether the intervention is effective in establishing glycemic control, to identify which feedback receipt techniques (human calls, automated calls, or automated text message reminders) are effective, to provide quantitative analysis on telecare interventions, and to identify areas for future research.

Methods

The Cochrane Library, PubMed, EBSCO, CINAHL, Science Direct, Journal of Telemedicine and Telecare, and CNKI were searched for articles relating to telemedicine and diabetes in title, abstract, and keywords. Telecare was defined as ''self-monitored transmission of glucometer data and feedback by health professionals, or automatic medical device.'' Two independent researchers reviewed the titles and abstracts for the studies, and if a study passed initial review the full text was further reviewed. Data on study location, design, intervention, and outcomes were extracted from articles that met inclusion criteria. HbA1c, fasting plasma glucose, post-prandial plasma glucose, BMI, and body weight were among relevant outcome measures analyzed.

Results

Eighteen studies published between 2000 and 2013 met the inclusion criteria, with a total of 3,798 participants at baseline. Compared to the control group receiving standard care, average HbA1c values were reduced by -0.54 (95% CI, -0.75 to -0.34; $P<0.05$), mean FPG by -9.00 mg/dL (95% CI, -17.36 to -0.64; $P<0.03$), and mean PPG levels by -52.86 mg/dL (95% CI, -77.13 to -28.58; $P<0.05$). Further meta-analysis on extracted data revealed that heterogeneity amongst telecare intervention groups stemmed from study location, sample size, and monitoring techniques, with location accounting for the largest differences.

Conclusions

Compared to routine care, telecare monitoring resulted in significant improvements in glycemic control in patients with type 2 diabetes. A more significant reduction in HbA1c was correlated with Asian populations, small sample size, and patients with a starting measurement above 8%. More studies on the cost-effectiveness of telecare-based interventions should be conducted.

Comment

Self-monitoring of blood glucose with adjustment of medication, diet, exercise, etc., is the hallmark of the glycemic management of diabetes. It is encouraging that improved control was demonstrated by the interaction of monitoring of blood sugar with the assistance of experts (person or system). Not surprisingly, those with higher A1c values did better. The challenge is to get more people to see the benefit of this approach and adopt it as their own.

Efficacy of a web-based intervention with mobile phone support in treating depressive symptoms in adults with type 1 and type 2 diabetes: a randomized controlled trial

Nobis S[1], Lehr D[1], Ebert DD[1,2,3], Baumeister H[4], Snoek F[5,6], Riper H[1,5,7,8], Berking M[1,3]

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*Diabetes Care 2015; **38:** 776–83*

Background

Comorbid depression with diabetes is a common problem related to adverse health outcomes. However, due to a variety of reasons including stigma, patients often go untreated for this depression. Internet-based interventions that do not require face-to-face contact may allow for the treatment of untreated depressed individuals. This study evaluates the efficacy of such an intervention in reducing depression in adults with types 1 and 2 diabetes.

Methods

A total of 260 study participants with diabetes and elevated depressive symptoms were randomly assigned to a guided Internet-based self-help intervention, GET.ON Mood Enhancer Diabetes, or to an online unguided education program for depression. The primary outcome measure was severity of depression symptoms, as measured by the Center for

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Epidemiologic Studies Depression Scale (CES-D). Secondary outcomes included participant satisfaction and diabetes-specific emotional distress (based on the Problem Areas in Diabetes [PAID] scale). Data were collected at baseline and 2 months following randomization. Covariance with baseline CES-D score as a covariate on intent-to-treat (ITT) and per-protocol (PP) basis was analyzed to identify outcome differences between groups.

Results

The intervention group demonstrated a significantly lower depressive symptom severity on the post-intervention measure based on ITT (d = 0.89) and PP analyses (d = 1.00), and a larger reduction in diabetes-specific emotional distress (d = 0.58, ITT). Participants expressed satisfaction with the intervention, with 95% (n = 121) who would recommend the training to a friend with diabetes in need of psychological help.

