

## Research Article

# Utilizing the Virtual World Environment for Diabetic Foot Self-Management Education

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**Abstract**

The importance of proper diabetic foot care self-management has been well documented in the literature however traditional methods such as in person education and pamphlets have been reported as not demonstrating improved self-management knowledge in patients with diabetes. Technology such as the Virtual World (VW) environment may prove beneficial by augmenting traditional self-management education methods. VW technology has been noted as a novel three dimensional (3D) virtual environment for learning, allowing the participant to learn the experience first then learn about a particular knowledge as they go through the experience. While some studies have been noted in the literature to have examined use of the VW environment for general diabetes self-management, no study to date has examined the use of the VW environment for foot care self-management education for individuals specifically at risk for diabetic foot ulcer. Examination in high risk patients may provide a viable alternative or addition to computer or pamphlet education and augment clinic education. Diabetes may put patients at risk for ulcers or amputation. Gaining education via a virtual self-management program may allow patients to better access foot care self-management education, learn to better manage their foot care as well as experience foot care management practices as an avatar in a 3 D environment. This VW foot care self-management education experience may increase foot care self-management knowledge and possibly reduce the likelihood of diabetes related foot ulcers or limb loss as well as improve patient quality of life.

**ABBREVIATIONS**

VW: Virtual World; 3D: Three Dimensional; Dfus: Diabetic Foot Ulcers; TAM: Technology Acceptance Model

**INTRODUCTION**

Patients may be at risk for foot ulcers or amputation if they have diabetes [1]. Factors such as: peripheral neuropathy, peripheral vascular disease, history of ulcer or amputation and foot deformity may put a patient with diabetes at risk for limb loss [1,2]. Diabetes and co morbidities were associated with approximately 73,000 limb amputations in the United States; the mortality rate being greater than some cancers [3,4]. A study examining diabetes related amputations reported that 82% of lower extremity amputations in the United States were also associated with vascular disease [5-7]. Diabetic peripheral neuropathy also contributes to amputation due to loss of protective sensation which promotes the likelihood of increased tissue breakdown when walking and encourages foot ulcer development [2].

Virtual World (VW) technology has been noted as useful for patient education in populations with chronic diseases such as diabetes [8]. A virtual environment or virtual world is a synchronous, 3D computer-based simulated persistent environment, which a person can represent themselves as an avatar [9]. Health care groups have used the virtual environment for immersive patient provider and patient peer interaction [10]. Literature is sparse when examining the effect of virtual environment on people with diabetes [11]. The efficacy of using VW to deliver self-management information is being examined for chronic diseases such as diabetes, examining areas such as diet, exercise, and glucose control with findings [12]. The objective of this pilot study is to develop a VW 3D environment for diabetic foot care self-management education intervention that will allow Veterans at risk for DFU or amputation to experience desired health behaviors and meet virtually to communicate experiences, learn and discuss self-management, and receive peer support. Our rationale for the proposed research will improve our understanding of the feasibility and participant acceptability of a diabetic foot care virtual self-management education intervention,

building on an existing virtual world environment community and pilot work to build a virtual world environment for diabetic foot care self-management for patients at risk for limb loss. Some of the preventative foot care experienced in this VW environment consists of: a 3D comprehensive diabetic foot care clinic (DFC) that includes foot inspection, washing, and wound care stations, supportive shoe store, offloading shoe and brace center, outdoor table and chair area designated for support group meetings, and a resource library which includes a treadmill and stationary bicycle. Study participants can log into the VW environment as an avatar, and learn foot care self-management via virtual learning modules and videos throughout the DFC. This pilot study will use quantitative and qualitative methods to examine the following aims: test the feasibility of providing diabetic foot education and support via a VW environment, evaluate the effectiveness of the VW diabetic foot self-management education program on foot care knowledge, and subject experience of the VW intervention, and user acceptance of VW.

## MATERIALS AND METHODS

Utilizing the Technology Acceptance Model (TAM) and foot care pre and post-test, this study will test the feasibility of providing education and support in a VW environment, evaluate the effectiveness of the VW self-management education program on foot care knowledge, subject experience of the VW intervention, foot care self-management education, and user acceptance of VW. Quantitative and qualitative methods will be used during this pilot study. Surveys will be used to examine participant foot care self-management knowledge pre and post intervention. This project includes both a development phase (Aim 1) and an evaluation phase (Aim 2). The evaluation phase will use a single group pre and post-test design for foot care knowledge and a post design for user experience and technology acceptance.

