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TITLE: Assistive Technology and Functional Outcomes Following Spinal Cord Injury

PRINCIPAL INVESTIGATOR: Kimberley Monden, PhD

CONTRACTING ORGANIZATION: Craig Hospital

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5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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8. PERFORMING ORGANIZATION REPORT NUMBER

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14. ABSTRACT

The activities accomplished in Year 1 include obtaining IRB and HRPO approval, establishing team-meeting teleconferences, and identifying and recruiting participants. We have also trained also study staff in qualitative procedures and each site has conducted one mock focus group. Study start-up was delayed by HRPO approval, which was not granted until August 2019. Recruitment began immediately following HRPO approval and the first focus groups is scheduled for November 7th. We are on track to complete four focus groups by the end of the calendar year.

15. SUBJECT TERMS
Spinal cord injury, assistive technology, qualitative, barriers, facilitators

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			USAMRMC
Unclassified	Unclassified	Unclassified	Unclassified	17	19b. TELEPHONE NUMBER *(include area code)*

TABLE OF CONTENTS

1. **INTRODUCTION:** *Narrative that briefly (one paragraph) describes the subject, purpose and scope of the research.*

Assistive technology (AT) for individuals with SCI, specifically computer and smartphone equipment and the hardware and software devices that make these more usable, is routinely prescribed in multidisciplinary rehabilitation programs and its use has been well documented in the literature. However, evidence regarding the impact of AT on functional (e.g., employment, social participation) and/or psychosocial (e.g., self-efficacy, quality of life) outcomes after tetraplegia is limited. The primary goals of this study are to (1) qualitatively examine barriers and facilitators to AT access and utilization after tetraplegia, (2) assess for variation of AT use across insurance providers, (2) assess the relationship between AT use and productivity, and (3) assess the relationship between AT use and psychosocial outcomes to inform clinical practice, inform future policy, and influence reimbursement standards for AT.

2. **KEYWORDS:** *Provide a brief list of keywords (limit to 20 words).*

spinal cord injury, assistive technology, qualitative, barriers, facilitators

3. **ACCOMPLISHMENTS:** *The PI is reminded that the recipient organization is required to obtain prior written approval from the awarding agency grants official whenever there are significant changes in the project or its direction.*

What were the major goals of the project?

Major Task 1: Obtain IRB and HRPO approval, establish team meeting teleconferences.

- Craig Hospital received IRB approval on 9/14/2018, which was before the target date of 10/31/18.
- LSCVAMC received IRB approval on 2/14/2019, which was two months behind the target date of 12/30/18.
- HRPO approval was anticipated by the end of March 2019, but was not received until 8/14/19.
- All research staff were hired by the target date of December 2018.

Major Task 2: **Conduct focus groups/interviews.**

- Focus group participants have been identified from hospital databases and invitations have been mailed. These activities took place in September and October 2019, which is approximately one month behind the projected timeline.
- Focus group training is complete at both sites, which have conducted mock groups for practice and mock group activities have been reviewed by the PIs (Monden & Charlifue) lead site (Craig).
- Focus group recruitment at both sites is on-going. First focus group at Craig scheduled for November 15, 2019 and first group in Cleveland scheduled for November 7, 2019.
- We expect to have 4/6 focus groups completed by the end of December 2019. It originally was projected that all six focus groups would be complete by the end of December.

Major Task 3: Analyze qualitative data.

- Data analysis is pending completion of first focus groups and will take place from November 2019 through January 2020. This is on target with the projected timeline.

What was accomplished under these goals?
For this reporting period describe: 1) major activities; 2) specific objectives; 3) significant results or key outcomes, including major findings, developments, or conclusions (both positive and negative); and/or 4) other achievements. Include a discussion of stated goals not met. Description shall include pertinent data and graphs in sufficient detail to explain any significant results achieved. A succinct description of the methodology used shall be provided. As the project progresses to completion, the emphasis in reporting in this section should shift from reporting activities to reporting accomplishments.

Major activities for this reporting period include:

- Establishment of biweekly local team meetings and monthly full team conference calls
- IRB approvals (Craig: September 2018, LSCVAMC: January 2019)
- HRPO approvals (August 2019).
- Commencement of study recruitment.
- Training of staff complete via conducting mock focus groups at both sites.
- Scheduling of the first focus groups at each site.

Data have not been collected and therefore not analyzed. We have no significant results to report at this time.

What opportunities for training and professional development has the project provided?
If the project was not intended to provide training and professional development opportunities or there is nothing significant to report during this reporting period, state "Nothing to Report."

Nothing to report.

How were the results disseminated to communities of interest?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Nothing to report.

What do you plan to do during the next reporting period to accomplish the goals?
If this is the final report, state "Nothing to Report."

Focus groups will all be completed (2-3 per site with 5-7 participants per site); audio recordings of focus group sessions will be transcribed, exported to NVivo 11 and qualitative analyses will be completed; manuscript describing barriers and facilitators to AT access and use will be prepared and themes for the quantitative study will be identified from focus group content. Any necessary IRB amendments and HRPO approvals for the quantitative study will be obtained. Quantitative interviews will be started (150 per site). Once the quantitative study questionnaires are finalized, a database will be created. Quantitative data will be entered into study database as it is collected.

