Examining A Persuasive Health Technology Intervention For Enhancing Foot And Leg Self-care In Patients With Peripheral Vascular Disease: A Single-group Pilot Study

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Abstract: The aim of this study was to: 1) examine participant perceptions of an email-based intervention to support foot health amongst persons with peripheral vascular disease (PVD) and 2) explore preliminary evidence of its usefulness in increasing frequency of foot and leg inspection. The intervention for this single-group pilot study consisted of a series of educational, supportive and reminder email messages delivered once per day for 60 days. Among the encouraged self-care behaviours, a simple daily inspection of the lower limbs and feet was emphasized. Participant perceptions were measured with items adapted from the Mobile Application Rating Scale at study end. Preliminary usefulness was measured with a single item concerning frequency of foot and leg inspection at baseline and study end. Sixty-five individuals participated and 20 withdrew. Participants who completed the user perceptions questionnaire generally viewed the intervention as helpful and persuasive, with at least 35/41 (85%) agreeing with items concerning use of it increasing awareness, intentions and care behaviour. Preliminary results concerning frequency of foot and leg inspection showed some improvements from baseline to study end. The study findings, while promising, point to the need for further evidence concerning the acceptability and effectiveness of email or text messages with randomized controlled trials.

Key words: *electronic mail, lower extremity, persuasive health technology, peripheral vascular disease, self-care, peripheral vascular disease*

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Peripheral vascular disease (PVD) is a serious chronic health problem involving compromised circulation outside the heart and brain.[1] The long-term sequelae include a greater susceptibility to lower-limb and foot wounds, which can lead to ulceration, infection, gangrene and, ultimately, surgical amputation.[2] As with persons with other chronic diseases, most individuals living with PVD will necessarily bear responsibility for managing most of their own day-to-day health and care,[3] supported intermittently by the health-care system.

According to Riegel et al.,[4] self-care refers to the process of maintaining health through health-promoting practices and managing illness. Self-care includes: a) self-care maintenance: behaviours performed to improve well-being, preserve health or to maintain physical or emotional stability; b) self-care monitoring: the process of regular, diligent body monitoring or surveillance, or 'body listening' in order to recognize that a change has occurred; and c) self-care management, i.e., evaluating the changes in physical or emotional signs and

symptoms to determine if further action is needed. Finding the best ways to support individual patients in their self-care activities is an ongoing challenge.

Persuasive health technology represents an extension of persuasive technology[5] and refers to "any technology purposely designed to influence, reinforce, change or shape health-related attitudes or behaviors".[6] These technologies typically draw upon theories of motivation, persuasion, and behaviour change.[7] There is a large range of technologies here, including many that could be accessed through a mobile phone.

It has been recommended that behavioural interventions should be feasible, uncomplicated, as convenient as possible and not unnecessarily time-consuming.[8-9] Four categories of persuasion principles were identified in the Persuasive System Design (PSD) model developed by Oinas-Kukkonen and Harjumaa: primary task support, dialogue support, credibility support and social support.[9] A recent systematic review by Almutairi et al. identified 11 PSD features that can increase patient engagement through using mobile device health, or mHealth, applications (apps), including: tailoring, personalization, self-monitoring, praise, reminders, suggestions, social role, trustworthiness, social learning and normative influence.[10] Nonetheless, the particular functionalities that are chosen for a persuasive health technology may best be determined considering the context, goals/objectives and real-world constraints.[6]

Recent research is ambivalent regarding the use of persuasive health technologies for foot health. Dincer and Bahcecik found significantly better knowledge, self-efficacy and foot care behaviour amongst those randomly assigned to use an animation-supported foot care app for persons with diabetes versus those who received standard in-clinic education.[11] Although Kilic and Karadag found significant improvements in knowledge, behaviour and self-efficacy in participants using their foot care app, the control group showed similar improvements in behaviour and self-efficacy.[12] Similarly, Marques et al. found no significant differences between intervention and control groups in their study of a mobile foot-care education app intervention.[13] However, the intragroup analyses revealed that the intervention group demonstrated increased frequency of foot self-assessments and adherence to foot self-care. Ogrin et al. used participant co-design for a foot-health app for people with diabetes.[14] The app was perceived positively, particularly for those newly diagnosed. However, uptake was low, with only 18/40 participants using it. Ploderer et al. identified three engagement patterns in their study of a foot care app: continuous, temporary and failed engagement.[15]