Conclusions

The Internet-based GET.ON Mood Enhancer Diabetes intervention, designed to reduce depression in adults with types 1 and 2 diabetes, is effective in reducing depressive symptoms and diabetes-specific emotional distress. The magnitude of the short-term effects on depression in this study compare to psychological and pharmacological interventions for depression in patients with diabetes. This suggests that more research on the long-term effects of such web-based diabetes interventions is needed.

Comment

This study addresses a very important and frequent issue for patients with diabetes. Depression not only makes self-management of diabetes harder but also can increase morbidity in other ways, so offering interventions that mitigate depressive symptoms is important. Strengths of the study are that the intervention is based on sound theory, specific elements were designed to increase engagement over time, and the program was integrated into clinical care. The major weakness was that outcomes were only measured 2 months post enrollment. Longer term outcomes are the key.

Evaluation of a chronic disease management system for the treatment and management of diabetes in primary health care practices in Ontario: an observational study

O'Reilly DJ[1,2], Bowen JM[1,2], Sebaldt RJ[1,3], Petrie A[3], Hopkins RB[1,2], Assasi N[1,2], MacDougald C[1,2], Nunes E[1,2], Goeree R[1,2]

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*Ont Health Technol Assess Ser [Internet] 2014; **14:** 1–37*

Background

Clinical practice guidelines on the treatment of diabetes includes both management by health-care professionals as well as patient self-management. However, in the management of chronic diseases such as diabetes, it is often challenging for clinicians to compare patient outcomes with clinical practice guidelines. Computerized chronic disease management systems (CDMSs) may help clinicians provide optimal diabetes care, especially when aligned with clinical practice guidelines. This study measures the difference between optimal diabetes care and actual diabetes care before and after the introduction of a computerized CDMS in clinics.

Methods

A CDMS was used in family practices for 1 year in this prospective, observational, pre/post study. Practice-level data from all diabetes patients (from a registry) were measured for the primary outcome of the change in proportion of patients with recommended frequencies of ''ABC'' (hemoglobin A1C, blood pressure, and cholesterol) monitoring. Secondary outcomes measured were changes in the frequency of other treatment elements such as retinopathy screening. The usability and user satisfaction with the CDMS were also analyzed.

Results

A total of 2,320 diabetes patients across nine sites and 38 health-care providers were included. Primary outcome measurements of the proportion of patients with up-to-date ABC monitoring (12%), HbA1c (45%), or cholesterol (38%) remained constant through the duration of the study, with the proportion of patients with blood-pressure monitoring increasing from 16% to 20%. Data on secondary outcome measures were either not available or not up to date at baseline for 98% of included patients. Health-care providers demonstrated more negative attitudes on training, usefulness, daily practice, and support from the service provider domains of the CDMS but positive attitudes toward learning, using, practice planning, CDMS, and satisfaction after the end of the study.

Conclusions

Overall, very few health-care providers used the web-based CDMS to assist their management of patients with diabetes. Therefore, determining the efficacy of this CDMS and similar ones was impossible, though results did show that simply making technologies available to clinicians does not ensure the use of such technologies.

Comment

This study is included not because it demonstrated a fantastically effective diabetes management service. On the contrary, it demonstrated just how hard it is to get people to change their behaviors. Just as patients are challenged to adopt and sustain new behaviors, so too are health-care providers. Just as the experience users have before they begin in a behavior change intervention is critical to the success of the program, so too do providers need to be brought along when expected to adopt a new

process. An interesting study would be how differing approaches to provider engagement would lead to different utilization of the online tool and different outcomes from patients. This should sound familiar. It is exactly what is needed in researching the impact of programs on patients.

Multifactorial intervention in diabetes care using real-time monitoring and tailored feedback in type 2 diabetes

Lim S[1,2], Kang SM[1,2], Kim KM[1,2], Moon JH[1,2], Choi SH[1,2], Hwang H[1,2], Jung HS[3], Park KS[3], Ryu JO[4], Jang HC[1,2]

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Acta Diabetol 2015. [Epub ahead of print]; DOI 10.1007/s00592-015-0754-8

Background

Ubiquitous (u)-healthcare, an individualized health management system employing advanced medical information technology, was demonstrated to be effective in helping to achieve glycemic control in patients with diabetes in 2011. The basis of such a u-healthcare system is an individualized clinical decision support system (CDSS), because it allows for individualization based on a patient's specific glucose control status, medications, lifestyle, and severity of hypoglycemia. A new multidisciplinary u-healthcare system was designed by improving the clinical decision support system (CDSS) rule engine and integrating a physical activity and dietary monitoring device and feedback mechanism into one package.

