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To cite this article: Sara J.T. Guilcher, B. Cathy Craven, Mary Ann McColl, Louise Lemieux-Charles, Tiziana Casciaro & Susan B. Jaglal (2012) Application of the Andersen's health care utilization framework to secondary complications of spinal cord injury: a scoping review, *Disability and Rehabilitation*, 34:7, 531-541, DOI: [10.3109/09638288.2011.608150](https://doi.org/10.3109/09638288.2011.608150)

To link to this article: <https://doi.org/10.3109/09638288.2011.608150>



Published online: 16 Nov 2011.



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REVIEW ARTICLE

Application of the Andersen's health care utilization framework to secondary complications of spinal cord injury: a scoping review

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Purpose: The purpose of this scoping review was to identify research priority areas related to secondary complications and associated health care use for individuals with spinal cord injury (SCI). **Method:** Data Sources: Peer-reviewed journals were identified using CINAHL, MEDLINE, PubMed, Embase, Social Sciences Abstracts, Social Works Abstract and PsycInfo search engines. Key references were hand searched. **Study Selection:** A total of 289 abstracts were identified from the initial search strategy. We removed studies that did not measure health care and those that did not involve analytical investigation. **Data Extraction:** The selected 31 studies were reviewed in detail using a coding template based on the domains and sub-components of the Andersen model (i.e. environmental, population characteristics, health behavior and outcome). **Results:** Most studies measured predisposing characteristics (e.g. age, gender) and need characteristics (e.g. level of injury). There was a notable absence of environmental characteristics (e.g. health system, neighborhood variables), enabling characteristics and health behaviors (beyond diet and nutrition). **Conclusions:** We identified a gap in the SCI literature. Future research should focus on longitudinal study designs with more representation of non-traumatic spinal cord injury, as well as utilizing more advanced statistical analyses (i.e. multivariate level) to adjust for confounding variables.

Keywords: Andersen model, environmental characteristics, health care use, secondary complications, spinal cord injury

Implications for Rehabilitation

- Secondary complications are problematic for individuals with a spinal cord injury (SCI).
- This scoping review aimed to identify research priority areas related to secondary complications and associated health care use for individuals with spinal cord injury.
- This research showed a gap in the SCI health services literature.
- Future research should focus on longitudinal study designs with more representation of non-traumatic spinal cord injury as well as utilizing more advanced statistical analyses (e.g. multivariate level) to adjust for confounding variables.

Introduction

Issue: secondary complications and spinal cord injury

Spinal cord injury (SCI) results in numerous motor, sensory, and autonomic impairments, which predisposes an individual to multi-system dysfunction [1]. With advancements in acute care management, more individuals with complex needs are surviving and being discharged to the community [2]. Given these medical improvements, SCI is viewed as a chronic condition. While survival rates following injury have improved, prevalence of medical complications related

to the injury continue to be high [1,2]. These secondary complications include chronic pain, bladder and bowel dysfunction, respiratory conditions, pressure ulcers, and autonomic dysreflexia [2]. They result in high health care utilization [3,4] and negatively impact the quality of life [5,6]. Many of the secondary complications are preventable [2], which raises pertinent questions as to what factors are involved in their development and what can we do, from a health services and policy perspective, to minimize their occurrence.

Almost twenty years earlier, Dejong and Batavia identified a paucity of health services research in SCI, particularly when examining secondary complications and associated outcomes [2]. A preliminary scan of SCI literature suggests that there continues to be a lack of health services research. A recent commentary by Hammell, noted that most of the research to date examining secondary complications has been narrow in scope; simply reporting prevalence of these complications, pathophysiologic characteristics and/or identified various non-modifiable clinical and demographic factors (such as age, sex, level of injury) [7]. Hammell concluded that there is a need to comprehensively examine secondary complications and factors related to their onset in a broader context by including aspects such as quality of life and community participation, which have been often neglected in this research [7]. Additionally, little research has been conducted on community factors, such as access, availability, satisfaction of service delivery, which may all play a role in the development of these complications, health care utilization patterns, and outcomes [8].

Andersen's behavioral model of health service utilization

Certainly the need to shift the research focus from clinical factors to a more complex and integrated map of potential factors related to secondary complications is not unique to SCI. Wagner identified this gap in research on chronic disease, as most research has focused on the acute illness rather than the structures, processes and outcomes that are pertinent to individuals living with a chronic disease in the community [9]. This type of health services research has been useful in understanding factors related to health outcomes and service utilization [10–12].

A substantial portion of rehabilitation research has used the International Classification of Functioning, Disability and Health (ICF) as a theoretical framework for classification of health and health-related domains [6]. The ICF, however, is not specifically designed for health services research. One of

the most widely used frameworks in health services field to understand health care and health outcomes is the Andersen's behavioral model of health service utilization (hereafter referred to as the Andersen model; see Figure 1) [13–18].