Messaging, whether through text (SMS/MMS) or email, has the potential to reach large audiences and possibly serve as an inexpensive intervention modality.[16-18] Few studies have examined messaging interventions for foot health. Hassan reported that, while 76% of participants with diabetes and no history of foot ulcers reported poor foot self-care initially, less than 1% reported poor foot self-care after receiving an in-clinic education session and two-three reinforcement text messages per week over the subsequent 12 weeks.[19]

Given the relative lack of research concerning persuasive health technology interventions in the PVD population, the aims of this study were twofold: to examine participant perceptions of an email-based intervention to support foot and leg health amongst persons with PVD, and second, to explore preliminary evidence of its usefulness in increasing frequency of foot and leg inspection.

Methods

Recruitment: Adults with PVD were recruited from an amputation clinic that provides ambulatory rehabilitation care and a peripheral vascular clinic in a city in Western Canada. To be eligible, participants required regular access to a smartphone or computer, at least one existing lower limb (below knee), functional English communication skills and sufficient cognitive ability to participate in the intervention. Clinic staff informed potentially eligible persons during clinic visits. If they expressed interest in learning more about the study, they met with

the study coordinator, an experienced nurse, who assessed eligibility. During recruitment, the study coordinator gave a verbal overview of the study and provided each interested person a study information letter. The coordinator answered any questions from prospective participants or reviewed the information letter with them, when requested. Participants were informed that the completion and return of each survey questionnaire would constitute consent to participate and permission for the researchers to use the data collected in the manner described in the information letter. Both the study information letter and the coordinator emphasized that participation was entirely voluntary, and that a participant's decision to participate or not would not affect the care they receive, and that they could withdraw from the study at any time. Participants were eligible to enter a draw for one of ten $20 gift cards. This study was approved on ethical grounds by the University of Saskatchewan Behavioural Research Ethics Board (BEH1732).

Intervention: The behavioural intervention focused on improving participants' knowledge, skills, and confidence. It was guided by the Persuasive Systems Design model,[9] incorporating principles under primary task support, computer-human dialogue support, system credibility support and social support. The intervention consisted of a series of educational, supportive and reminder email messages. Messages included simple text, copyright-free images and links to videos regarding recommended self-care behaviours. Some messages included more interactive elements, including asking if the participant had been carrying out the recommended behaviour and praising or encouraging, depending upon their response. To make the messages more attractive, images of [the province of] Saskatchewan, Canada and coloured backgrounds were also used.

Among the encouraged self-care behaviours, a simple daily inspection of the lower limbs and feet was emphasized. A daily inspection is recommended for at-risk individuals living with PVD.[2, 20, 21] The intervention included information to facilitate early identification of changes in the lower limb and foot that may indicate the early development of wounds and encourage prompt care-seeking and treatment when changes were noticed.

Message delivery was fully automated, and messages were sent to participants' email addresses via the REDCap system hosted at the University of Saskatchewan.[22-23] Participants received semi-randomly scheduled messages once per day over 60 days, from day six of study participation to day 65. There were 36 messages, so some were delivered repeatedly. Examples of messages are included in Figure 2.

Measures: Participants were asked to complete questionnaires at multiple time points, using REDCap electronic data capture tools. Demographics and baseline health information were measured at study start. User perceptions were measured after participants completed the study with items adapted from the Mobile App Rating Scale (MARS).[24] The MARS has been shown to have acceptable validity and reliability.[25]

Foot and leg inspection was measured with a single item at baseline, and then three, six and nine weeks later. At baseline, the item read: "How often do you (or the person you ask to help you) closely inspect your legs and feet, looking for changes from what they usually look, feel, or smell like?" The response options were: *every day, most days each week (4-6 days), some days each week (1-3 days), a few times a month, less than a few times a month*, or *I only inspect my legs or feet if I think there is a problem*. A version of this item was also asked during and after the intervention; however, on those days it asked participants to think back over the past two weeks. Results from participants who responded at baseline and study end are included here. Data collection occurred between February 2021 and January 2022.