4. IMPACT: D*escribe distinctive contributions, major accomplishments, innovations, successes, or any change in practice or behavior that has come about as a result of the project relative to:*

What was the impact on the development of the principal discipline(s) of the project?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe how findings, results, techniques that were developed or extended, or other products from the project made an impact or are likely to make an impact on the base of knowledge, theory, and research in the principal disciplinary field(s) of the project. Summarize using language that an intelligent lay audience can understand (Scientific American style).

Nothing to report.

What was the impact on other disciplines?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe how the findings, results, or techniques that were developed or improved, or other products from the project made an impact or are likely to make an impact on other disciplines.

Nothing to report.

What was the impact on technology transfer?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe ways in which the project made an impact, or is likely to make an impact, on commercial technology or public use, including:

- *transfer of results to entities in government or industry;*
- *instances where the research has led to the initiation of a start-up company; or*
- *adoption of new practices.*

Nothing to report.

What was the impact on society beyond science and technology?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe how results from the project made an impact, or are likely to make an impact, beyond the bounds of science, engineering, and the academic world on areas such as:

- *improving public knowledge, attitudes, skills, and abilities;*
- *changing behavior, practices, decision making, policies (including regulatory policies), or social actions; or*
- *improving social, economic, civic, or environmental conditions.*

Nothing to report.

5. CHANGES/PROBLEMS: *The PD/PI is reminded that the recipient organization is required to obtain prior written approval from the awarding agency grants official whenever there are significant changes in the project or its direction. If not previously reported in writing, provide the following additional information or state, "Nothing to Report," if applicable:*

Changes in approach and reasons for change
Describe any changes in approach during the reporting period and reasons for these changes. Remember that significant changes in objectives and scope require prior approval of the agency.

Nothing to report.

Actual or anticipated problems or delays and actions or plans to resolve them
Describe problems or delays encountered during the reporting period and actions or plans to resolve them.

As mentioned above, delays in HRPO approval resulted in delay in ability to begin recruitment for focus groups. Nonetheless, we anticipate completing focus groups as close to the proposed study timeline as possible.

Changes that had a significant impact on expenditures
Describe changes during the reporting period that may have had a significant impact on expenditures, for example, delays in hiring staff or favorable developments that enable meeting objectives at less cost than anticipated.

Dr. Morse left her position at Craig Hospital. Dr. Jeffrey Berliner has replaced Dr. Morse on the project; however, while we were waiting for approval, none of Dr. Berliner's time was charged. Therefore, we have not paid out the anticipated amount in salaries. Now that we have approval, the amount will be paid out with carry over funds.

Delays in receiving IRB/HRPO approvals also means we have not yet conducted a focus group. Therefore, no payments to participants have been made.

Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents
Describe significant deviations, unexpected outcomes, or changes in approved protocols for the use or care of human subjects, vertebrate animals, biohazards, and/or select agents during the reporting period. If required, were these changes approved by the applicable institution committee (or equivalent) and reported to the agency? Also specify the applicable Institutional Review Board/Institutional Animal Care and Use Committee approval dates.

Significant changes in use or care of human subjects

Nothing to report.

Significant changes in use or care of vertebrate animals

Nothing to report.

Nothing to report.

Significant changes in use of biohazards and/or select agents

6. PRODUCTS: *List any products resulting from the project during the reporting period. If there is nothing to report under a particular item, state "Nothing to Report."*

- **Publications, conference papers, and presentations**
  Report only the major publication(s) resulting from the work under this award.

Journal publications. *List peer-reviewed articles or papers appearing in scientific, technical, or professional journals. Identify for each publication: Author(s); title; journal; volume: year; page numbers; status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).*

Monden, K.R., Sevigny, M., Ketchum, J.K., Charlifue, S., Severe, E., Tefertiller, C., Berliner, J., Coker, J., Taylor, H.B., Kolakowsky-Hayner, S.A., & Morse, L.R. (2019). Associations between insurance provider and assistive technology use for computer and electronic devices one year after tetraplegia: Findings from the Spinal Cord Injury Model Systems National Database. *Archives of Physical Medicine & Rehabilitation.* [Epub ahead of print]. PMID: 31351077

- Federal support was acknowledged.

(*article attached in Appendices*)

Books or other non-periodical, one-time publications. *Report any book, monograph, dissertation, abstract, or the like published as or in a separate publication, rather than a periodical or series. Include any significant publication in the proceedings of a one-time conference or in the report of a one-time study, commission, or the like. Identify for each one-time publication: author(s); title; editor; title of collection, if applicable; bibliographic information; year; type of publication (e.g., book, thesis or dissertation); status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).*

Nothing to report.

Other publications, conference papers and presentations. *Identify any other publications, conference papers and/or presentations not reported above. Specify the status of the publication as noted above. List presentations made during the last year (international, national, local societies, military meetings, etc.). Use an asterisk (*) if presentation produced a manuscript.*

*Monden, K.R., Sevigny, M., Charlifue, S., Coker, J., Severe, E., Berliner, J., Taylor, H., & Morse, L. (2019, April). *Associations between insurance provider and assistive technology use one year after tetraplegia spinal cord injury: findings from the Spinal Cord Injury Model Systems National Database*. Presented at the 2019 SCI Summit of the American Spinal Injury Association (ASIA). Honolulu, HI.

- **Website(s) or other Internet site(s)**

Nothing to report.

- **Technologies or techniques**

Nothing to report.

- **Inventions, patent applications, and/or licenses**

Nothing to report.