The four main domains of the model include, environmental characteristics (health system, external community environment), population/individuals characteristics (predisposing, enabling and need), health behavior (personal health practices and use of health services) and health outcomes (perceived and evaluated health status, consumer satisfaction). The model proposes that health behavior and ultimately health outcomes are influenced by the environment or context of care, as well as population or individual characteristics. The model includes feedback loops acknowledging that these components are interrelated and dynamic.

Population characteristics are comprised of three important sub-components: predisposing, enabling and need factors. Predisposing characteristics are factors that influence an individual to use health services such as sociodemographics (e.g. age, gender, education level, occupation, and marital status), and attitudes/beliefs (e.g. self-efficacy, personality traits). Enabling resources may help promote improved health outcomes as they help supply an individual with the necessary components to facilitate accessing appropriate care. Enabling factors can be grouped at the individual (i.e. insurance, income) and at the provider level (e.g. physician-patient communication). Need factors can be subjective and/or objective which influence health behavior and health outcomes (e.g. number of other chronic conditions/comorbidities, level of injury, functional status).

Given that there is a high prevalence of preventable secondary complications and high health care utilization among community dwelling individuals with SCI, the Andersen model may be helpful in understanding the various levels of influential factors at the macro (health system), meso (community, provider level) and micro (individual) levels. Improving our understanding of these factors may help identify risk factors for poor health outcomes and high utilization such that researchers and policy-makers can improve outcomes [19,20].

Thus, the overall purpose of this paper was to identify research priorities related to secondary complications and health service research for individuals with SCI. Identifying research priorities is an important initial step for advancing health services research in order to improve quality of care, clinical outcomes and decrease unnecessary costs.

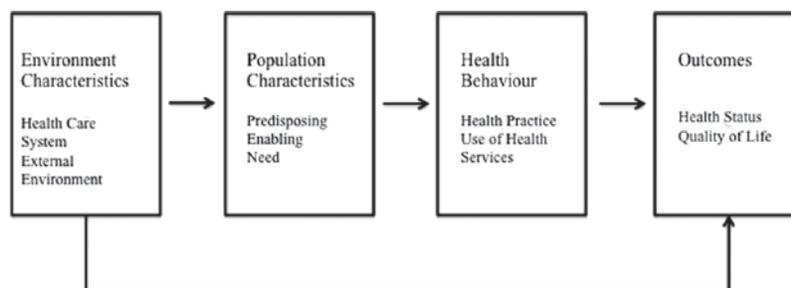


Figure 1. Diagram based on Andersen's behavioral model of health service utilization.

Specifically, our objectives of this review were to, (1) identify in the literature, factors related to secondary complications and associated health care use in the SCI population (2) highlight current gaps and (3) provide recommendations for future research on how the Andersen's behavioral model of health service utilization may help in understanding factors related to preventing secondary complications and associated health care use.

Methods

To address the objectives, a scoping review was conducted [21,22]. This methodology is a rigorous and useful method for identifying gaps in the literature and providing guidance for future research [21,22]. The five steps include (1) develop a research question, (2) search for relative material (3) define study selection, (4) chart the data and (5) collate, summarize and report results.

Research question

“What is known from the literature about factors affecting secondary complications and associated health service use for community dwelling individuals with SCI?”

Similar to previous work [23,24], we utilized a more traditional definition of secondary complications (e.g. pressure ulcers, urinary tract infections, pain, autonomic dysreflexia etc.). However, we are cognizant of broader definitions including comorbidities resultant of aging with a SCI [6], as well as social participation [25].

Searching for relevant material

In efforts to keep the search strategy broad to ensure key articles were not missed, in consultation with two senior health research librarians, the following key search terms were included: spinal cord injury, spinal cord injuries, secondary complication, medical complication, medical condition, secondary condition, health service, utilization, hospitalization, and readmission (see Figure 2). A number of electronic computerized databases were searched for peer-reviewed material. No restrictions were placed on publication year. We utilized MEDLINE + OLDMEDLINE 1947 to July 2010, PubMed; CINAHL (from 1981); Embase Class + Embase 1947 to 2010; Social Sciences Abstracts; Social Works Abstract 1968 to June 2010; and PsycInfo 1806 to July 2010. Articles were limited to English only due to time and costs associated with translating material. Of the articles identified, key references were hand searched to ensure all relevant articles were captured.

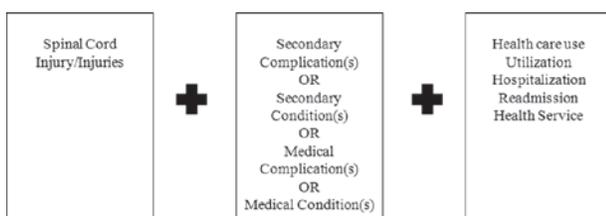


Figure 2. Search strategy to identify articles.

