**Supplemental Information**

Detailed information regarding Methods and Outcome Measures follow:

Recruitment: Patients were identified by their primary care provider (PCP) at the Minneapolis VA Health Care System (MVAHCS) Spinal Cord Injury and Disorders (SCI/D) Center as potential participants. The study coordinator then mailed the approved letter to the interested patient and followed up the next one to two weeks with a more complete informational phone call. The Institution Review Board (IRB) also approved presentation of the study at a Paralyzed Veterans of America (PVA) Minnesota Chapter meeting. Stratified sampling during recruitment was employed to obtain a balance of manual and power wheelchair users, to ensure user dexterity and pressure relief technique variation was accommodated during app development.

Phase 1: Veterans with spinal cord injury (SCI) were recruited to participate in two different focus groups, held at the MVAHCS SCI/D Center. Inclusion criteria for Phase 1 were that the Veteran be between 18 and 80 years old, have a C-4 or below SCI, be free of active pressure injury on their seated area, and ability to verbally communicate.

Phase 2: Veterans with SCI were recruited to test the redesigned Comprehensive Mobile Assessment of Pressure (CMAP) system in their home environments for six weeks. Inclusion criteria for Phase 2 were that the Veteran be aged 18-80 years, have a C4 or below SCI, be a wheelchair user, able to demonstrate independent access to the mobile app using a smartphone. Further the participant would need to tolerate sitting in their wheelchair for a minimum of 6 hours per day, 7 days per week and perform their pressure relief maneuvers independently. The participant needed to live in an area with cellular phone coverage and have successful phone connectivity with the pressure map and server within their home environment. Anyone with an active pressure injury on their seated area at the start of the in-home testing was excluded as well as anyone who had a behavior flag in their medical record, for the safety of study staff during home visits.

Formative Focus Groups: (Phase 1a) For the initial focus group, Veterans with SCI (n=12) who met inclusion criteria were consented into the study and then shown an orientation video, which reviewed the purpose of the study. Under the guidance of the qualitative researcher, participants were then introduced to the CMAP prototype system. They were not permitted to sit on the pressure mat or use the existing CMAP app, but were provided the opportunity to see and touch the existing system. Participants then viewed a PowerPoint presentation with potential redesign options and watched as study personnel used the CMAP system to demonstrate its functionality. The qualitative researcher then conducted the focus group according to the semi-structured moderator guide developed by the research team, prompting discussion among the participants (Table 1). The sessions were recorded, transcribed and summarized to guide the app designers towards a user-friendly product.

Usability Study Interviews and Focus Groups: (Phase 1b) Several months later, with the completion of the initial app redesign, the same formative focus group participants returned to the study site to test usability of the improved CMAP system. The Occupational Therapist/Assistive Technology (OT/AT) Specialist (T.V.D.) demonstrated to the participant the app set-up and features, after which the participant gave a return demonstration using the technologies. The interaction between the OT/AT and the participant was observed and documented by the qualitative researcher and the nurse scientist (C.O.). Observational data of hand written notes and voice recordings were immediately collated and reviewed and used by the study team (J.E.+C.O.) to inform and guide the discussion during a summative focus group where the day’s participants could reflect on their experience and make any last recommendations for the final app re-design before the field-based study. See Figure 4: Guide for observation, usability and follow-up interviews

Field Use Feasibility Interviews: (Phase 2) A field-based study was conducted to test the feasibility of personal use of the redesigned CMAP system in the home and community environments. Prior to initiation of this phase, the study team developed a users’ manual to accompany the CMAP system while used in the home environment and an interview guide, to collect user thoughts at the end of the in-home trial to share salient feedback with the design engineers. Four home visits, over a six-week period, were scheduled with each Veteran (n=6). At the first home visit, a full description of the study was reviewed with the Veteran prior to obtaining consent. The study nurse and therapist then visually inspected the skin of the participant’s seated area to ensure there were no areas of concern and which would need to be resolved before continuing. Then the participant’s wheelchair seat was mapped with a high resolution XSENSOR® X3 system (XSENSOR Technology Corporation), consistent with system used in Minneapolis VA seating and mobility assessments, to assess the participant’s seat interface pressure, to identify potential issues that could possibly cause increased pressure to the participant’s seated area. An Actigraph (https://actigraphcorp.com/support/activity-monitors/; Model GT3X) connected to an elastic strap was then placed on the participant’s upper chest, with the Actigraph at the center of the chest to measure body movement. Instructions about the Actigraph were reviewed, along with a daily log, for the participant to note times of day it was donned and doffed. During the second home visit, a skin assessment of the seated area was conducted first. Then the CMAP mat (BodiTrack Seat System) was installed on the participants’ wheelchair seat and was given a mobile device (iPhone 6s) equipped with the CMAP app. An introduction to the CMAP System by the Occupational Therapist/Assistive Technology Specialist was given to the participant, with time allotted for questions. Users self-select the timing and method for delivery of reminders to shift weight. Selection options for frequency of reminders ranges from 5 to 60 minutes and the duration of weight shift indicator ranges from 30 seconds to 5 minutes. These values are based on several guidelines2-6 with understanding that there is little evidence to support the guidelines7 and also given recent evidence showing that wheelchair users perform pressure reliefs sporadically and much less frequent that indicated in the guidelines.8 The paper based user manual was reviewed by the study nurse, again allowing time for questions. The study team also reviewed the participant’s Actigraph usage and checked the log to ensure the participant was noting if wearing it daily. The Actigraph was exchanged, during this visit, for one with a charged battery. The primary purpose of the third home visit was to conduct a semi-structured interview (J.E.) to document the participant’s experience using the CMAP system and user manual in their home environment. The qualitative researcher recorded the interview, which was then coded, categorized and summarized (J.E. and C.O.) to inform the research and design team, using the framework approach.1 Another purpose of the third visit was to retrieve the CMAP System from the participant’s wheelchair thus ending their four-week experience using the system. The participant also completed two usability surveys, the System Usability Scale (SUS) and the User Experience Questionnaire (UEQ). A skin assessment of the participant’s seated area was conducted by the study nurse (C.O. and T.V.D.) to ensure there were no areas of concern. The mobile device became the participant’s personal property at the conclusion of the study, complying with the VA policy for protection of health information. The Actigraph was again exchanged to ensure there was enough battery to support capturing participant daily activity during the final week of the study. The fourth home visit consisted of the study nurse and therapist retrieving the Actigraph, conducting a final skin assessment of the seated area, for any possible residual issues, and capturing any other thoughts the participant may want to share. Other data collected throughout the six-week in-home trial were the information collected during the scheduled weekly phone calls from the study nurse to the participant, to specifically address barriers to success with the CMAP system, any skin concerns, and address any questions or concerns the participant may have about the CMAP system. Participants were encouraged to call the study nurse anytime if they were having troubles with the CMAP system or other concerns.

