External Validation of the Detection of Indicators and Vulnerabilities for Emergency Room Trips (DIVERT) Scale: A Retrospective Cohort Study

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Abstract

Background: The Detection of Indicators and Vulnerabilities of Emergency Room Trips (DIVERT) scale was developed to classify and estimate the risk of emergency department (ED) use in home care clients. The objective of this study was to externally validate the DIVERT scale in a secondary population of home care clients.

Methods: We conducted a retrospective cohort study, linking data from the Home Care Reporting System and the National Ambulatory Care Reporting System. Data were collected on older long-stay home care clients who received a RAI Home Care (RAI-HC) assessment. Data were collected for home care clients in the Canadian provinces of Ontario and Alberta, as well as in the cities of Winnipeg, Manitoba and Whitehorse, Yukon Territories, between April 1, 2011 and September 30, 2014. The DIVERT Scale was originally derived from the items of the RAI-HC through the use of recursive partitioning informed by a multinational clinical panel. This scale is currently implemented alongside the RAI-HC in provinces across Canada. The primary outcome of this study was an ED visit within six months of a RAI-HC assessment.

Results: The cohort contained 1,001,133 home care clients. The vast majority of cases received services in Ontario (88%), followed by Alberta (8%), Winnipeg (4%), and Whitehorse (<1%). Across the four cohorts, the DIVERT scale demonstrated similar discriminative ability to the original validation work for all outcomes during the six-month follow-up: ED visitation (AUC =0.617-0.647), two or more ED visits (AUC = 0.628-0.634), and hospital admission (AUC = 0.617-0.664).

Conclusions: The findings of this study support the external validity of the DIVERT scale. More specifically, the predictive accuracy of the DIVERT scale from the original work was similar to the accuracy demonstrated within a new cohort, created from different geographical regions and time periods.

Introduction

Emergency departments (ED) are a common access point for older adults in search of medical attention.[1,2] Older adults often present to the ED with extensive medical and psychosocial histories, increasing their risk for functional decline, readmission, and death post discharge.[3] The time

pressures and high client volumes in the ED often hinder emergency clinicians from providing comprehensive geriatric assessments and chronic disease management.[4,5] To better support the needs of older adults, clinicians, researchers, and policy makers have placed a greater emphasis on improving community-based disease management and service integration to prevent avoidable ED visitation.[6]

Approximately one-quarter of older adults in Canada are receiving home care services, with the rate of home care enrollment increasing with age.[7,8] Older home care clients are a medically complex cohort with relatively poor access to effective chronic disease management. As a result, older home care clients visit the ED at approximately twice the rate of long-term care residents and autonomous older adults living in a private dwelling.[9] Prior work has demonstrated the utility of prognostic tools and home-based supports in supporting the identification community-dwelling older adults at risk for ED visitation.[10-13]

Costa and et al developed and validated a prognostic case-finding tool known as the Detection of Indicators and Vulnerabilities of Emergency Room Trips (DIVERT) scale.[14] The purpose of this scale was to estimate and classify the risk of ED use in home care clients to better identify high risk home care clients who may benefit from additional chronic disease management services in the community.[14] A number of organizing bodies have recommended utilizing the DIVERT scale during the provision of home care services,[14,15] as the scale supports an organized population level response to community-based chronic disease management needs.[15,16] At this time, the DIVERT scale is currently being utilized in an ongoing pragmatic cluster randomized controlled trial to determine the efficacy of a cardiorespiratory disease management model in preventing or postponing future ED admissions in home care clients.[17]

The original validation study for the DIVERT scale was tested on a single hold-out sample. Predictive models require external validation using datasets different from that used to develop the original model.[18,19] We set out to examine the external validity of the DIVERT scale, across multiple

jurisdictions, provinces, and during a different time period. Given the population-level predictions and face validity of the DIVERT scale, we hypothesized that the scale would provide a similar performance in this new cohort.

Methods

Study Design

We conducted a population-based retrospective cohort study of home care clients in the provinces of Ontario and Alberta, and in the regions surrounding Winnipeg, Manitoba and Whitehorse, Yukon.

Data Sources

We linked multiple, anonymized, administrative health databases to construct our cohort. Home care clinical assessment data was extracted from the Home Care Reporting System, a national database that contains demographic, clinical, functional and service utilization information on publicly funded home care clients in Canada. Emergency department utilization data were extracted from the National Ambulatory Care Reporting System, which houses comprehensive data on hospital and community-based ambulatory care visits in Canada. The databases used in this study are routinely checked for validity and have been extensively used in health services research.[18-22] We received ethics approval from the Hamilton Integrated Research Ethics Board.

Participants

Home care clients in Canada are periodically assessed using the Resident Assessment Instrument for Home Care (RAH-HC). We created a retrospective cohort of all RAI-HC assessments completed between April 1, 2011 and September 30, 2014. Data were accessed on clients in the provinces of Ontario and Alberta. as well as in the Winnipeg Regional Health Authority in Manitoba and in the Whitehorse census subdivision of the Yukon Territory. The cohorts in Manitoba and Yukon were restricted to areas surrounding the cities of Winnipeg and Whitehouse due to limitations in the coverage of the National Ambulatory Care Reporting System. The RAI-HC assessments in the cohort were linked to emergency department records to identify all ED visits within six months of the assessment date.

Measurement.