- **Other Products**

Identify any other reportable outcomes that were developed under this project. Reportable outcomes are defined as a research result that is or relates to a product, scientific advance, or research tool that makes a meaningful contribution toward the understanding, prevention, diagnosis, prognosis, treatment and /or rehabilitation of a disease, injury or condition, or to improve the quality of life. Examples include:

- *data or databases;*
- *physical collections;*
- *audio or video products;*
- *software;*
- *models;*
- *educational aids or curricula;*
- *instruments or equipment;*
- *research material (e.g., Germplasm; cell lines, DNA probes, animal models);*
- *clinical interventions;*
- *new business creation; and*
- *other.*

Nothing to report.

7. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

What individuals have worked on the project?

Provide the following information for: (1) PDs/PIs; and (2) each person who has worked at least one person month per year on the project during the reporting period, regardless of the source of compensation (a person month equals approximately 160 hours of effort). If information is unchanged from a previous submission, provide the name only and indicate "no change".

Name:	Kimberley Monden, PhD
Project Role:	Co-PI
Researcher Identifier:	https://orcid.org/0000-0002-5207-0452
Nearest person-month worked:	2.29
Contribution to Project:	No change
Name:	Susan Charlifue, PhD
Project Role:	Co-PI
Researcher Identifier:	https://orcid.org/0000-0001-6032-1154
Nearest person-month worked:	1.10
Contribution to Project:	No change
Name:	Jennifer Coker, MPH
Project Role:	Study Coordinator
Researcher Identifier:	https://orcid.org/0000-0003-0760-7449
Nearest person-month worked:	1.80
Contribution to Project:	No change
Name:	Martin Kilbane, PT, DPT, OCS
Project Role:	Site PI
Researcher Identifier:	
Nearest person-month worked:	1.25
Contribution to Project:	No change
Name:	Emily Johnson
Project Role:	Research Assistant
Researcher Identifier:	
Nearest person-month worked:	1.25
Contribution to Project:	No change
Name:	Abigail Welch
Project Role:	Research Assistant
Researcher Identifier:	
Nearest person-month worked:	1.20
Contribution to Project:	No change
Name:	Bria MacIntyre
Project Role:	Research Assistant
Researcher Identifier:	
Nearest person-month worked:	1.15
Contribution to Project:	No change

Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Kimberley Monden (Co-PI, Craig Hospital):

- Grant from the American Psychological Foundation, "Stigma following Spinal Cord Injury and its impact on Psychosocial Outcomes" has closed. 0.02 FTE.
- Grant from the Knoebel Center for the Study of Aging, "Aging and Glutathione Antioxidant Status as Major Determinants of Injury and Recovery from Traumatic Injury" has closed. 0.02 FTE.
- Grant from PCORI, "Comparative Effectiveness of Sleep Apnea Assessment Strategies to Maximize TBI Rehabilitation Outcomes (C-SAS)" has closed. 0.07 FTE.
- Grant awarded from the New Jersey Commission of Spinal Cord Research, "Development and Validation of an Abbreviated Cognitive Screening Battery for Individuals with SCI." Role: Site PI. 0.05 FTE.
- Grant awarded from the Craig H. Neilsen Foundation, "Biofeedback for Treatment of Anxiety Associated with Chronic Spinal Cord Injury." Role: PI 0.10 FTE
- Grant awarded from the Craig Hl Neilsen Foundation, "Craig Caregiver Assessment of Rewards and Effort (C^2ARE). Role: Co-I 0.50 FTE

Susan Charlifue (Co-PI, Craig Hospital)

- Grant awarded from the Craig Hl Neilsen Foundation, "Craig Caregiver Assessment of Rewards and Effort (C^2ARE). Role: PI. 0.50 FTE

Martin Kilbane (Site PI, LSCVAMC)

- Grant awarded from the Craig Hl Neilsen Foundation, "Craig Caregiver Assessment of Rewards and Effort (C^2ARE). Role: Site PI

What other organizations were involved as partners?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Organization Name:	Louis Stokes Cleveland VAMC
Location of Organization:	Cleveland, OH
Partner's contribution to the project:	Collaboration

8. SPECIAL REPORTING REQUIREMENTS

QUAD CHART: Follows

Assistive Technology and Functional Outcomes Following Spinal Cord Injury

Log Number: SC170159

Award Number: W81XWH-81-1-0806

PI: Kimberley Monden, PhD **Org:** Craig Hospital **Award Amount:** $638,083

Study/Product Aim(s)

Aim 1 (Qualitative): To examine perceived barriers to or facilitators of AT access and utilization and the impact on functional and psychosocial outcomes after tetraplegia.

Aim 2 (Quantitative): To assess for variations in use of AT among individuals with tetraplegia across insurance providers and socioeconomic status in veterans and civilians with tetraplegia.

Aim 3a (Quantitative): To assess the relationship between AT use and productivity (employment/school) in veterans and civilians with tetraplegia.

Aim 3b (Quantitative): To assess the relationship between AT and psychosocial outcomes (e.g., mood, self-efficacy) in Veterans and civilians with tetraplegia.

Approach

Mixed methods design with qualitative focus group interviews and quantitative surveys conducted at two study sites (civilian and veteran).

Timeline and Cost

Activities FY	18-19	19-20	20-21
IRB, identify subjects, conduct focus groups			
Analyze qualitative data and conduct quantitative data collection			
Analyze quantitative data and prepare manuscript/presentations			
Estimated Budget ($K)	**$200,764**	**$213,366**	**$223,955**

Accomplishment: IRB and HRPO approval has been obtained for both sites, Craig Hospital and LSCVAMC. Participants are being recruited and screened; focus groups are anticipated to begin in Nov 2019. Team meetings continue to be held biweekly/monthly.