Selecting studies for analysis

Exclusion criteria

A total of 289 abstracts were identified from the initial search strategy. We used the following main exclusion criteria:

1. Studies that did not measure health care use (e.g. physician visits, readmissions) for community dwelling individuals with SCI following their discharge from index acute care and/or initial rehabilitation stay.
2. Studies that did not involve analytical investigation of factors related to secondary complications and associated health care use (i.e. review papers, grey literature, and conceptual papers), as the purpose of this review was to examine how studies have conceptualized explanatory variables with secondary complications and health care use.

The initial screening process was conducted by the primary author (SG) with agreement of the senior author (SJ). In the cases where the abstract did not provide sufficient information, entire articles were reviewed for relevance [21]. Application of the screening criteria excluded 258 articles (see Figure 3).

Chart the data, collate and summarize findings

The selected 31 studies were reviewed in detail using a coding template that authors SG and SJ developed for this scoping review. Similar to the coding of Phillips et al. in their review of health care utilization literature in the general population using the Andersen model [10], key components of the coding template included the domains and sub-components of the model (i.e. environmental, population characteristics, health behavior

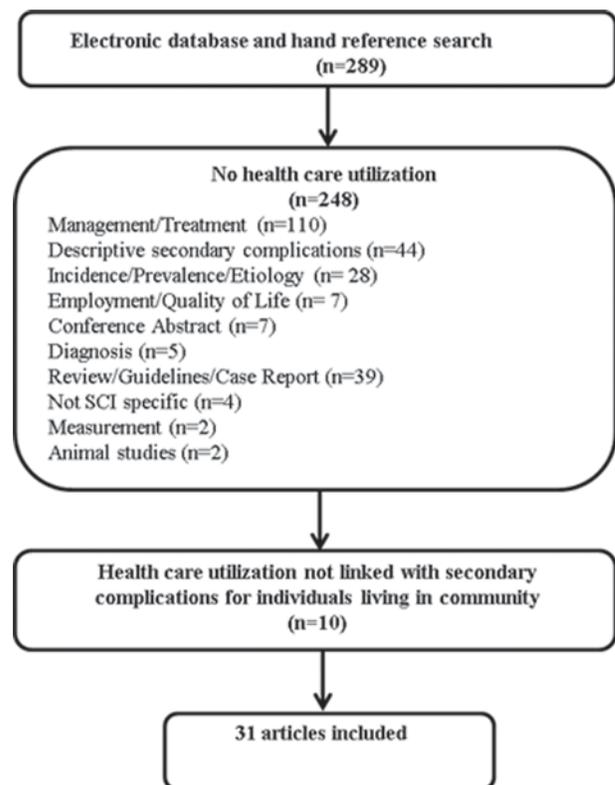


Figure 3. Inclusion and exclusion criteria to identify selected studies.

and outcome; see Table I). In addition, we collected the following relevant study information: author(s), year of publication, location of study, study design, study population, data source, objectives of the study, methodology used, outcome measures, statistical analyses, variables adjusted, results, and conclusions. Each study was thoroughly reviewed and coded, based on our coding template. Specific variables measured in the included studies were categorized and the information was entered into an electronic data extraction spreadsheet. This method allowed us to examine the studies in a more standardized manner and helped to categorize, classify and compare studies based on commonalities, differences and gaps.

The data were collated in two main ways: (1) descriptive numerical analysis on the extent, nature, and distribution of studies (e.g. range of study designs, data sources, variables measured, statistical analyses used); and (2) thematic

organization based on commonalities and differences among the reviewed studies of the constructs in the Andersen model [21,22]. For example, if an article included age, self-efficacy, and level of injury, we labeled this study as including at least one predisposing, enabling and need variable.

Results

Descriptive analyses

Study design, source data, population, statistical analyses

Of the 31 studies reviewed (see Table II), we identified considerable heterogeneity in study design, source data and size of samples studied. A large proportion of the studies used a cross-sectional survey design ($n=15$; 48.4%) and retrospective longitudinal ($n=10$; 32.3%), with fewer studies being prospective longitudinal ($n=5$; 16.1%) or retrospective case-control ($n=1$; 3.2%).

Table I. Coding template for categorizing the included studies.

Constructs	Examples of variables
Environmental	
Health system	Policies, resources organization, financial arrangements that influence health care, primary care models
External environment	Economic climate, politics, societal norms
Community level	Community level attributes that influence ability to obtain services (e.g. availability of services provided within a community, physician/population ratio)
Population characteristics	
Predisposing	Demographic variables such as age, gender, race/ethnicity, education level, occupation, marital status, years post injury, personality traits, self-efficacy
Enabling	Family resources, financial resources, housing situation (e.g. assisted living), insurance, income, individual access to services and transportation, knowledge of illness
Need	Physical function, level of injury, severity of injury, etiology of injury number of comorbidities, pre-injury utilization, bladder function
Health behavior	
Personal health choices	Nutrition, smoking, alcohol and drug use, physical activity
Health use	Number of medical visits, number of hospitalizations, reasons for visits
Health outcomes	
Perceived health status	Number of self-reported secondary complications, self report health status
Evaluated health status	Number of clinician evaluated secondary complications
Consumer satisfaction	Quality of life, life satisfaction

Table II. Summary of reviewed studies based on the Andersen model.