*Added information about the Outcome Measures*

System Usability Scale (SUS): An example statement in the SUS is: “I think that I would like to use this product frequently.” Scores are converted to a total score ranging from 0 (least positive) to 100 (most positive) using manufacturer instructions. Total scores convert to percentiles. For example, a total score of 68 converts to the 50th percentile, considered average for this usability scale. The interpretation is similar to grading on a curve. To score in the 90th percentile, a minimum score of 80.3 is required. The SUS has strong reliability (even in small samples), validity and is widely used internationally. Because there is only a modest correlation with actual task performance, we will combine the information from this assessment with qualitative and observational data for a richer analysis.

User Experience Questionnaire (UEQ): The UEQ was designed to measure a user’s comprehensive impression of user experience quickly by soliciting immediate expression of feelings, impressions, or attitudes experienced when using the system being evaluated. Examples of word pairs include “usual vs leading edge” and “complicated vs easy”. Users select a number from 1 to 7 between the two words to indicate which resonates most closely with their experience. Scores are converted and compared against benchmarking scores from over 240 studies. Validity and reliability for the UEQ were reported as satisfactory through comparison with task completion time and with an existing similar measure of user experience. While the UEQ can be used to compare products, the purpose in this study was to evaluate if the CMAP system had sufficient user experience following iterative development as well as to determine next steps for improvement.

Trouble Shooting Notes: Notes were collected by the study nurse during the weekly “trouble shooting” phone calls with participants in Phase 2. These data supplemented the interviews and assisted designers to learn the weaknesses in the system.

*Other measures (results not included in this paper):*

Actigraphy: The chest strap Actigraph (https://actigraphcorp.com/support/activity-monitors/; Model GT3X) measured the three-dimensional movements of the CMAP user during waking hours during the 6-week home environment testing (Phase 2). These data would inform the researchers of movement-related behavior changes occurring over the testing period.

Participant Log: A supportive log in which the participant documented time of donning and doffing the Actigraph.

Mobile Application Usage: Each participant in Phase 2 (in home environment) used a production-level mobile app developed based on requirements provided by the research team following focus groups in Phase 1 (Area 10 Labs, Inc, Rochester, MN). Within that app, user-uploaded seating pressure measures from the CMAP system and count of how many times the user accessed various features of the CMAP app are stored. These data will be reported in another paper.

**References**

1. Krueger RA, Casey MA. Focus groups: a practical guide for applied research. Sage publications; Singapore.; 2014 Jul 22.

2. National Pressure Ulcer Advisory Panel. Prevention and Treatment of Pressure Ulcers: Quick Reference Guide. Cambridge Media: Perth, Australia; 2014.

3. Houghton PE, Campbell KE. Canadian best practice guidelines for the prevention and management of pressure ulcers in people with spinal cord injury. A resource handbook for clinicians. 2013 [Available from: http://www.onf.org].

4. Mayo Clinic. Mayo Clinic Guide to Living with a Spinal Cord Injury. New York, New York: Demos Medical Publishing; 2009.

5. Makhsous M, Priebe M, Bankard J, Rowles D, Zeigler M, Chen D, et al. Measuring tissue perfusion during pressure relief maneuvers: Insights into preventing pressure ulcers. J Spinal Cord Med 2007;30(5):497-507.

6. Coggrave MJ, Rose LS. A specialist seating assessment clinic: changing pressure relief practice. Spinal Cord 2003;41(12):692-5.

7. Groah SL, Schladen, M., Pineda, CG, Hsieh, CJ Prevention of pressure ulcers among people with spinal cord injury: A systematic review. PM&R 2015;7(6):613-36.

8. Sonenblum SE, Sprigle S, Martin JS. Everyday sitting behavior of full time wheelchair users. J Rehabil Res Dev 2016;53(5):585-98.