Methods

In this randomized controlled trial, 100 patients over the age of 60 with type 2 diabetes were randomly assigned to either a self-monitored blood glucose (SMBG) group or to a u-healthcare group for 6 months. Primary outcomes measured were the proportions of patients achieving HbA1c of 7% without hypoglycemia. Secondary outcomes included changes in body composition and lipid profiles. The intervention group was educated to use a special glucometer and activity monitor that transferred test results to a hospital server, and an automated CDSS rule engine generated and sent patients tailored messages about glucose control, diet, and physical activities via their mobile phones and a website.

Results

At the end of the 6-month study period, the u-healthcare group demonstrated a significant reduction in HbA1c level without hypoglycemia [8.0 ± 0.7% (64.2 ± 8.8 mmol/mol) to 7.3 ± 0.9% (56.7 ± 9.9 mmol/mol)] when compared to the SMBG group [8.1 ± 0.8% (64.9 ± 9.1 mmol/mol) to 7.9 ± 1.2% (63.2 ± 12.3 mol/mol)] ($P < 0.01$). Secondary outcomes such as body fat mass and lipid profiles were also improved in the u-healthcare group but not in the SMBG group.

Conclusions

Patients who used the u-healthcare intervention demonstrated better glycemic control and favorable changes in body fat mass and lipid profiles than patients in the SMBG group. Such an intervention should be examined for effectiveness in terms of long-term adherence, effects on self-management, cost, satisfaction, and hard endpoints such as cardiovascular events and mortality.

Comment

This well-designed and well-executed study with a relatively small number of participants demonstrates the possibility that patient-oriented decision support programs will be effective in helping patients manage their diabetes. Such approaches are fundamentally based on the assumption that a person just needs access to information on what to do in a variety of circumstances. While this may work for some people, it is the rare individual who only needs data and information. Most need to overcome barriers to using the knowledge the data provides, and that must also be included in decision support programs if they are to be successful at scale.

Mobile applications for diabetics: a systematic review and expert-based usability evaluation considering the special requirements of diabetes patients age 50 years or older

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*J Med Internet Res 2014; **16:** e104*

Background

The self-management of patients with diabetes types 1 and 2 is often supported by mobile health (mHealth) apps. This review examines all currently available diabetes apps for Android and iOS (iPhone) operating systems to look at functions, target user groups, accessibility, and ratings versus costs.

Methods

All available diabetes apps in the Google Play Store and Apple App Store were found by keyword and category search in each app store. Information in the app stores and the apps themselves were used to review the applications. In addition, an expert-based usability evaluation was conducted with three experts to determine whether applications serve the

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needs of patients aged 50 or older, based on a representative 10% sample of diabetes apps. Data on function of app, targeted user group, accessibility, user ratings, and cost were extracted from all apps.

Results

In total, 656 apps were found, with 276 exclusively on iOS, 266 exclusively for the operating system Android, and 114 available for both operating systems. Of these 656 apps, 355 (54.1%) offered just one function and 348 (53.0%) provided a documentation function for users to document and track blood sugar levels. In all, 96% of users were patients (630/656), and an analysis of cost revealed a moderate trend toward free apps (53.7%, 352/656), with a median price of paid apps at €1.90. An analysis of user ratings revealed an average rating of 3.6 out of 5 stars, with no significant differences in user rating between free and paid apps. Less than 5% of the available apps had an interface to measurement devices. Of the 66 apps evaluated in the usability evaluation, apps were rated best regarding ''comprehensibility'' (4.0 out of 5.0), while showing a lack of ''fault tolerance'' (2.8 out of 5.0). Of the 66 apps, 48 (72.7%) offered the ability to read the screen content aloud. The number of functions was significantly negative correlated with usability.

