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Skin Self-Screening Camera for Veterans with Spinal Cord Injury

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1 Background

Veterans with spinal cord injury (SCI) are at high risk for developing debilitating pressure injuries, particularly to their seated areas (e.g. coccyx, sacral and gluteal) [1]. To prevent development of a pressure injury the Veteran with SCI is encouraged to invoke multiple prevention strategies [2]. One recommended prevention strategy is to conduct twice daily skin self-screenings. Skin self-screening is usually conducted in the bed, prior to arising in the morning and prior to sleep in the evening. The current method to conduct skin self-screening utilizes a mirror at the end of a long handle. The Veteran with SCI examines at-risk areas for changes in their skin integrity such as discoloration, swelling, or changes in skin texture. This method can take up to 20 minutes to complete. In the event there is a change to skin integrity, the pressure injury prevention protocol advises the Veteran with SCI to off-load that particular area for at least 24 hours [3]. Further, he/she is advised to consult with their skin specialist if the area does not resolve to normal color or texture within that next 24 hour period. The consequences of ignoring an early stage pressure injury can be serious e.g. weeks to months of hospitalization attempting to heal the injury, tens to hundreds of thousands of dollars in healthcare costs, possible surgery to close the wound and possibly death [4].

Informal interviews with Veterans with SCI clarified and validated that conducting skin screening with the mirror could be very challenging due to barriers such as: not having a baseline image to compare to; the mirror image not being viewable to the user due to lack of user flexibility or body habitus; the mirror does not easily allow a complete view of all the at-risk areas; the user not being able to discern what he/she is actually viewing possibly due to mirror image distortion and limited visual acuity.

The need for a better skin self-screening device was evidenced by the advanced pressure injuries Veterans presented to their healthcare providers. Finding a pressure injury in the early stages of development and intervening immediately, such as repositioning, can improve the trajectory of the injury [5]. Therefore the project goal was to offer a better tool for and improve the efficacy of skin self-screening for the Veterans with SCI. To overcome the identified barriers, our team of VA clinicians and engineers of the Minneapolis Adaptive Design & Engineering (MADE) program invented such a device at the Minneapolis VA. This paper presents the patient centered iterative process that was used to develop a skin self-screening device and the future directions for this technology.

2 Methods

The initial prototype of the skin self-screening device design was a web-camera attached to the end of a flexible mirror stick (Figure 1). The web-camera image was viewed on a laptop computer. Feedback from Veterans with SCI and clinicians validated this idea of a camera being separated from the viewing monitor. Initial testing of the device identified the web-cam technology was not capable of providing high quality images from a practical distance. Therefore, this initial prototype was only slightly better than using a mirror in that the user was unable to obtain a focused picture of their entire seated region, let alone give perspective as to size or progression of a skin integrity issue. We also learned that the mirror stick (metal) was prone to breaking after numerous manipulations i.e. material fatigue.


Figure 1: Initial prototype: Web-cam connected to the mirror stick.

Based on user feedback of the first design iteration the MADE team was able to identify the design changes needed to achieve an efficacious skin self-screening device. The following paragraphs describe identified design requirements and our approach to meet each requirement:

Distance
The skin self-screening device needed a camera capable of capturing a large area e.g. a person's entire backside. To get the camera to the backside of the body the stick needed to be capable of the extending the needed distance. A telescoping stick, like a selfie-stick, was determined to fill this specification as it extends out 95 cm (Figure 2).

Relativeness
The device user would like to know the relative size of a skin issue, e.g. whether the red spot on the ischial tuberosity the size of a dime or a quarter. A high resolution wide-angle lens is capable of capturing an image of the entire backside area, giving perspective (relative size) of a pressure injury. We tested several wide angle lenses and chose a 100-degree angle camera lens.

Weight and Stability
The initial prototype used a web-cam at the end of a stick, which was heavy enough to cause "wobble" when the stick was fully extended. To address this issue, the new wide-angle lightweight lens was encased in a small, lightweight custom designed box. The total weight of the camera lens, stick and handle is 178 grams.

Flexibility
Veterans and clinicians agreed that the end of the stick, where the camera lens is located, needed flexibility to get around the body shape to view the back side. We chose to add a gooseneck to meet this specification (Figure 2).


Figure 2: Telescoping stick and gooseneck at the end provide the distance and flexibility needed to view the body's backside

Image Quality
Image quality testing was conducted using cameras with several different angled high-resolution lens options (80-, 100- and 120-degree angles). The 100-degree angle camera lens was determined to best capture an image with limited distortion.

Interface
The initial design interfaced with a laptop computer. Veterans found the idea of a computer in bed for viewing their backside to be somewhat clumsy. We therefore moved to using a smart phone or tablet, with on-the-go interface.

Image Size
Once an image is obtained on the screen of the smart phone/tablet, the user wanted to have capability to conduct a closer examination of the area of concern. The zoom function of most smart phones and tablets will provide this capability (Figure 3).


Figure 3: Zoom function for better visualization.

Communication
Veterans with SCI and clinicians agreed they would like the device to be capable of sending an image of the concerned area to their health care provider at the VA. We have established that the VA's secure messaging system called MyHealth*e*Vet, offers the capability for the Veteran to send three (3 MB each) attachments with each message to their health care provider.

Portability
Veterans with SCI wanted the device to be easily portable. They agreed that the idea of a collapsible stick would make the device small enough for transport (24 cm in length) thus using a collapsible selfie-stick met that specification (Figure 4).

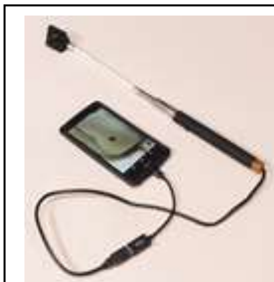
Figure 4: Collapsibility of telescoping stick for portability and storage.

Durability
The initial device used a long-handled mirror, which after multiple manipulations cracked and broke. The changes made to the design using the selfie-stick with a flexible gooseneck will prevent the need for "bending" the handle.

3 Clinical Interpretation and Future Goals

The current skin self-screening device evolved from a need to help Veterans with SCI conduct their twice daily skin screenings for pressure injury. The early design concept [of using a web-camera to view skin integrity of the seated area] took on new life when mobile devices and camera technologies became more advanced and less expensive. With these added device capabilities, persons with limiting dexterity, neck rotation and shoulder mobility, or persons with a larger girth, will be able to view their seated areas with greater accuracy and efficiency.

Further design goals are to incorporate lighting into the skin self-screening device and provide the capability of voice commands. We will also address the issues of multiple cleanings and general wear and tear of the device.

Next, our MADE team plans to test the device by sending the camera home with Veterans with SCI. We will determine if any modifications are needed to the design is needed, and overcome any barriers that exist for communication with the skin specialist.

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