Statistical Analysis: Descriptive analyses for this pilot study were performed using IBM SPSS Statistics (version 28). The McNemar test was used to examine changes in reported behaviour.

Table 1: Demographic information.

		Total sample (n=45) n (%)
Age		
	40-49y	4 (9%)
	50-59y	14 (31%)
	60-69y	20 (44%)
	70-79y	3 (7%)
	Over 79y	4 (9%)
Marital Status		
	Married or common-law	28 (62%)
	Divorced, widowed, or separated	9 (20%)
	Single, never married	7 (16%)
	Missing	1 (2%)
Education		
	Less than high school	1 (2%)
	High school diploma	9 (20%)
	College, trade, or other non-university certificate or diploma	20 (44%)
	University certificate, diploma, or degree	15 (33%)
Current Employment Status		
	Employed (full or part-time)	14 (31%)
	Retired	22 (49%)
	On leave or unable to work	6 (13%)
	Other	3 (7%)
Household Income		
	$10-40K	7 (16%)
	$40-70K	14 (31%)
	$70-100K	6 (13%)
	Over $100K	10 (22%)
Residence		
	Large city	25 (56%)
	Other city	10 (22%)
	Farm or acreage	7 (16%)
	Other	3 (7%)
Internet Use		
	Daily	37 (82%)
	A few times a week	8 (18%)

Results

Sixty-five persons with PVD participated and ten formally withdrew. In addition, five participants appeared not to have opened any emails and another five seemed to have ceased opening emails during the study, leaving 45 participants (17 females, 28 males). Median age band was 60-69y. Additional demographics are presented in Table 1. Baseline health measures are presented in Table 2 and user perceptions are presented in Table 3.

Table 2: Baseline health information.

		Total sample (n=45) n (%)
Self-rated Physical Health		
	Excellent	0
	Very good	4 (9%)
	Good	21 (47%)
	Fair	14 (31%)
	Poor	5 (11%)
	Missing	1 (2%)
Self-rated Mental Health		
	Excellent	5 (11%)
	Very good	11 (24%)
	Good	20 (44%)
	Fair	9 (20%)
Has a Health-care Provider told you that you have diabetes? (yes)		30 (67%)
Have you had a lower-limb amputation? (yes)		16 (36%)
Have you had a wound on your toes, feet or lower legs that healed slowly, poorly, or not at all? (yes)		28 (62%)
Medication to lower BP? (yes)		35 (78%)
Medication to thin blood? (yes)		22 (49%)
Medication to lower cholesterol? (yes)		27 (60%)
Currently smoke tobacco?		
	Daily	6 (13%)
	Less than daily	0
	Not at all	39 (87%)

Table 3: User perceptions results (n=41).

	Strongly disagree n (%)	Disagree n (%)	Neutral n (%)	Agree n (%)	Strongly agree n (%)	No opinion n (%)
This app is likely to increase people's awareness about the importance of caring for their legs and feet daily.	0	0	4 (10%)	25 (61%)	12 (29%)	
This app is likely to increase a person's knowledge/ understanding of why it is important to care for their legs and feet daily.	0	0	3 (7%)	26 (63%)	12 (29%)	
This app is likely to change people's attitudes about caring for their legs and feet daily.	0	0	4 (10%)	26 (63%)	10 (24%)	1 (2%)
This app is likely to increase people's intentions/ motivation to care for their legs and feet daily.	0	0	6 (15%)	30 (73%)	5 (12%)	
Use of this app is likely to encourage people to seek out additional help if they need support when caring for their legs and feet daily.	0	0	5 (12%)	27 (66%)	9wvw (22%)	
People using this app are likely to increase the number of days each week they care for their legs and feet.	0	0	6 (15%)	25 (63%)	9 (22%)	1 (missing)