Authors study design	Population data source	Number of environment variables	Number of population characteristics variables			Number of health behavior variables
			External & community setting	Predisposing	Enabling	
1 Bloemen-Vrencken 2007 [53]; Cross-sectional	Primary $n=410$ SCI ^a	X	√√√	√	√√√	√√
2 Burns 2000 [54]; Retrospective case control	Administrative model system cohort 1: $n=2618$; cohort 2: $n=6090$ SCI	X	√√√	X	√√√	X
3 Cardenas 2004 [55]; Cross-sectional	Administrative model system $n=8668$ SCI	X	√√√	√	√√√	X
4 Charlifue 2004 [56]; Retrospective longitudinal	Administrative model system $n=7981$ TSCI ^b	X	√√√	√	√√√	X
5 Divanoglou 2010 [57]; Prospective longitudinal	Primary $n=117$ TSCI	√	X	√	√√√	X
6 Davidoff 1990 [58]; Retrospective longitudinal	Medical records; $n=88$ SCI	X	√√√	√	√√√	√

(Continued)

Table II. (Continued)

Authors study design	Population data source	Number of environment variables	Number of population characteristics variables			Number of health behavior variables
		External & community setting	Predisposing	Enabling	Need	Personal health
7 Donnelly 2007 [28]; Cross-sectional	Primary <i>n</i> = 373 SCI	√	√√√	√√	√√	X
8 Dorsett & Geraghty 2008 [26]; Prospective longitudinal	Primary <i>n</i> = 53 TSCI	X	√√	X	√√√	X
9 Dryden 2006 [59]; Retrospective longitudinal	Provincial administrative data <i>n</i> = 233 TSCI	√	√√	X	√√√	X
10 Eastwood 1999 [60]; Retrospective longitudinal	Administrative model system, <i>n</i> = 3904 TSCI	X	√√√	√√	√√√	X
11 Franeschini 2003 [61]; Cross-sectional	Primary <i>n</i> = 251 NTSCI + TSCI ^c	X	√√√	√√√	√√√	X
12 Jaglal 2009 [62]; Retrospective longitudinal	Provincial administrative data; <i>n</i> = 559 TSCI	√	√√	√	√√√	X
13 Johnson 1998 [63]; Prospective longitudinal	Primary <i>n</i> = 170 TSCI	X	√√	√√√	√√	√√
14 Krause et al. 2010 [64]; Cross-sectional	Primary <i>n</i> = 1388 TSCI	X	√√√	X	√√√	√√√
15 Krause et al. 2009 [65]; Cross-sectional	Primary <i>n</i> = 1386 TSCI	X	√√√	√	√√	√√√
16 Pershouse et al. 2000 [66]; Retrospective longitudinal	Primary <i>n</i> = 68 NTSCI + TSCI	X	√√	X	√√√	X
17 Lavela et al. 2004 [27]; Cross-sectional	Administrative data VeteransAffairs (VA) <i>n</i> = 8983 NTSCI + TSCI	√√√	√√√	√	√√	X
18 Liem et al. 2004 [67]; Cross-sectional	Primary <i>n</i> = 352 SCI	√	√√√	X	√√√	X
19 Meyers et al. 1985 [68]; Cross-sectional	Primary; <i>n</i> = 96 SCI	√	√√√	√√√	√√	√√
20 Meyers et al. 1999 [69]; Cross-sectional	Primary <i>n</i> = 114 SCI	√	√√√	√√√	√√	√√√
21 Middleton et al. 2004 [70]; Retrospective longitudinal	Administrative data <i>n</i> = 432 SCI	X	√√	X	√√√	X
22 Morse et al. 2009 [52]; Prospective longitudinal	Primary and administrative (VA) <i>n</i> = 328 SCI	X	√√√	X	√√√	√√√
23 Noreau et al. 2000 [71]; Cross-sectional	Primary data <i>n</i> = 482 TSCI	X	√√√	√	√√√	X
24 Paker et al. 2006 [72]; Retrospective longitudinal	Medical chart review <i>n</i> = 733 NTSCI + TSCI	X	√√√	X	√√√	X
25 Pagliacci et al. 2008 [73]; Prospective longitudinal	Primary <i>n</i> = 511 TSCI	X	√√√	√√√	√√√	X
26 Saikkonen et al. 2004 [74]; Cross-sectional	Primary <i>n</i> = 76 TSCI	X	√√√	√√	√	X
27 Savic et al. 2000 [75]; Retrospective longitudinal	Medical records and primary data <i>n</i> = 198 TSCI	√	√√√	X	√√√	X
28 Smith et al. 2008 [76]; Cross-sectional	Primary <i>n</i> = 2574 TSCI	X	√√√	√	√√√	√√
29 Suzuki et al. 2007 [30]; Cross-sectional	Primary <i>n</i> = 270 NTSCI + TSCI	√	√√√	√√√	√√	√√√
30 van Loo et al. 2009 [77]; Cross-sectional	Primary <i>n</i> = 453 SCI	X	√√√	√	√√√	X
31 Young et al. 2006 [78]; Retrospective longitudinal	Administrative <i>n</i> = 61 TSCI	√	√√	X	√√√	X