Goals/Milestones

FY18-19 Goal – Conduct focus groups

✓ Obtain IRB/HRPO approval at both study sites

☐ Conduct focus groups

FY19-20 Goals – Qualitative analysis and quantitative data collection

☐Analyze qualitative data and develop additional survey items

☐Conduct quantitative data collection

FY20-21 Goal – Analysis and reporting

☐ Analyze quantitative data and prepare reports/presentations

☐ Develop plans/proposals for future investigations of AT use for veterans and civilians with SCI

Comments/Challenges/Issues/Concerns

- Timeliness of IRB and HRPO approvals has been an issue

Budget Expenditure to Date

Projected Expenditure: $200,764

Actual Expenditure: $142,262

9. APPENDICES

A copy of our published article is attached as an appendix.

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Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2019;■:■■■-■■■

ORIGINAL RESEARCH

Associations Between Insurance Provider and Assistive Technology Use for Computer and Electronic Devices 1 Year After Tetraplegia: Findings From the Spinal Cord Injury Model Systems National Database

Kimberley R. Monden, PhD,[a,b] Mitch Sevigny, MS,[a] Jessica M. Ketchum, PhD,[a] Susan Charlifue, PhD,[a,b] Ellen Severe, OTRL,[a] Candy Tefertiller, DPT,[a] Jeff Berliner, DO,[a] Jennifer Coker, MPH,[a] Heather B. Taylor, PhD,[c] Stephanie A. Kolakowsky-Hayner, PhD,[d] Leslie R. Morse, DO[a,b]

From the [a]Rocky Mountain Regional Spinal Injury System, Craig Hospital, Englewood, Colorado; [b]Department of Physical Medicine and Rehabilitation, University of Colorado School of Medicine, Aurora, Colorado; [c]Spinal Cord Injury and Disability Research, TIRR Memorial Hermann, Houston, Texas; and [d]Department of Rehabilitation and Human Performance, Icahn School of Medicine at Mount Sinai, New York, New York.

Abstract

Objective: To investigate the association between insurance provider and reported assistive technology (AT) use to access computers and electronic devices 1 year after sustaining tetraplegia.

Design: Multicenter cross-sectional study.

Setting: Participants enrolled in the Spinal Cord Injury Model Systems (SCIMS) National Database.

Interventions: Not applicable.

Participants: Men and women with tetraplegia (N=498) enrolled in the SCIMS National Database were included in the analysis.

Main Outcome Measures: The primary study outcome was the use of AT when operating a computer or other mobile electronic device. The primary predictor was the subject's principal health insurance provider, which was grouped into the 3 categories: government (Medicare, Medicaid, and other government), private (private insurance, private funds, and other), and workers' compensation.

Results: Overall, 34.7% of participants reported using AT to access computers and electronic devices. Results of logistic regression analysis revealed sex, injury level, injury completeness, self-perceived health status, and 12-month history of pressure ulcer were all significantly associated with AT use. After adjusting for these factors, participants with workers' compensation were more likely to report AT use than individuals with either government or private insurance.

Conclusions: Despite significant technological advances, AT is not readily available to the people who might benefit most from its use. Findings from the present study are the first to shed light on AT funding sources and reveal that individuals with workers' compensation are more likely use AT than individuals with either government or private insurance. Additional work focused on AT use and functional outcomes is needed to assess the effect of barriers to use. Collectively, this work may inform insurers of the importance of having AT available for this unique population to potentially improve quality of life and participation.

Archives of Physical Medicine and Rehabilitation 2019;■:■■■-■■■

Presented to the American Spinal Injury Association, April 2-5, 2019, Honolulu, HI.

Supported by the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR 90SI5007, 90SI5015-01-00, 90SI5017, 90SI5027) and the Office of the Assistant Secretary of Defense for Health Affairs endorsed by the Department of Defense through the Spinal Cord Injury Research Program Qualitative Research Award (award no. W81XWH-18-1-0806). The U.S. Army Medical Research Acquisition Activity, 820 Chandler Street, Fort Detrick, MD 21702-5014, is the awarding and administering acquisition office. Opinions, interpretations, conclusions, and recommendations are those of the authors and are not necessarily endorsed by the Department of Defense.

Disclosures: none.

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Numerous assistive technology (AT) systems have been developed to enable individuals with physical disabilities the opportunity to use computers, including devices or programs such as voice recognition software, sip-and-puff devices, mouth sticks, head devices, adapted mouse controls, and specialized wrist or arm devices. Despite significant technological advances, AT is not readily available to the people who might benefit most from its use. It was recently reported that among individuals with spinal cord injury (SCI), AT use is considered an essential means to participation, autonomy, and inclusion. However, the availability, funding, and high cost of AT are important determinants limiting the purchase or repair of such devices. In a survey designed to assess the use of personal computers, along with other areas of AT for those with intellectual disability, the most cited reason for lack of use was funding.[1] Although people with disabilities stand to gain the most from new technologies, they have among the lowest use rates with 75% requiring some type of accommodation to improve their productivity. However, substantial coverage for such items is often not available through insurance, federal or state programs, or personal resources.[2] While published data on insurance funding rates of AT devices are not available, Center for Assistive Technology Act Data Assistance indicates there were $7,867,423 in state financial loans issued across the United States in 2018, resulting in the acquisition of only 4859 devices nationally.[3] Even if funding is available, many individuals with disabilities, their family members, and some rehabilitation providers are not aware of the availability and benefits of AT devices. For individuals to have access to AT, rehabilitation providers must have the requisite knowledge and skills to evaluate individual needs, make appropriate AT recommendations, and advocate for their patients by writing letters of necessity justifying insurance funding for AT devices.