**Sample and Recruitment:** This is a pilot study and up to 10 Veteran subjects will be recruited for research via Institutional Review Board (IRB) approved research flyers that will be posted in designated IRB approved areas throughout the hospital campus.

Inclusion criteria for this study include: patients aged 18 to 95 years (inclusive), with diabetic foot ulcer, history of diabetic foot ulcer, or distal lower extremity amputations associated with diabetes and procedures including: distal foot amputations (i.e. partial or complete toe amputation, partial ray amputation, total ray amputation, transmetatarsal amputation (TMA), Lisfranc joint amputation Chopart's joint amputation, sub-total calcaneotomy) and more proximal limb amputations, patients with type 1 or type II diabetes, with computer and internet access, as well as ability to read and speak English. Exclusion criteria for this study include: patients who sustained a traumatic amputation.

This IRB approved study is minimal risk because all study team members will be properly trained in the management of patient health information, assessment of safety, and possible adverse events. All research records related to this protocol will be maintained per institution requirements. All study team members will inform the principle investigator (PI) of any breach of confidentiality, safety issues, or adverse events immediately

upon discovering such a problem. The study PI will take appropriate action by informing the Security Information Officer and Privacy officer following institution guidelines.

The proposed study poses minimal risk to the privacy of the subjects. Only trained study personnel will have access to the virtual environment and the study surveys. The proposed study poses minimal risk to the privacy of the subjects. Only trained study personnel will have access to the virtual environment and handle the study surveys. All research recordkeeping related to this protocol will be managed and maintained per institution guidelines.

## Hypothesis

Gaining education via a VW diabetic foot ulcer self-management program will improve patient access to diabetic foot care self-management education and promote better foot self-care to reduce the likelihood of ulcer or amputation.

For our proposed study, we will enroll up to ten subjects with type I or type II diabetes aged 18 to 95 years with diagnosis of a foot ulcer, history of foot ulcer, or distal lower extremity amputation.

This project includes both a development phase which consists of the creation of a diabetic foot center which includes a clinic, library, shoe store, and brace center, as well as self-management education modules consisting of evidence based diabetic foot care education and video. The evaluation phase consists of using quantitative and qualitative methods such as a descriptive survey and semi-structured interview respectively. While in the VW environment, participants will have the opportunity to perform, as an avatar, foot inspection, foot washing as well as learn about supportive shoes, shoe gear selection, shoe inspection, and wound care. Participants will also have opportunities within the VW for leisure and social interaction that will allow Veterans to have safe access to support group meetings via a virtual environment without barriers such as transportation or immobilization due to disability. For example, an organized structured, scheduled group will be offered to participants with topics including problems encountered when caring for their feet, discussing self-management, coping with DFU or amputation, and discussing resources.

The evaluation phase will use a single group pre and post-test design for foot care knowledge and a post design for user experience and technology acceptance. The Technology Acceptance Model (TAM) measure will be used to assess user acceptance of the VW technology [13]. The TAM describes a person's behavioral tendency, and is used to predict, and interpret an individual's behavior as well as subjective norms surrounding behavior performance [14]. The TAM measurement scale has been noted as a useful tool to assess use behaviors in terms of perceived usefulness and ease of use for technology acceptance and historically was used for assessing computer workplace user acceptance in 1989 by Davis [15]. This validated model has been successfully used in a variety of healthcare settings [16]. The TAM is based on perceived usefulness, perceived ease-of-use, and. For our proposed study perceived usefulness is defined as the extent to which an individual believes that using

a virtual world education intervention will enhance their ability to self-manage their foot care, and is influenced by perception of success and efficiency in task completion. Perceived ease of use is defined as the degree to which an individual believes that using the virtual world diabetic foot education would be free of effort [16].

**Data collection**

Demographic information will be collected and a Foot Care survey [17] will be administered at baseline (pre-test). See Table (1). Subjects will have four weeks to complete the VW training.

**Procedure**

Subjects will undergo a training session with the PI to orient the subject to the VW and select an avatar. A VW orientation manual will be provided to each subject and will contain step by step instructions regarding how to select and use an avatar for VW. When subjects have reported to the PI that they have completed the training or at the end of four weeks, whichever comes first, the Foot Care Survey post-test, the technology acceptance measure, and the semi-structured interview will be administered.