X, no variables, √, one variable, √√, two variables, √√√, three or more variables.

^aStudy did not explicitly mention definition of SCI, therefore, it is unclear whether also included non-traumatic (NTSCI).

^bStudy explicitly stated sample included traumatic (TSCI).

^cStudy explicitly mentioned sample included both NTSCI and TSCI.
n = 31.

Source data varied and included primary data collection ($n = 18$; 58.1%), large national administrative databases (e.g. National Spinal Cord Injury Model Systems (NSCISC) or the Model Spinal Cord Injury System (MSCIS), Veterans Affairs, $n = 9$; (29.0%)), administrative hospital records and chart reviews ($n = 2$; 6.5%), primary data and administrative data ($n = 1$; 0.03%), and primary data and chart review ($n = 1$; 0.03%). Sample sizes varied from 53 participants [26] to 8983 [27].

For almost one-third of studies ($n = 11$, 35.5%), it was unclear whether their sample included those with traumatic SCI only and/or non-traumatic SCI as these studies did not explicitly operationalize the definition of SCI. Most studies involved individuals who sustained a traumatic SCI ($n = 15$; 48.4%) and only 5 (16.1%) explicitly stated that their samples also included those with non-traumatic SCI. Most studies performed basic statistical analyses at the univariate and bivariate level ($n = 19$; 61.3%), with about one-third ($n = 12$; 38.5%) conducted multi-level analyses adjusting for confounding variables.

Measurement: Andersen's behavioral model variables

Environmental variables

Only twelve studies examined the influence of environmental variables ($n = 11$; 35.5%; see Table II). Of these, only two studies examined health system variables (such as the type of primary care delivery models delivered within their community setting) or the availability of services within the community (such as physician to population ratio) [28,29]. Further, most of the environmental variables were related to whether participants lived in an urban/rural area or region ($n = 10$; 32.3%).

Population characteristics: predisposing, enabling and need

Most of the studies measured predisposing variables, with the most common being age ($n = 30$; 96.8%), gender ($n = 30$; 96.8%), age at injury and/or years post injury ($n = 19$; 61.3%), educational level ($n = 15$; 48.4%), marital status ($n = 14$; 45.2%), and race/ethnicity ($n = 10$; 32.3%). A few studies ($n = 3$; 9.7%) measured psycho-social and cognitive variables such as self-efficacy and personality characteristics (e.g. optimism, health locus of control).

Similar to environmental variables, enabling variables were often less measured. The most common enabling variables measured were living arrangements ($n = 10$; 32.3%) and insurance ($n = 8$; 25.8%). Most of the social support variables were related to support received from family and/or friends ($n = 4$; 12.9%), although a few ($n = 3$; 9.7%) measured the perceived support received from health care practitioners. Only five studies (16.1%) measured access to and availability of services.

Most of the need variables included level of injury (i.e. cervical, thoracic, lumbar), neurological impairment (e.g. tetraplegia complete/incomplete, paraplegia complete/incomplete), functional ability at the time of discharge (American Spinal Cord Injury ASIA impairment score, Functional Independence Measure, FIM). Very few studies measured co-morbid conditions ($n = 4$; 12.9%) (Table III).

Health behavior

Personal health choices were mostly related to nutrition and alcohol consumption with only three studies (9.7%) measuring

Table III. Distribution of variables among the included studies ($n = 31$).

Andersen construct	Variables	Total ($N = 31$) $n = (\%)$
Environmental characteristics		
	Urban/rural/region	10 (32.3)
	Supply (e.g. physician-to-population ratio)	0
	Health care system characteristics	2 (6.5)
Population characteristics		
Predisposing		
	Age	30 (96.8)
	Gender	30 (96.8)
	Age at onset disability or years post injury	19 (61.3)
	Education level	15 (48.4)
	Marital status	14 (45.2)
	Race/ethnicity	10 (32.3)
	Employment status	9 (29.0)
	Self-efficacy or autonomy self-management	3 (9.7)
Enabling		
	Insurance	8 (25.8)
	Interpersonal support, social support	6 (19.3)
	Accessibility and availability of health care	5 (16.1)
	Health care provider attitude (provider level)	3 (9.7)
Need variables		
	Level and/or severity of injury	31 (100.0)
	Physical function	18 (58.1)
	Comorbidities	4 (12.9)
	Previous utilization	0
Health behavior characteristics		
Personal health choices		
	Diet/alcohol/smoking/drug use	7 (22.6)
	Exercise	3 (9.7)
Use of health services		
	Physician visits	11 (35.5)
	Allied health care visits	6 (19.4)
	Emergency visits	3 (9.7)
	Readmissions	29 (93.5)
Outcomes		
	Self-reported secondary complications	20 (64.5)
	Evaluated secondary complications	11 (35.5)
	Consumer satisfaction, quality of life	10 (32.3)