Conclusions

These results demonstrate that while many apps for diabetes exist, most offer similar functions and only offer a few functions in each app. Both patients and physicians should play a larger role in app development in the future, as the data transmission of health parameters to physicians will likely gain more importance in future applications. The usability of diabetes apps for patients aged 50 or older was moderate to good, though multifunctional apps performed considerably worse in terms of usability, and accessibility features were lacking overall.

Comment

Cell phone apps, most of which have one function such as uploading glucose results, have the ability to facilitate patient self-management. To be effective they need to be designed for the specific population targeted by the app. In this case, the analysis determined that many of the apps were appropriate for adults. This article demonstrates the key elements needed for effective apps. While apps have the potential for extraordinary penetration into the population there are some key challenges with their ability to impact large numbers of patients over time. The biggest challenge is the inability for companies that develop and sell apps to create sustainable business models. Another challenge is that apps with limited functions are currently not designed to change the behaviors necessary to help patients become motivated to use the app. The irony may be that many apps may work best for patients who are highly motivated and don't really need the support the app provides to adopt and sustain health-promoting behaviors.

Automated telephone self-management support for diabetes in a low-income health plan: a health care utilization and cost analysis

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Popul Health Manag 2015. [Epub ahead of print] DOI 10.1089/pop.2014.0154

Background

The Department of Health and Human Services has determined that automated telephone self-management support (ATSM) may be a viable strategy to augment care for low health literacy and limited English proficiency populations with chronic conditions. This study seeks to examine data from the government-sponsored project Self-Management Automated and Real-Time Telephonic Support Study (SMARTSteps) to determine whether ATSM affects health-care cost or utilization amongst low-income and linguistically diverse health plan members with diabetes.

Methods

The project was conducted between 2009 and 2011 and involved a 6-month ATSM intervention for 362 English, Spanish, or Cantonese-speaking members with diabetes from four publicly funded clinics. Participants were randomly assigned to either receive immediate intervention or be placed on a wait list. Automated messages in the patient's preferred language provide information and support to the patient. If the patient's response is deemed to indicate that support is needed, a trained health-care provider reaches out to the patient. Baseline data on demographics and cardio-metabolic profiles were extracted from EHRs and telephone surveys. Medical claims, including hospitalizations, ambulance use, emergency department visits, outpatient visits, and pharmacy claims were primary outcome measures compared between the two groups and were obtained from the managed care plan for each patient for the year prior to study enrollment and 6 months following randomization.

Results

The intervention group generated half as many emergency department visits and hospitalizations (rate ratio 0.52, 95% CI 0.26, 1.04) than the wait-listed participants, although these differences did not reach statistical significance ($P = 0.06$). The intervention group also demonstrated a nonsignificant reduction in total health-care costs ($26.78) compared to the other group.

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Conclusions

These results demonstrate that ATSM could play an important role in health plans that provide coverage for chronic disease patients in safety net settings. Programs such as the SMARTSteps program have the potential to yield a positive economic impact for low-income health plans and Medicaid. These results suggest that ATSM should be scaled up in terms of patients and duration in order to determine whether it also can effectively reduce health-care utilization and costs.

Comment

This study, using automated telephone self-management support, is a creative approach to bringing self-management support interventions to low-income and low-literacy adults. While the small study didn't show statistical significance, it is still important. Impacting vulnerable populations are a worldwide challenge and promising approaches should be encouraged.

Using mHealth tools to improve rural diabetes care guided by the chronic care model

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*Online J Rural Nurs Health Care 2014; **14:** 43–65*

Background

There are several challenges in the treatment of diabetes in people in rural, underserved populations. Fortunately, mHealth interventions may improve the ability of providers to give care, improve access to care, and improve outcomes of care amongst patients with diabetes in such populations. This review investigates the impact of mHealth interventions on people from rural or underserved areas with type 2 diabetes.

Methods

PubMed was searched for keywords relating to diabetes and mHealth, and articles matching search criteria were reviewed based on title, abstract, and keywords to include research studies that used mHealth as an intervention in patients with type 2 diabetes. Articles that met inclusion criteria were then categorized and evaluated on the basis of the Chronic Care model.

Results

mHealth interventions and technologies improve outcomes, are cost effective, and are culturally relevant. Specifically, mHealth technologies that have led to improved outcomes include: web-based access to health information, online appointment scheduling and medication refills, secure messaging, computerized interventions to manage a chronic condition, use of a personal health record, use of remote monitoring devices, and support from others with similar health concerns through social networks.