While there is limited information on the use of AT after SCI, the national SCI Model System (SCIMS) database began collecting information on technology use to access computers or electronic devices in April 2011. Six percent of the US population with a new SCI are enrolled in this database, making it the largest in the United States. Although funding has been identified as a major barrier to AT use after SCI, there is no information on which providers are more likely to provide funding. Therefore, this study sought to assess the association between insurance provider and use of AT to use computers or similar electronic devices in individuals with tetraplegia. We hypothesized that significant variations would exist in funding for AT use based on provider.

Methods

Participants

Participants were selected for this analysis from the SCIMS National Database[4]; the study was funded through the National Institute on Disability, Independent Living, and Rehabilitation Research and incorporates longitudinal data from 29 institutions. Institutional Review Board approval for studies using the SCIMS National Database was obtained by each of the SCIMS centers participating in this study. Participants were eligible for inclusion in the SCIMS National Database if they had a SCI due to an external traumatic event resulting in temporary or permanent loss of sensory or motor function, were admitted to a SCIMS acute or rehabilitation hospital within 1 year after injury, received no organized rehabilitation prior to SCIMS admission, lived in the admitting SCIMS's catchment area at the time of injury, were discharged from the system as having completed inpatient rehabilitation, had not achieved a neurologic status of normal or minimal deficit or expired, and gave informed consent for longitudinal data collection. For this analysis (fig 1), we included all participants 18 years or older with tetraplegia who had completed a 1-year follow-up interview. Because AT survey questions were modified in the 2011 grant cycle (ie, 2011-2016), we restricted our analysis to those followed between October 1, 2011, and November 3, 2017. Of the 682 eligible participants, we excluded 8 who reported having no insurance and 7 with Veterans Administration insurance because there were too few in those categories to make meaningful comparisons. We excluded 169 participants who reported not using a computer or other mobile electronic device such as a tablet or smartphone. The final cohort consisted of 498 men and women with tetraplegia enrolled from 14 contributing SCIMS centers.

List of abbreviations:

AIS	**American Spinal Injury Association Impairment Scale**
AT	**assistive technology**
OR	**odds ratio**
SCI	**spinal cord injury**
SCIMS	**Spinal Cord Injury Model Systems**

Variable definition

The primary outcome of interest was the use of AT when operating a computer or other mobile electronic device. AT use was considered as a dichotomous variable (AT use: yes/no). Participants were considered to use AT if they reported using assistive devices to operate a computer or other mobile electronic device such as a brace or splint, a modified or onscreen keyboard, an adapted mouse, a trackball, a Bluetooth joystick, speech recognition software, or infrared technology.

Our primary predictor for this study was the subject's principal health insurance provider. For the SCIMS National Database, this was a multilevel variable coded as private insurance, Medicare, Medicaid, workers' compensation, Veterans Administration, other government, no pay, private funds, other, or unknown. Insurance provider was further grouped into the following 3 categories: government (Medicare, Medicaid, other government), private (private insurance, private funds, other), and workers' compensation.

The following demographic and injury characteristics were also considered: age at injury, education level, race, sex, marital status, employment status, category of neurologic impairment, neurologic level of injury, pain severity, self-perceived health status, and occurrence of a pressure injury in the last 12 months. Pain and health-related variables were chosen for inclusion in the analysis based on literature indicating an association between predisposition for AT use and (1) achieving pain relief or (2) achieving a better life.[5] Education was dichotomized as high school degree or general equivalency diploma or less and greater than a high school diploma or general equivalency diploma. Race was dichotomized as either white or other. Pain severity was measured on a scale from 0-10 where 10 indicated severe pain. Neurologic impairment was classified as American Spinal Injury Association Impairment Scale (AIS) A (motor and sensory complete, no motor or sensory function below the neurologic level of