$n = 31$.

physical activity. Few studies ($n = 6$; 19.4%) measured visits to health care professionals (e.g. nurses, allied health care professionals, alternative health care providers) other than physicians.

Health outcomes

The majority of secondary complications identified were based on participants self-reporting the frequency of complications during the year prior to the time of data collection. Only eleven studies (35.5%) measured secondary complications by physical examination and/or hospital records. Ten studies (32.3%) measured global health status, life satisfaction and/or quality of life.

Trends in reviewed studies

Our scoping analyses identified several key trends currently in the literature (see Table IV). Overall the review identified a gap in the literature examining secondary complications and associated health care utilization as only 31 studies met the selection criteria. Additionally, we highlighted methodological concerns, particularly with respect to design, sample size, measures and statistical analyses. Most studies that utilized primary data collection were often cross-sectional in design, which limit the analyses to associations rather than prediction models. Further, most of these studies had small sample sizes and as a consequence were not able to adjust for potential confounding variables. These issues raise concerns regarding the validity of conclusions drawn. Of the 31 studies most were not guided by a theoretical model or conceptual framework. We identified only one study, conducted by Suzuki and colleagues that utilized the Andersen model in their study [30]. Another common

Table IV. Common thematic issues identified in scoping review analysis.

Common themes identified in review

- Few studies examining secondary complications and health care use
- Studies with primary data collection often had small sample sizes
- Most studies did not adjust for confounding variables
- Most articles did not use theoretical framework
- Poor representation of non-traumatic SCI

Table V. Suggested variables to consider for future research based on scoping review.

Environment	Population characteristics			Health behavior
	Predisposing	Enabling	Need	
<ul style="list-style-type: none"> • Service delivery models (funding and delivery structures) • Societal norms/culture • Supply of services • Level of crime 	<ul style="list-style-type: none"> • Age • Sex • Gender • Marital status • Ethnicity • Health beliefs & personality (e.g. self efficacy) • Years post injury 	<p>Community level</p> <p><i>Access to and availability of services</i></p> <ul style="list-style-type: none"> • Transportation • Distance to clinics • Community layout • Physician availability, wait-times • Regular source of care • Convenience to accessing care <p>Cultures/norms</p> <p>Quality of air, water, climate</p>	<ul style="list-style-type: none"> • Level/severity of injury • Physical function • comorbidities 	<ul style="list-style-type: none"> • Previous health care use (e.g. alternative care, allied care such as physiotherapy, occupational therapy, physician use) • Self-management practices • Diet & nutrition • Alcohol • Smoking • Medication use • Physical activity
		<p>Individual level</p> <p><i>Financial capital</i></p> <ul style="list-style-type: none"> • Out of pocket medical expenses • Income (personal and household) • Insurance status <p><i>Social capital</i></p> <ul style="list-style-type: none"> • Marital status • Informal networks (family, friends, community groups) • Quality of relationships/emotional support (e.g. with informal and formal care providers) • Satisfaction with care provision (communication, trust, clinical expertise etc) <p><i>Physical capital</i></p> <ul style="list-style-type: none"> • Equipment • Attendant care services • Home layout 		

trend was that predisposing characteristics measured were often non-modifiable.

Discussion

The Andersen model provides a helpful mechanism for organizing important constructs to measure and/or consider when developing SCI research priorities. In using the model, we were able to highlight strengths and gaps in the literature regarding the study of secondary complications and health care utilization in the SCI population. Strengths in the published literature included the inclusion of many predisposing characteristics, as well as a diverse array of study designs and data sources used. Several areas in which to develop future research included evaluating the effect of environmental characteristics (e.g. health system and service delivery models), enabling characteristics (both at the individual and provider level), and health behaviors (beyond diet and nutrition) on secondary complications and associated health care use (see Table V). In addition, we identified a need for future research to focus on longitudinal study designs with more representation of non-traumatic spinal cord injury, as well as utilizing more advanced statistical analyses (i.e. multivariate level) to adjust for confounding variables. Further discussion of these recommendations for research priorities will be presented in more detail below.