Conclusions

Applying the Chronic Care model to mHealth technologies can help mHealth interventions be effectively used in clinical practice. In general, many of the principles of the Chronic Care model, such as the importance of a prepared community, hold true for interventions involving technology; however, a sustainable mHealth delivery model and a way to integrate mHealth into rural health-care systems are still needed.

Comment

This article highlights two key issues: (1) outcomes improve when patient care is in the context of available community resources and enabled by self-management education and support (the Chronic Care model); and (2) to benefit from an intervention the person needs to have easy access. It is no surprise that when individuals have access to proven-effective online diabetes interventions, outcomes improve. In many rural areas in developed countries and many urban and rural areas in developing countries access to high-speed Internet is not possible. But when available, Internet-based education and support can help overcome many barriers, such as distance from providers and social isolation. At the very least it helps people get some of the support they need by connecting people to others with similar circumstances.

Internet delivered diabetes self-management education: a review

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*Diabetes Technol Ther 2015; **17:** 55–63*

Background

Any successful diabetes management regimen hinges upon self-management education. Internet-based education is a fairly recent, yet increasingly popular, method to increase access to self-management education. This review investigates several Internet-based methods of delivering self-management education to patients with diabetes and evaluates their effectiveness in improving outcomes.

Methods

Six databases (CINAHL, PubMed, Medline, EBSCO, Cochrane Library, and Web of Science) were searched using the terms: ''type 2 diabetes AND internet/web based AND education'' and ''type 2 diabetes AND diabetes self-management education (DSME) AND web-based/internet OR technology assisted education.'' Articles in the English language and published in the last 10 years were included in the search, and data on study design, sample size, intervention type, outcomes, and findings were extracted. Two independent reviewers reviewed search results based on inclusion and exclusion criteria.

Results

Of the 111 articles found by the search terms, 14 met inclusion criteria. Nine of these studies were randomized

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control trials with study lengths ranging from 2 weeks to 24 months, with a total of 2,802 participants. Internet-based diabetes self-management interventions were more effective than print-based educational material and usual care at improving glycemic control and diabetes knowledge, with both types of education being more effective than usual care. Following participation in online education, patients demonstrate increased attendance at clinic appointments and an improvement in eating habits, though the usage of Internet material waned over time.

Conclusions

Internet-based diabetes self-management education is more effective in improving glycemic control and diabetes knowledge as compared to usual care. The advantage of Internet-based education over print or face-to-face education seems to be the ability to reach many patients and the convenience of accessing material at any time. Further research on the long-term impact of and cost-benefit analysis on Internet-based diabetes education and ways to maintain patient engagement are needed.

Technology and diabetes self-management: an integrative review

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*World J Diabetes 2015; **6:** 225–33*

Background

Technology can be used in several ways to enable easier self-management of diabetes. Technology-enabled educational interventions help patients learn more about diabetes management, while other technologies can be used for motivational support, blood-glucose monitoring, exercise, healthy eating, medications, monitoring, and problem solving. This review evaluates different types of technology used to facilitate the self-management of type 2 diabetes and the effects of technologies on diabetes outcomes.

Methods

Three databases (Medline, PubMed, and PsychINFO) were searched using the search terms: diabetes self-management, technology, type 2 diabetes, smartphones, cell phones, and diabetes mellitus. Articles from 2008–2013 were included, and those that relied on secondary data (editorials, systematic reviews) or only described study protocol were excluded.

Results

The final review included 14 studies including qualitative, quasi-experimental, and randomized controlled trials. Data on outcomes such as HbA1c levels, self-management behaviors, and diabetes self-efficacy were extracted and compared.

Conclusions

Technology-enabled interventions had mainly positive impacts, although some interventions only had short-term or no improvements in hemoglobin A1C levels, diabetes self-management behaviors, and diabetes self-efficacy. Technological interventions can provide a cost-effective and ongoing conjunctive mode of therapy for people with diabetes.