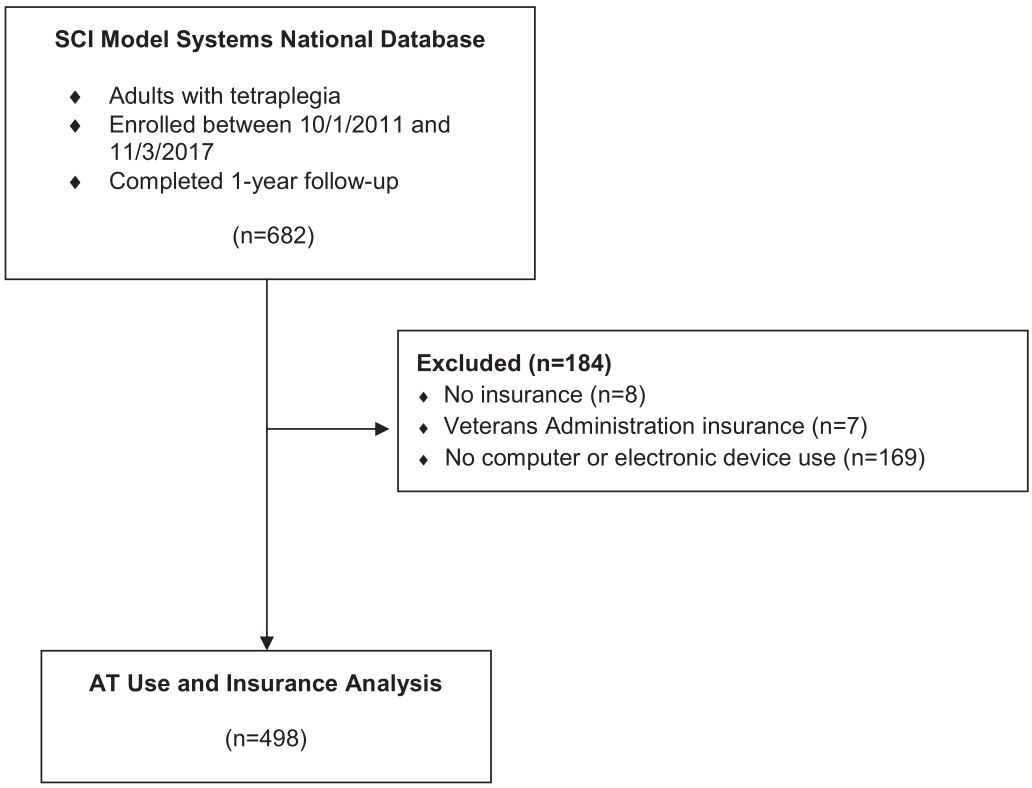

Fig 1 Enrollment diagram.

injury), AIS B (motor complete, no motor function below the neurologic level of injury), AIS C (motor incomplete, motor function preserved below the neurologic level, and more than half the key muscles below the neurologic level are not strong enough to overcome gravity), and AIS D (motor incomplete, motor function preserved below the neurologic level, and more than half the key muscles below the neurologic level are strong enough to overcome gravity). Neurologic impairment was then dichotomized as complete (AIS A) and incomplete (AIS B, C, D). Neurologic level of injury was considered dichotomously as C1-C5 and C6-C8. Self-perceived health status was dichotomized as excellent to good and fair to poor.

Statistical analysis

All statistical analyses were conducted using SAS version 9.4[6,a] assuming a significance level of $\alpha = 0.05$, unless otherwise specified. Demographic and injury characteristics were summarized for the entire sample size as well as separately for the AT use groups. Means and standard deviations are reported for the continuous variables, and frequency counts and percentages are reported for the categorical variables. These characteristics were compared between the AT use groups using *t* tests for the continuous variables and chi-square tests for the categorical variables. The data were tested for normality to ensure parametric statistics were appropriate.

First, the unadjusted relationship between AT use and insurance provider was examined using logistic regression. The unadjusted odds of AT use were compared between the 3 insurance providers using odds ratios (ORs) and 95% confidence intervals. Next, the adjusted relationship between AT use and insurance provider was assessed using logistic regression controlling for all relevant participant characteristics (age at injury, education level, employment status, race, sex, category of neurologic impairment, neurologic level of injury, pain severity, self-perceived health status, and occurrence of a pressure injury in the last 12 months). Indicators of pain, health, and self-perceived health status were included in the models based on the a priori hypothesis that these factors may influence AT use. A manual backward selection process was used to remove those covariates not significant in the multivariable model. In this process all possible covariates were added to a full model, and then the covariate with the highest *P* value was removed. The model was run again, and the covariate with the highest *P* value was removed again. This was repeated until every covariate in the model had a *P* value $<.05$. Adjusted ORs and 95% confidence intervals were estimated from this final model. Pairwise comparisons were tested using a Bonferroni correction. A Cox and Snell pseudo-R^2 statistic was estimated.[7]

Results

Participant characteristics

Demographic and injury characteristics are summarized in table 1. Participants were 42.6 ± 16.6 years old at injury (range, 18-89 years) with an average pain severity score of 3.9 ± 2.7. At 1-year follow-up, the majority of participants were male (79%), white (80%), non-Hispanic (88%), unemployed (80%), and lived in a private residence (93%). A total of 171 participants (34%) used AT. Participants who used AT were injured at a younger age,