		n (%)
Would you recommend this app to people who might benefit from using it?		
	Not at all. I would not recommend this app to anyone.	0
	There are very few people I would recommend this app to.	3 (7%)
	Maybe. There are several people whom I would recommend it to.	10 (24%)
	There are many people who I would recommend this app to.	4 (10%)
	Definitely. I would recommend this app to everyone who might benefit.	22 (54%)
	No opinion	2 (5%)
Did the app improve your knowledge about caring for your legs and feet?		
	Not really	1 (2%)
	A little bit, but mostly just reminded me of things I already knew.	8 (20%)
	Somewhat more.	16 (39%)
	Yes, I learned a great deal.	14 (34%)
	No opinion	2 (5%)
Did the app offer you useful skills and tips that help when caring for your legs and feet?		
	Not really	2 (5%)
	Maybe a little	8 (20%)
	Yes definitely	29 (71%)
	No opinion	2 (5%)
Do you think your experience with the app helped boost your confidence, when caring for your legs and feet?		
	Not really	3 (7%)
	Maybe a little	12 (29%)
	Yes definitely	24 (59%)
	No opinion	2 (5%)
Do you think a daily reminder (to inspect and wash the legs and feet), sent to peoples' smartphones from this app would be helpful?		
	Yes	7 (17%)
	Yes – if people had the option to turn the reminder on/off and set the time of day to receive the message.	19 (46%)
	No	3 (7%)
	Unsure	9 (22%)
	No opinion	3 (7%)

Self-care behaviour results are displayed in Figure 1. Thirty-nine completed the foot and leg inspection item at baseline and study end (16 females, 23 males). Four more participants reported daily inspections at study end (15/39, 38%) versus baseline (11/39, 28%; P=.39). There was a non-significant increase in those reporting inspections on at least, "most days each week (4-6 days)" from baseline (20/39, 51%) to study end (28/39, 72%; P=.06). Eleven increased their frequency to meet this threshold and three decreased their frequency below the threshold. However, looking at those reporting inspections at least "some days each week (1-3 days)", 24/39 (62%) reported this at baseline and 36/39 (92%) reported this at study end (P<.001). Twelve increased their frequency to meet this threshold and none decreased below the threshold.

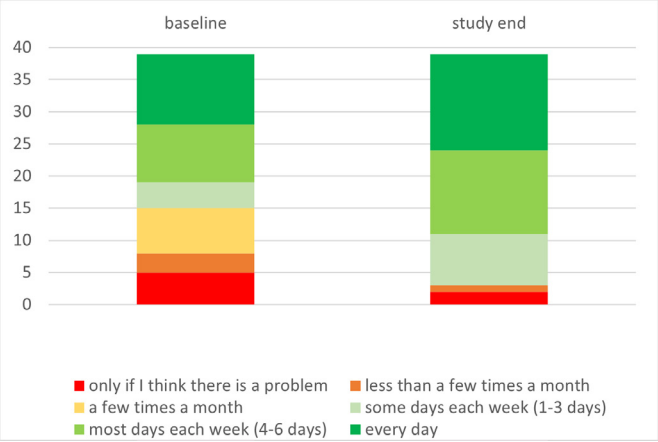

Figure 1: Frequency of leg/foot inspection (n=39).

Discussion

Participants who remained in the study generally viewed the intervention as helpful and persuasive. There was a small increase in the number of participants reporting inspections on at least four days each week and a large increase in those reporting inspections on at least one day each week. Global health-care systems are increasingly struggling to meet the acute and chronic needs of patients in the face of limited resources. As a solution, individuals are turning to self-management strategies to monitor and treat their personal health-care needs.[26] This is an interesting adaptive phenomenon reminiscent of pre-socialized medicine, whereby a nascent health-care system with limited resources often required individuals, their families and allied professionals to intervene with creative personalized solutions. At the same time, the use of persuasive technology, through advances in communication technology, is growing in health care.[6] Such technologies offer a promising approach to providing solutions to current system challenges by influencing patients to be more involved in their own health surveillance by changing behaviour in real time.