Comments For The Previous Two Articles

There is little doubt, at least in the reviewers' minds, that increasing a person's ability to manage his or her own condition is, and should be, central to any approach to improve the health of a person with, or at risk for, diabetes. The question raised by these articles is: Do technology-enabled programs help individuals self-manage their conditions? The resounding answer is … it depends. That shouldn't surprise anyone since the specifics of each intervention and the characteristics of the patients who receive the intervention make all the difference. These articles provide a good summary of interventions designed to impact outcomes in patients with diabetes.

The role of exergaming in improving physical activity: a review

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*J Phys Act Health 2014; **11:** 864–70*

Background

Low energy expenditure (EE) due to high levels of physical inactivity has been a major factor in the ''obesity epidemic'' in America. Because Americans spend so much time on screens, and there is a correlation between screen-time and physical inactivity, video games that promote physical activity, called ''exergames,'' are rising in popularity. Most studies to date have investigated exergaming in pediatric or adolescent populations, so it remains unclear whether exergaming is an appropriate strategy to help American adults increase their physical activity. This review seeks to investigate the effect of exergaming on energy expenditure among Americans.

Methods

PubMed was searched to identify previous studies that investigated energy expenditure levels using a single active video game or a combination of active video games. While reviews were omitted, references were used to conduct hand search of relevant articles.

Results

In all, 27 studies met inclusion criteria and their data suggest a strong correlation between exergaming and increased energy expenditure. Most active video games tested led to moderate intensity physical activity levels, which meets the American College of Sports Medicine's guidelines for health and fitness. Most studies in this review were short

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duration (10–30 minutes of exercise per session), though research suggests that a longer duration of exergaming could result in even greater health benefits.

Conclusions

Exergaming is growing in popularity and holds promise to improve physical activity levels among Americans. However, there is a paucity of evidence regarding the effects of exergaming among adults (only five studies in this review focused on adults) and amongst different ethnic groups. Because age and ethnicity are often factors that alter levels of obesity, physical inactivity, and screen time, studies should be done to examine the consistency of the effects of exergaming among these different populations.

The use of videogames, gamification, and virtual environments in the self-management of diabetes: a systematic review of evidence

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*Games Health J 2015; **4:** 352–61 [Epub ahead of print]; 10.1089/g4h.2014.0114*

Background

The use of games for health-care interventions has been increasing due to its ability to increase motivation and engagement. However, there is a gap in understanding how games—including video games, gamification methods, and virtual environments—are used for the self-management of people with diabetes. This review examines behavioral, knowledge-based, biological, and psychological outcomes of studies on the use of games in patients with diabetes.

Methods

PubMed, Web of Science, Scopus, and PsychINFO were searched for relevant articles published between 2000 through 2014. Ten articles of 307 initially identified met the inclusion criteria. Data on study design, intervention details, and outcomes were extracted and compared between studies.

Results

Five of the 10 studies reviewed were quantitative, four were mixed, and one was qualitative. Only one study was a randomized controlled trial. Most studies had small sample sizes and were conducted over short durations. Though the included studies were heterogenous in intervention type, all interventions focused on a behavioral outcome of some sort, whether by examining diabetes-related risk or the promotion of healthy behaviors. Four studies' intervention was video games, three had virtual reality environments, and three studies applied principles from gamification methods.

Conclusions

The use of games seems to be beneficial in aiding the management of diabetes, though there is a relative lack of studies on the subject. Of the three intervention types examined, video games seem to be helpful for education, while gamification and virtual environments were more suited to increasing motivation and positive reinforcement.

The effect of active video games by ethnicity, sex and fitness: subgroup analysis from a randomised controlled trial

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*Int J Behav Nutr Phys Act 2014; **11**: 46*

Background

Preventing and treating childhood obesity is a significant public health issue and challenge. The Electronic Games to Aid Motivation to Exercise (eGAME) study was a randomized controlled trial (RCT) designed to evaluate the effect of active video games on body composition, physical activity, and cardiovascular fitness in overweight and obese children in New Zealand. However, in order to employ effective obesity interventions and to reduce health inequalities, analysis of different subgroups within populations must be done to determine risk profiles as well as differential effects of interventions. This study seeks to investigate the results of the eGAME trial among specific important subgroups because of different risk profiles for overweight and screen-based behaviors among certain groups.