Table 1 Summary of subject demographic and injury characteristics

Characteristics	Total (N=498)			AT Use (n=171)			No AT Use (n=327)			
Continuous Variables	N	Mean	± SD	n	Mean	± SD	n	Mean	± SD	*P* Value
Age at injury (y)	498	42.6	±16.6	171	40.5	±16.6	327	43.7	±16.6	.0391*
Pain severity	495	3.9	±2.7	169	3.7	±2.7	326	3.9	±2.7	.3932
Categorical Variables		N	(%)		n	(%)		n	(%)	
Insurance provider										.0076*
Workers' compensation		24	(4.8)		15	(8.8)		9	(2.8)	
Government		197	(39.6)		60	(35.1)		137	(41.9)	
Private		277	(55.6)		96	(56.1)		181	(55.3)	
Sex										.4955
Female		105	(21.1)		39	(22.8)		66	(20.2)	
Male		393	(78.9)		132	(77.2)		261	(79.8)	
Race										.9225
White		394	(79.1)		136	(79.5)		258	(78.9)	
Other		100	(20.1)		34	(19.9)		66	(20.2)	
(Missing)		(4)	(0.8)		(1)	(0.6)		(3)	(0.9)	
Category of neurologic impairment										<.0001*
Complete		122	(24.5)		72	(42.1)		50	(15.3)	
Incomplete		376	(75.5)		99	(57.9)		277	(84.7)	
Neurologic level of injury										<.0001*
C1-C5		329	(66.1)		136	(79.5)		193	(59.0)	
C6-C8		145	(29.1)		27	(15.8)		118	(36.1)	
(Missing)		(24)	(4.8)		(8)	(4.7)		(16)	(4.9)	
Marital status										.8003
Married/living with partner		232	(46.6)		81	(47.4)		151	(46.2)	
Not married		266	(53.4)		90	(52.6)		176	(53.8)	
Employment status										.0811
Employed/ student		100	(20.1)		27	(15.8)		73	(22.3)	
Unemployed		397	(79.7)		144	(84.2)		253	(77.4)	
(Missing)			(0.2)			(0)			(0.3)	
Education										.3757
HS degree/GED or less		267	(53.6)		87	(50.9)		180	(55.0)	
Greater than HS degree/GED		231	(46.4)		84	(49.1)		147	(45.0)	
Pressure injuries										<.0001*
Yes		108	(21.7)		54	(31.6)		54	(16.5)	
No		386	(77.5)		114	(66.7)		272	(83.2)	
(Missing)		(4)	(0.8)		(3)	(1.8)		1	(0.3)	
Self-perceived health status										.0400*
Excellent-good		374	(75.1)		137	(80.1)		237	(72.5)	
Fair-poor		121	(24.3)		32	(18.7)		89	(27.2)	
(Missing)		(3)	(0.6)			(1.2)		(1)	(0.3)	

Abbreviation: GED, general equivalency diploma; HS, high school.
* Significant at $\alpha=0.05$.

tended to have higher level (C1-C5) complete injuries, reported higher self-perceived health status, and were more likely to have a pressure injury in the past 12 months.

Association between insurance provider and assistive technology use

In bivariate analyses, there was a significant relationship between AT use and insurance provider ($P=.0118$). The ORs comparing AT use between the 3 insurance providers is summarized in table 2. After controlling for multiple comparisons ($\alpha=0.05/3=0.0167$), participants with workers' compensation had 3-4 times greater odds of using AT (vs no AT use) than those with government (OR, 3.806; $P=.0029$) or private (OR, 3.142; $P=.0093$) insurance providers. There were no significant differences in AT use between those with government and private insurance.

In a multivariable model, there was no significant association between AT use and race, employment status, education, or marital status. A significant association was found between AT use and insurance provider ($P=.0039$) after adjusting for sex, category of neurologic impairment, neurologic level of injury, self-perceived health status, and the occurrence of a pressure injury in the past 12 months. Participants with workers' compensation

Table 2 Unadjusted logistic regression results between AT use and insurance provider

Categorical Variables	OR	95% CI	*P* Value
Insurance provider			.0118*
Workers' compensation vs government	3.806	(1.578, 9.178)	.0029†
Workers' compensation vs private	3.142	(1.326, 7.446)	.0093†
Private vs government	1.211	(0.819, 1.792)	.3378

N=498
Pseudo-R^2=0.0184
Abbreviation: CI, confidence interval.
* Significant at α=0.05.
† Significant at Bonferroni adjusted α=0.0167.

had greater odds of AT use than those with government (OR, 4.534; P=.0026) or private insurance (OR, 2.731; P=.0407). Those with private insurance had greater odds of AT use than individuals with government (OR, 1.660; P=.0284). After adjusting for multiple comparisons (α=0.0167), workers' compensation was shown to have significantly greater odds than government insurance. The pseudo-R^2 for this multivariable model was estimated to be 0.19. Model results are displayed in table 3.

Discussion

We examined the association between insurance provider and AT use to access computers and electronic devices 1 year after tetraplegia. We found that female sex, complete SCI, high tetraplegia, higher self-perceived health status, and a history of a pressure injury in the preceding year were all associated with higher odds of AT use. After adjusting for these factors, participants with workers' compensation were 3-4 times more likely to report AT use than those with government and private insurance. While it is clear that not all individuals with tetraplegia require AT use to access a computer, our findings suggest insurance provider is an important factor in obtaining access for those who do require AT.

Table 3 Adjusted logistic regression results between AT use and insurance provider

Categorical Variables	OR	95% CI	*P* Value
Insurance provider			.0039*
Workers' compensation vs government	4.534	(1.697-12.11)	.0026†
Workers' compensation vs private	2.731	(1.043-7.150)	.0407
Private vs government	1.660	(1.055-2.613)	.0284
Sex			
Female vs male	1.778	(1.051-3.010)	.0320*
Category of neurologic impairment			
Complete vs incomplete	4.958	(2.954-8.320)	<.0001*
Neurologic level of injury			
C1-C5 vs C6-C8	4.376	(2.562-7.475)	<.0001*
Self-perceived health status			
Excellent-good vs fair-poor	1.794	(1.048-3.070)	.0331*
Pressure injuries in last 12 months			
Yes vs no	1.770	(1.034-3.031)	.0374*

N=469
Pseudo-R^2=0.1867
Abbreviation: CI, confidence interval.
* Significant at α=0.05.
† Significant at Bonferroni adjusted α=0.0167.