The findings reported here support and reinforce this trend in medical care. Previous research has found similar acceptability and utility results when studying foot health apps in people with diabetes. Ogrin et al. used participant co-design and their app was perceived positively; however uptake was low, with only 18/40 participants using it.[14] Hassan reported that, while 76% of participants with diabetes and no history of foot ulcers reported poor foot self-care initially, less than 1% reported poor foot self-care after receiving an in-clinic education session and two-three reinforcement text messages per week over the subsequent 12 weeks.[19]

Our intervention consisted of daily educational, supportive and reminder email messages concerning foot and leg health for persons with PVD. Participants did not unanimously endorse the helpfulness of the information included in the messages. Several reported that they already knew the information. It is also plausible that many of those who elected not to continue or to not fill out the user perceptions questionnaire did not find the information helpful. Many different kinds and intensities of interventions may be necessary, so that individuals can access those that they find acceptable and helpful.

Despite reported complications, there was a desire to engage in preventative strategies that would promote their perceived wellbeing. Complications such as general malaise, pain and loss of independence can present as a significant barrier to self-management.[27] It is apparent that persuasive technology was valued and embraced by the remaining participants who viewed it as a means

to improve their health outcomes even in the face of significant complications related to peripheral vascular disease.

Figure 2

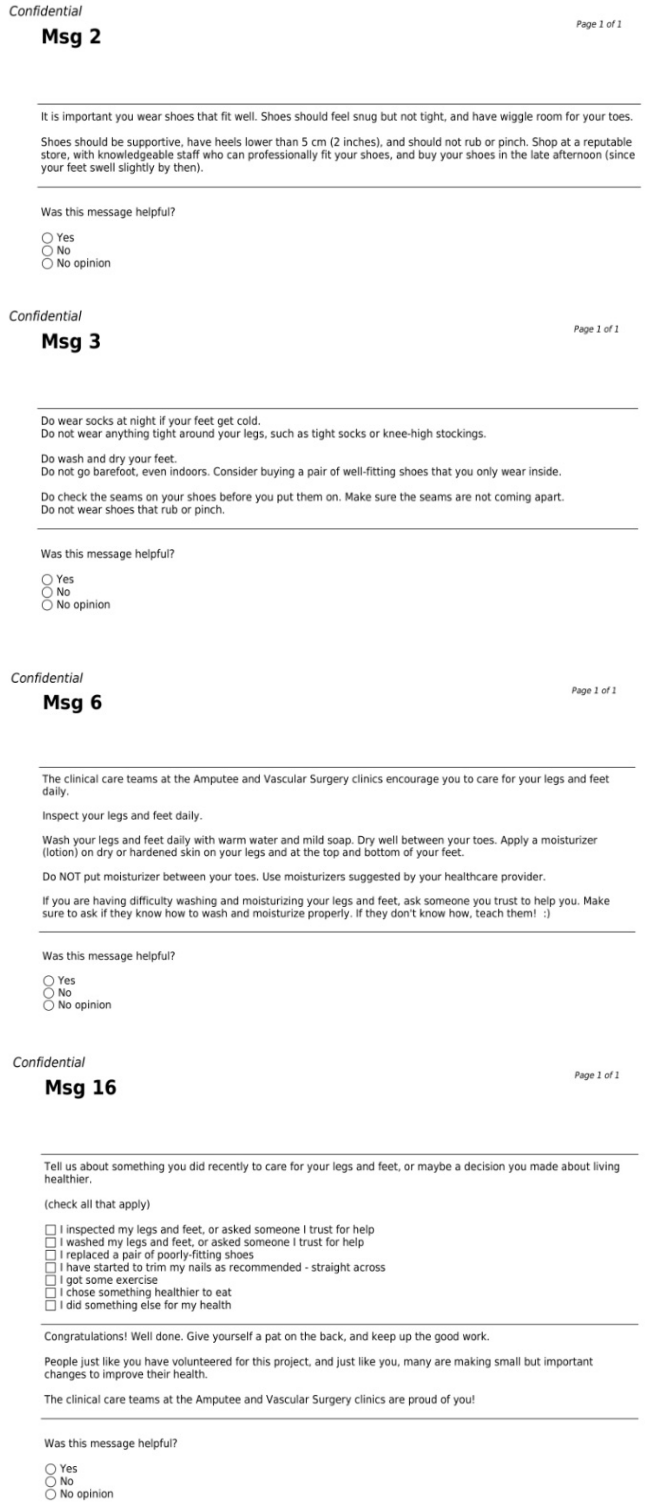

Figure 2 contains a sample of messages sent to participants. These interventions were developed using principles from the Persuasive Systems Design model.[9] Primary Task Support underscores the value of reducing complex behaviours into simple tasks to manage peripheral vascular disease. Behaviours such as regular inspection were encouraged in messages. Computer-human Dialogue Support is integral to ongoing engagement in persuasive health technology. Embedded in some of the messages were congratulations for task achievement followed by celebratory animation. Other messages reminded participants to inspect their feet by also rewarding them with congratulatory animation if they answered "yes". System Credibility Support was achieved by incorporating expert advice to persuade. In this case, referencing the need to care for their lower extremity as advocated by the teams in amputee and vascular clinics was embedded into messages.

A key component of persuasive technology is employing motivation techniques in a non-threatening manner to achieve positive outcomes.[9] Progressive monitoring, reminders or alert messages may contribute to encouraging and reinforcing behaviours. In this study, 63% (26/41) of the participants reported a desire to receive daily reminders to inspect and wash their lower extremity, underscoring the value of this technology in fostering self-care and engagement in real time. Also, nearly half (49%, 20/41) reported that it would be helpful for clinic staff to be able to see patient responses in order to reinforce and acknowledge their achievements and identify individuals who are struggling.