Methods

A two-arm, parallel RCT was conducted in overweight or obese children (n = 322; aged 10–14 years) to determine the effect of active video games on body composition. Following initial study analysis, further analyses were conducted to assess the consistency of findings across subgroups such as ethnicity, sex, and baseline VO_2.

Results

Subgroup analysis did not demonstrate any statistically significant interaction effects between the treatment and subgroup terms in the main regression model ($p = 0.36$ to 0.93), indicating a consistent treatment effect across these groups.

Conclusions

The results of the eGAME trial and this subgroup analysis suggest that active video game interventions have a positive and consistent effect on body composition across subgroups. This suggests that video games may be a potential public health intervention to reduce obesity among children without exacerbating health inequalities.

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Comments For The Previous Three Articles

While it might be counterintuitive to use ''screen time'' to increase physical activity, these articles are presenting far more than just the actual activity being facilitated while using the screen. Effective interventions of any kind capitalize on what the participant (or prospective participant) wants to do, and couples that with other elements that accomplish the goals of the program. If it is fun to use a game to encourage and facilitate more physical activity, the individual will be more likely to be active. If the game helps connect the person to others, they will have increased their ability to get social support. If a game is properly designed it can impart a lot of information in an engaging and effective way. It is important to demonstrate these and other impacts on subgroups in the population if we are going to take real advantage of gamification to improve health outcomes.

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eHealth interventions for the prevention and treatment of overweight and obesity in adults: a systematic review with meta-analysis

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Obesity Reviews 2015; ***16:*** *376–92*

Background

Few systematic reviews on eHealth and diabetes have encompassed an evaluation of all information technologies on both prevention and treatment of obesity and weight gain. This review seeks to investigate the efficacy of eHealth interventions in the prevention and treatment of obesity and weight gain in adults, as assessed by weight-related outcomes.

Methods

English-language studies from 1995 through September 2014 from eight databases were reviewed. After review by two independent reviewers, data from included studies were extracted. Subgroup meta-analysis was conducted to analyze outcomes.

Results

In total, 84 studies, of which 76% had an eHealth component, were included. Sixty-one studies had weight loss as a primary goal, 10 weight loss maintenance, 8 weight gain prevention, and 5 weight loss and maintenance. Most eHealth interventions were delivered over the Internet, but email, text messages, monitoring devices, mobile applications, computer programs, podcasts, and personal digital assistants were also methods of intervention delivery. Meta-analysis demonstrated significantly greater weight loss in eHealth weight loss interventions compared with control (MD -2.70 [-3.33, -2.08], $P<0.001$) or minimal interventions (MD -1.40 [-1.98, -0.82], $P<0.001$), and in eHealth weight loss interventions with extra technology (MD 1.46 [0.80, 2.13], $P<0.001$) compared with standard eHealth program alone.

Conclusions

eHealth weight loss or weight gain prevention interventions demonstrated statistically significant, though modest, weight loss compared with no or minimal treatment. The addition of extra features, components, or technologies to eHealth interventions results in a more effective intervention than a standard eHealth program alone. However, due to a paucity of studies comparing results from eHealth intervention to standard treatment, there is still insufficient evidence to determine whether eHealth weight loss maintenance or weight gain prevention interventions are effective, and which types of eHealth intervention are most effective.

Comment

This article is a well-done review and meta-analysis of the literature regarding the impact of eHealth interventions on weight loss and weight maintenance. As with nearly all meta-analyses, the conclusions are less than perfect, but we can learn important information nonetheless. As expected, good results are seen when interventions are based on ones that are known to be effective in person, or are based on sound behavior change principles. The summary at the end of the article on implications for research are quite sound and worth looking at. As expected, the review was unable to take into account the impact on experiences participants had during the recruitment phase of a study.

Social networking strategies that aim to reduce obesity have achieved significant although modest results

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Health Affairs 2014; ***33:*** *1641–47*

Background

Obesity accounts for a high proportion of the socioeconomic burden of noncommunicable diseases worldwide. Along with government, public health initiatives, and primary care, a sustainable way to treat obesity will likely include community-based treatments involving health, fitness, and nutritional

support. Social networking services offer a community-based way to treat and prevent obesity and enable obese and overweight patients and their health-care providers to communicate effectively.