**Outcomes and study measures**

This study will examine the feasibility of providing diabetic foot education and support in a VW environment; evaluate the

effectiveness of the VW diabetic foot self-management education program on foot care knowledge, subject experience of the VW intervention, and user acceptance of VW. Outcomes measured at week one will be demographics, and pretest foot care survey and at the end of week four the foot care survey posttest and technology acceptance measure See Figure (1).

**Statistical analysis**

Descriptive statistics will be used to calculate the mean and median change score between the pre and post-test Foot Care survey scores. Effect size of the change in foot care knowledge will also be calculated. Phenomenology qualitative methods will be used to analyze the structured interview data. Mean and median values will be used to analyze the Likert-type scale TAM survey data.

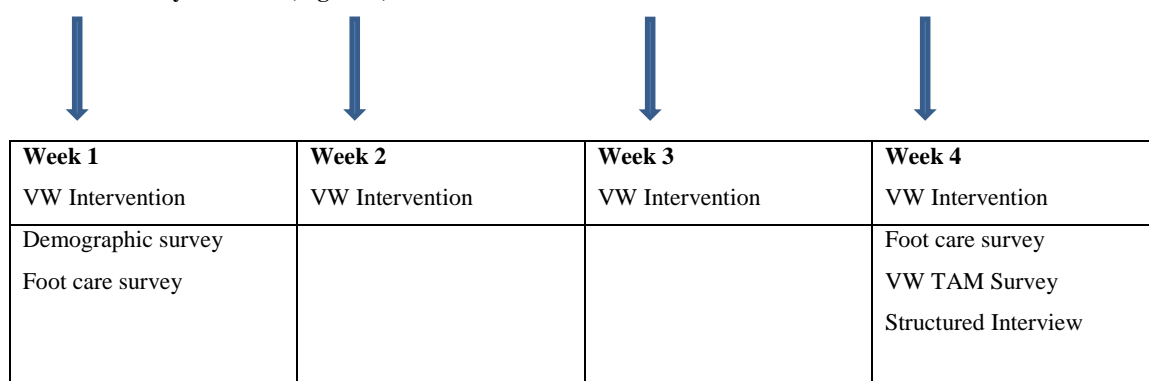
**DISCUSSION**

Diabetic foot self -management education is an important area of primary prevention which has been noted to increase patient knowledge and encourage good foot health behaviors [18-20]. However, the literature indicates possible gaps in care due to inconsistent diabetes self-management education with areas of decreased access due to high volume primary practices which may not consistently examine patient feet, lack of appropriate provider training to adequately educate the patient about diabetic foot risks, and lack of personnel or resources [19].

**Table 1:** Operational definitions of outcome, demographic, and qualitative variables.

VARIABLE AND TYPE*		MEASURE	TIME
<b>OUTCOME VARIABLES</b>			
Foot care knowledge (Aim 2)		Foot Care Survey	Pre intervention Post intervention
Technology acceptance (Aim 2)		Technology Acceptance Model Measure	
<b>DEMOGRAPHIC VARIABLES</b>			
Age	C	Age at date of initial interview	Electronic medical record Baseline interview
Gender	N		
Race/ethnicity			
<b>QUALITATIVE VARIABLES</b>			
Patient experience (Aim 2)	T	Semi-structured interview	Semi-structured interview
* C = continuous; Co = count; N =nominal; D=dichotomous; T=text			

**DFU VW Study Timeline (Figure 1)**



Strengths of this study are: it will allow patients to have open virtual access to diabetic foot self-management education and thus enhanced access to patient education that will be patient driven. Additional strengths to this study are the use of a standardized VW education program with a qualitative pre and post foot care knowledge survey as well as a quantitative technology acceptance survey evaluation. Study limitations are: this is a pilot study, with a small sample size, which will be examined further in a larger randomized controlled trial if this study is determined to be feasible and the population being examined is Veterans, which mostly consist of men, and thus the generalizability may be limited.

The importance of proper foot care self-management has been well documented in the literature. Daily foot inspection, maintaining foot hygiene, supportive shoe gear, and refraining from walking barefoot are some examples of good foot care self-management [21]. Gaining education via a VW self-management program may allow a patient to better manage their foot care by learning proper self-care behaviors and reduce the likelihood of foot ulcers and amputations. VW education has been shown useful in chronic disease self-management studies and noted to promote improved behavior change via participant experience [22].

## CONCLUSION

This pilot study will be examined further in a larger robust randomized controlled trial if this study is determined to be feasible in subjects with diabetes. If deemed feasible, the data from this study may be applicable for self-management education for other chronic diseases.

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