In our scoping review, we identified a notable absence of environmental characteristics, with a predominance of studies mainly focusing on population characteristics and their respective associations with secondary complications and health care use. This measurement gap in health services research is not unique to the SCI literature. Barr and colleagues highlighted this gap with the overall study of chronic disease and suggested that future research specifically consider environmental factors [31]. Phillips et al. identified that few studies measured environmental characteristics in their review of health care utilization studies within the general population [10]. Similarly, we identified that the most common environmental variable was rurality (urban/rural), which has been identified as an imprecise proxy for more meaningful measures such as supply of services and access to care [10]. Few of the reviewed studies measured or discussed broader health system variables, such as the influence of service delivery models and the potential impact of these models on secondary complications, health care utilization and health outcomes. McColl et al. identified six different primary care delivery models: (1) Clinical approach (most common model); (2) Self-management; (3) Case management; (4) Shared care; (5) Outreach; and (6) Community-based rehabilitation (please refer to McColl et al. for more detailed review) [32]. The extent to which these models influence secondary complications and health care use, warrants future research. Other important environmental variables not considered, were care coordination and financial structures such as fee-for-service and primary care delivery models.

In addition to the macro environmental characteristics, we also identified an absence of meso-community level variables among the studies. The role of the neighborhood has been previously shown to influence access and utilization of health care in the general population [33]. Specifically, Macintyre and colleagues suggest research should consider the influence of material infrastructure (e.g. transportation, distance to health care clinics, decent housing, quality of air and water, climate) and collective social functioning (e.g. political ideologies and practices, shared norms, traditions, values, levels of crime, networks of community support etc.) on health outcomes [34].

Research that fails to acknowledge provider-level variables is likely to ignore a significant component of explained variance [10]. We identified that practitioner attitudes and expertise, interaction between practitioners and patients, as well as the type of practitioner providing care were rarely measured, again suggesting that there is a gap in the SCI secondary complications literature related to provider-level characteristics. Variables such as quality of communication, trust, clinical expertise, and satisfaction of care are important to consider, as previous studies have shown that the interaction between health care provider and patients are important in health outcomes and patient satisfaction [35,36]. In particular, McColl has identified that clinicians' attitude and expertise are important barriers that need to be addressed in providing optimal health care for individuals with disabilities [37]. This gap in literature is not unique to the SCI research, as Phillips et al. also noted the absence in provider-related variables in their

review of health care utilization research in the general population [10].

Another important factor is the type of practitioner providing care (i.e. specialist versus general practitioner) and the setting [28]. Using a cross-sectional survey, Donnelly and colleagues compared health care utilization of individuals with long-term spinal cord injuries among the United States, Canada and the United Kingdom. These researchers identified significant differences in utilization between the countries, as Canadians were more likely to receive health care from family physicians and Americans were more likely to receive care from specialists [28].

We know from general volume outcome studies, patients who are provided care by practitioners who do not treat certain conditions frequently often have worse outcomes [38]. Differences in volume may affect the practitioner's self-efficacy [35], knowledge and attitudes [39], social network with other health professionals [40], all of which may influence the quality of care delivered [37,39,41]. Previous literature has shown that general practitioners have expressed concern that they are not able to deal with the complexity of SCI [39,42].

We identified most of the variables in the reviewed studies to be predisposing characteristics and need characteristics. However, most of these variables were non-modifiable such as age, gender, race/ethnicity, education level, income, insurance, level of injury, and injury severity. Enabling characteristics and health behavior were measured less often. For example, measures of comorbidity, functional status, the effects of aging over time, access to services, social and financial capital constructs and health behavior (such as physical activity) were often not considered. Previous research has shown that access to formal and informal services [32,43–45] social capital [45], financial capital [2], comorbidity and the effects of aging with a SCI [46], as well as health behavior such as previous health care use [10], self-management and physical activity [47,48] are important to constructs for consideration.

With the exception of studies that mainly used the National SCI Statistical Center database, the majority of studies reviewed were cross-sectional in design. The type of design is important since Charlifue et al. showed significant differences in results between cross-sectional data and longitudinal data [49]. Charlifue and colleagues noted that differences shown in their study were likely due to changes in medical health services over time, which the cross-sectional data would not accurately reflect [49].

There are significant advantages in using longitudinal research designs for examining factors related to secondary complications and associated health care use. More frequent evaluations enhance the reliability of measures and results are less susceptible to random error [50]. Importantly, environmental characteristics, population characteristics and health behaviors can change over time.

The use of large national administrative data may help provide the necessary infrastructure to encourage more longitudinal studies [6]. Assuming good data quality, administrative data has the opportunity to track health care utilization, if linked to hospital admissions data, without biases intrinsic

to primary data collection (e.g. recall bias, volunteer bias). However, a challenge with using solely an administrative hospital database is the focus of variables collected for the purposes of remuneration and therefore, lacking in clinical detail.