Technology can lessen the effect of mobility limitations that are inherent among those with SCI. The role of an assistive device is one that "will promote good quality of life for the user and to the extent to which it makes the user feel competent, confident, and inclined (or motivated) to exploit life's possibilities."[8(p34)] As such, AT is routinely prescribed in multidisciplinary SCI rehabilitation programs with the intent of allowing individuals with disabilities to achieve previously unattainable goals through computer or Internet use. In fact, individuals with SCI have described how AT use enables employment and education as well as recreational participation, autonomy, and inclusion.[9-11] Although the current study found no association between education or employment and AT use, these associations should be further explored in larger longitudinal studies. An important goal in SCI rehabilitation is maximizing vocational potential and social participation—employment, school, housework, volunteer work, and recreation. The benefits of working after injury extend beyond the economic because individuals with SCI who are employed report feeling better about their quality of life.[12,13] People living with SCI are able to successfully engage in competitive employment if appropriate accommodations are provided.

Although smartphones, tablets, and other devices are part of mainstream society and most peoples' everyday lives, it has been found that individuals with disabilities are typically underserved in the realm of AT for various reasons including their own lack of knowledge or exposure to such technology, limited availability of trained personnel, lack of resources, lower educational attainment, and lower household income.[2] In one report, athletes with both paraplegia and tetraplegia participating in the 2010 National Veterans Wheelchair Games used AT to access computers at similar rates (38% and 28%, respectively).[14] However, roughly 10% of all wheelchair athletes, both with paraplegia and tetraplegia, reported having never been exposed to such technology.[14] Additionally, electronic devices are not universally accessible for individuals with disabilities because of financial constraints that limit the ability to purchase the devices and/or Internet service. Functional impairments also make controlling the device difficult.

In this study, we found that participants with more severe injuries (high level tetraplegia) were most likely to report AT use. We also found that individuals with pressure injuries in the preceding 12 months reported higher AT use, as did individuals with higher self-perceived health status. Intuitively, it is understandable that those with higher level injuries and greater self-perceived health status would report increased AT use. Given this is a cross-sectional analysis, additional longitudinal work would be needed to address causality. For instance, does higher self-perceived health status lead to increased likelihood of using AT or does increased use of AT lead to higher self-perceived health status? It is also plausible that individuals with pressure injuries that may require prolonged periods of bed rest were more likely to use AT to access computers or the Internet as a way to occupy themselves. Unfortunately, a review of the literature did not bring to light any further information on this relationship. A future qualitative study may help elucidate these relationships.

With respect to sex differences, results of this study show that women with tetraplegia were almost twice as likely to use AT as men. There is limited information on the association between sex and AT use in general. However, our findings are in agreement with a prior finding that women with traumatic SCI are nearly twice as likely to use the Internet as men.[15]

Findings from this study reveal that individuals with workers' compensation were more likely to receive funding than individuals with government or private insurance. This is consistent with disparities found in wheelchair procurement among people with SCI, where the only payer group for which all beneficiaries received wheelchairs that met standard of care were those provided by workers' compensation or the Veterans Administration.[16]

Our sample included a low percentage of people with workers' compensation (n=24, 4.8%) compared with those with government (n=197, 39.6%) or private insurance (n=227, 55.6%). Despite this low percentage, the majority of those with workers' compensation used AT (n = 15, 62.5%) compared with government (n = 60, 30.5%) or private (n = 96, 34.7%) insurance. Our sample did not include individuals with no insurance. When designing this study we anticipated a higher uninsured rate; however, only 8 individuals reported not having insurance and were removed from the sample.

Study limitations

This study contains some limitations. The first limitation is the lack of diversity of the sample, which was primarily white and male. However, even with a small group of women, a significant difference in AT was found. The SCIMS sample also tends to be younger, have a higher percentage of individuals who are employed, and have fewer who are retired than the general SCI population,[17] which may limit the generalizability of the findings. Second is lack of specificity regarding the relationship between self-perceived health status, pressure injury, and AT use. Third, 169 participants were excluded from the study because they did not use a computer. Unfortunately, further information about why these participants did not use a computer (eg, personal choice, lack of access) cannot be ascertained from the SCIMS National Database. Our analysis did adjust for level and completeness of injury. However, future studies are needed to fully address AT use, or lack thereof, based on functional needs. Finally, we were unable to compare AT use between those with and without insurance. Future work in a different population will need to be conducted to address this question. Given the cross-sectional nature of this study, we are unable to determine any reasoning why AT differed between various groups or if differences in AT use were actually because of insurance funding. Our final model explained approximately 20% of the variation in AT use. While our findings suggest insurance provider is an important factor explaining this variation, additional factors have yet to be identified. Potential factors to consider in future studies include whether or not individuals and their family or caregivers were introduced to AT for access to electronic devices during inpatient rehabilitation, the effect of having a family member or caregiver who is technologically savvy, access to the Internet, and whether or not their job requires use of a computer or other electronic device.

Conclusions

This analysis was exploratory in nature and hypothesis-generating; however, findings from the present study are the first to shed light on AT funding sources and reveal that individuals with workers' compensation are more likely use AT than individuals with either government or private insurance. Additional work focused on AT use and functional outcomes is needed to assess the effect of barriers to use. Collectively, this work may inform insurers of the importance of having AT available for this unique population to potentially improve quality of life and participation.

Supplier

a. SAS version 9.4; SAS Institute, Inc.

Keywords

Insurance; Rehabilitation; Self-help devices; Spinal cord injuries

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