Methods

Three databases (Medline, Embase, PsychINFO) were searched from inception through 2014 for medical subject headings (MeSH) such as social networking, BMI, obesity, overweight, weight loss, weight change, body mass index, mobile phone, cellular phone, text message, smartphone, SMS, web, web-based, Internet, and Internet-based. Meta-analysis using a random-effects model was performed on data extracted from the studies meeting inclusion criteria to evaluate the role of interventions in changing BMI.

Results

Twelve studies met inclusion criteria, with a total of 1,884 patients. In all, 941 of these patients received social networking services as an intervention for obesity, and cumulatively demonstrated a 0.64% reduction in BMI as compared to control patients. Nine of the 12 studies used only web-based interventions, one used Internet combined with mobile interventions, and two used Internet combined with telephone-based interventions. Durations of studies ranged from below 6 months to above 12 months, with optimal durations (as measured by effect on reducing BMI) of 6 to 12 months.

Conclusions

Social networking services hold promise in gradually but significantly reducing BMI in obese and overweight people. Issues such as compliance/engagement and access may play a role in diminished outcomes, and more clinical trials should be conducted on these interventions. The results of this review can be employed by policy makers to enact reforms to promote and facilitate the usage of social networking services as an intervention for obesity.

Comment

If social support is the wonder drug of the 21st century, then the Internet and cell phones are an ideal drug delivery system for many people—but not everyone. At least that is what we think, and this article summarizes some of the reasons this might be true. While this article addresses the impact on obesity, there are lessons to be applied to a variety of conditions. Of course, the devil is in the details, such as how people are recruited into a network; what individual characteristics predict engagement and impact; how effective groups are created; what elements of network design are most effective with which populations or subpopulations; how networks can be sustainable financially, etc. There is no doubt that social networks have become important in the direct-to-consumer social support field. Time will tell how effective they are in health-care settings.

Final Remarks

As with prior yearbooks, the articles in this yearbook do not have a final answer to the question, ''*What contribution to the prevention and treatment of diabetes can we expect to get from Health Information Technology (HIT)?*'' But the articles do represent emerging trends in digital health that hold great promise for the prevention of diabetes and for the self-management of personal health.

There is no doubt that HIT will ultimately transform health-care delivery, self-management education, and behavior change interventions. This year's articles also demonstrate a maturing of the research enterprise, with promising paths for innovation and growth. But these trends also bring about new organizational challenges.

The newest challenge for health-care providers and payers: direct-to-consumer approaches can innovate, deploy, evaluate, and redeploy at cost and speeds that are uncomfortable in a health-care setting. Health-care organizations tend to slow innovation due to required evidence of effectiveness, privacy requirements, fear of liability, integration into existing technology ecosystem, and demands for a demonstrated return on investment.

At the same time, consumer brands are entering the digital health arena and making big bets on direct-to-consumer approaches *without proof of important or long-term impacts* (think health monitoring devices for wellness and gamification with health focus). This leads to the proliferation of well-designed experiences that promise to improve health but may have minimal effect. At the same time, these well-designed experiences raise consumers' expectations for the look, feel, and interaction of digital programs used within the context of a clinical relationship.

So while consumer expectations escalate, health-care providers slow down their pace of innovation and change. And this will increasingly impact consumer engagement, consumer satisfaction, and consumers' perception of value. To bridge the gap, health-care organizations must start now with (1) pilots to learn about the unique impacts of digital health programs on their populations, and (2) road maps to scale digital health solutions over time. So rather than considering program or technology *purchases*, health-care organizations should consider population *partnerships* with vendors who will start small and scale over time to impact population health.

Author Disclosure Statement

N.K. has a potential conflict of interest with the articles ''Internet delivered diabetes self-management education: a review'' (*Diabetes Technol Ther* 2015; **17:** 55–63) and ''Technology and diabetes self-management: An integrative review'' (*World J Diabetes* 2015; **6:** 225–33), since his company has the license to sell one of the programs referenced in it (ref. 18 and 17, respectively). I.K. has no conflicts of interest.

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