We also noted an absence of studies including non-traumatic SCI even though we did not restrict our literature search to either traumatic SCI or non-traumatic SCI. We only identified five studies that included non-traumatic SCI. Further, none of the studies that we reviewed had stratified their samples by traumatic or non-traumatic SCI. There are potential differences in all of the Andersen domains between these two groups given the nature of the etiology, age of onset, extent of informal care provision, and insurance coverage for example.

Very few studies in our scoping review acknowledged the statistical complexity involved in mapping predictors of secondary complications and health services use. As Andersen's model demonstrates with multiple levels (e.g. aggregated community, provider and/or individual patient factors) and feedback loops, understanding the interactions between these variables is not a simple task. Most of the studies we examined used very elementary statistical analyses (such as univariate and bivariate) with a handful of studies adjusting for confounding variables. In fact, only 12 studies (38.5%) reviewed utilized multivariate statistical analyses. Given the complexity and potential collinearity of variables, multi-level models such as hierarchical linear regression analysis and mixed (random and fixed-effects) models are recommended for investigating contextual effects as they are more robust [50,51]. Morse and colleagues demonstrated the importance of multivariate statistics in examining predictors of osteoporosis fracture risk. The univariate analysis showed injury duration to be a significant predictor of fracture related hospital admission; however, after adjusting for neurological completeness in subsequent multivariate analysis, injury duration was no longer significant in the model [52].

Another positive example of addressing these statistical challenges is the work of Suzuki and colleagues [30]. In using the Andersen framework as a guide, these researchers examined the association of predisposing characteristics and enabling characteristics with secondary complications among 270 individuals with SCI. Suzuki et al. recognized the inter-related complexity of variables and conducted F increment tests of multiple regression to assess the associations among predisposing and enabling variables, personal health behavior, health care use and secondary outcomes. In addition, path analyses were also performed to assess mediating effects of these variables. They identified that predisposing characteristics, enabling and health care practice/use accounted for 12, 16 and 13% respectively of unique variance in the presence of secondary complications [30].

Limitations of our scoping review

Overall, the Andersen model was helpful in our scoping review as it facilitated our ability to compare and contrast the reviewed literature using a more structured and standardized tool. The model is relatively flexible, simple and adaptable to

various clinical populations and types of research. Given this, future studies would benefit from using this model as a framework for guiding research, especially with respect to variable consideration. However, it should be noted that due to its flexibility, we did find it challenging at times to categorize certain variables within domains as variables may arguably fit into numerous categories. Significant discretion also remains for researchers in deciding how to specify the relative importance of different factors (i.e. should certain variables be weighted differently?).

Given the nature of a scoping review, it is possible that some important articles were missed [22]. We attempted to minimize this as much as possible by searching numerous databases, consulting a health research librarian and hand searching key articles. We also started our search with very broad search terms and criteria in order to optimize sensitivity. It is important to acknowledge that our scoping review did not involve a formal critical appraisal of study quality. Scoping studies provide a descriptive narrative of the literature rather than a formal systematic review of literature quality [21,22]. Another challenge with a scoping study is that the guidelines for synthesizing the included literature still remains unclear, which can pose challenges when reviewing studies of different designs [21,22].

Finally, we are aware of the controversial debate regarding the various definitions of secondary complications [6]. Given this was the first scoping review examining this topic to our knowledge, we chose to use a more traditional and narrower definition; however, we appreciate that aging with SCI and associated health care use might be an area for future research.

Summary

It is clear from our review that there are gaps in the SCI literature related to secondary complications and health outcomes, particularly at the macro (health system) and meso level (community and health care setting). We suggest that the Andersen model provides a conceptual framework, which is helpful in organizing variables at the macro, meso and micro level (individual). More specifically, there is a need for research to (1) include measures in more domains of the Andersen model other than individual characteristics (i.e. environmental and provider level); (2) examine enabling variables (both at the provider and individual level) and individual health behavior; (3) include not only traumatic SCI, but also non-traumatic SCI; (4) be longitudinal in design, (5) use administrative data and primary data; and (6) utilize appropriate statistical analyses.

It is almost twenty years since Dejong and Batavia called for increasing capacity in health services research and SCI [2]. We must move beyond using the same methods and measuring simple socio-demographic variables and "give more attention to the responsiveness of the health care system to the particular needs of people with SCI as an explanatory factor" (p.382) [2]. The Andersen model is a helpful tool in assisting with moving the research agenda forward in this regard.

Acknowledgments

The authors acknowledge the support of the Toronto Rehabilitation Institute (TRI), which receives funding under the Provincial Rehabilitation Research Program from the Ministry of Health and Long-Term Care in Ontario. The views expressed do not necessarily reflect those of the Ministry.

Declaration of interest: Ms. Guilcher's doctoral training has been supported by the Canadian Institute for Health Research, Women's College Research Institute, Ontario Neurotrauma Foundation, TRI, Community University Research Alliance, and Ontario Training Collaborative Program in Health Services and Policy Research. Dr. Jaglal is the TRI Chair at the University of Toronto in Health Services Research.

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