The Persuasive Systems Design (PSD) model describes principles that include social support mechanisms. Cooperation and competition were explored as motivating factors amongst participants in this study. Although comparison between participants can promote positive outcomes, participants were divided on this approach, with 49% (20/41) anticipating increased motivation to adopt healthier habits if the program anonymously compared their performance with others

performing the same self-care activity, while 20% (8/41) rejected the approach and 24% (10/41) were unsure. Respondents reported slightly more interest in cooperating or communicating with like individuals through support or online chat groups. Interestingly, when asked if they would support frank competition by awarding points for higher completion rates (resulting in small rewards), the majority (71%, 29/41) either responded negatively or weren't sure about this approach.

Limitations: Although results supported the intervention's potential acceptability and utility, this study had several limitations, which should be acknowledged. Firstly, generalizability may be a concern. The initial study sample was relatively small (N=65) and 15% (n=10) formally withdrew, along with another ten (15%) discontinuing. This is unfortunate; however, the authors agree with Jacobs,[28] that persuasive technology must always support the autonomy of persons, and that consent must be ongoing and explicit. Furthermore, data for these analyses were only available for approximately 87-91% of the remaining sample. Participants may have been better educated and of higher socioeconomic status than many with PVD. Finally, the study design precludes inferences concerning the effectiveness of the intervention. A properly powered randomized-controlled trial, which includes possible moderators (e.g., pain) is needed.

Conclusions

Our intervention, which consisted of daily emails concerning foot and leg health for those with PVD, was viewed positively by a majority of those who completed the end-of-study survey. Preliminary results concerning foot and leg inspection showed some improvements from baseline to study end. Participants reported increased frequency of foot and leg inspections at study end. Nonetheless, the generalizability of these results may be limited. Further evidence concerning the acceptability and effectiveness of email or text messages in this population should be sought using randomized controlled trials.

Ethics statement

This study was approved on ethical grounds by the University of Saskatchewan Behavioural Research Ethics Board (BEH1732).

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Conflict of interest/Funding

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Author contribution

DN analysed data and drafted and edited the manuscript. GL and DG oversaw project design and data collection and drafted and edited the manuscript. NO oversaw project design and data collection and edited the manuscript.

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