The DIVERT scale was developed through the use of recursive partitioning on the assessment items of the RAI-HC. The RAI-HC is a comprehensive clinical assessment of over 250 items that have demonstrated validity and reliability in documenting the domains of function, health, social support, and health service use.[22,23] The RAI-HC is currently used for standardized home assessments in most Canadian provinces and territories, half of U.S States, and in many countries around the world including: Estonia, Finland, Hong Kong, Iceland, Ireland, Italy, Japan, The Netherlands, New Zealand, Singapore, Spain, and Switzerland. At this time, the DIVERT scale has been implemented as a standard scale within the RAI-HC assessment.

Outcome Measure. The primary outcome of this study was an ED visit within 6 months after a RAI-HC assessment date. Secondary outcomes include: (a) two or more ED visits within 6 months of a RAI-HC assessment, and (b) any ED visits that resulted in a hospital admission. Data were censored at date of death. All outcomes were selected to parallel the figures in the original derivation study.[14] A 6-month follow-up period was chosen to reflect the contemporary home care assessment intervals.

Data Analysis

The DIVERT scale was derived and validated using home care assessment data linked to ED records from Ontario and Winnipeg between 2006 and 2010.[14] Our examination of data from Ontario, Alberta, Winnipeg, and Whitehorse between 2011 and 2014 enables us to test of the scale's validity within the two original regions, but also at a later time period validating the temporality of the predictions. We measured the predictive ability of the DIVERT scale using the area under the receiver operating curve (AUC), or c-statistic. The AUC is the area under the curve created by plotting sensitivity against 1-specificity at various thresholds and is a common measure of the discriminative ability. Within each region, we calculated the AUC of the DIVERT scale for each outcome. All analysis was performed using SAS/STAT 13.1.

Results

Sample Characteristics

Within the four regions of our study, we identified 1,001,133 RAI-HC assessed cases occurring between April 1, 2011 and September 30, 2014. The vast majority of cases (88%) were in Ontario

(88%), followed by Alberta (8%), Winnipeg (4%) and Whitehorse (<1%). A descriptive profile of the home care clients within each region can be found in Table 1. Overall, the home care clients were predominantly female with a mean age of approximately 79.

Home care clients in Ontario had the highest level of physical and cognitive impairment while clients in Whitehorse had the lowest. Home care clients in Ontario also were more likely to have a live-in caregiver, and were more likely to have informal caregivers who express distress. However, clients in Whitehorse were the most likely to rate their health as poor and had the highest proportion of clients scoring 3 or higher on the Depression Rating Scale.

External Validation

The proportion of outcomes and the discriminative ability of the DIVERT scale across all regions can be found in Table 2. For the primary outcome of ED visitation, the AUCs of the DIVERT Scale within Ontario, Alberta, and Winnipeg are very similar to one another (0.617-0.624) and to the original validation work (0.62). However, the AUC for the Whitehorse cohort was slightly higher for this outcome (0.647).

For the secondary outcome of two or more ED visits in the six months following a RAI-HC assessment, the AUCs within all four regions were similar to one another (0.628-0.634) and to the original validation work (0.63). For the outcome examining hospital admission through the emergency department, the AUCs within Ontario, Alberta and Winnipeg again very similar to one another (0.617-0.624), while the AUC within Whitehorse was slightly higher (0.664).

Discussion

Important Findings

Our study provides external validation of the DIVERT scale, demonstrating that the scales discriminative ability is generalizable to external populations in new geographic regions (Winnipeg, Manitoba and Whitehorse, Yukon Territories). Furthermore, we validated that the performance of the DIVERT scale is robust to temporal changes. The DIVERT scale was able to adequately predict ED visitation, multiple ED visits, and hospitalization in a sample of Canadian home care clients.

Comparison to Similar Works

To our knowledge, the original derivation and validation study for DIVERT scale was the first study to predict ED use among older home care clients using population level data. The DIVERT scale performed similarly to other predictive models examining ED and hospital use among older adults. [24-27] Only one other study to date has attempted to predict ED use among home care clients. Jones et al. used a series of machine learning algorithms to predict ED use for an injurious fall within six moths of a RAI-HC assessment.[27] A key difference between the DIVERT scale and prior work is that the DIVERT scale aims to inform program planning and preventative interventions prior to ED visitation by stratifying risk among sub-groups.

Clinical and Policy Implications

Health systems (both public and private) are often limited by budgetary constraints, resulting in some clients not receiving adequate care. This is especially true of home care services, where many Canadian clients receive only partial care needs.[28] Limited home care services in Canada underscore the clinical relevance of systematically identifying clients who are at highest risk of hospital use to target enhanced risk assessment or preventative efforts.

The DIVERT scale provides real-time risk estimation, and provides information that can supplement decision making surrounding resource allocation and preventative interventions. For example, clients with unstable cardiorespiratory symptoms might benefit from referral to a specialist, whereas those without these symptoms may be considered more appropriate for preclinical diagnosis and preventative measures in primary care. Beyond its use for case finding, it may also be used to stratify or adjust organizational, regional, and national level ED utilization metrics in home care. Our study demonstrated the external validity of the DIVERT scale, demonstrating that this prognostic tool is likely to benefit home care clients across Canada. The RAI-HC is currently implemented as standard practice in many nations around the world, suggesting that knowledge translation efforts and clinical integration of the DIVERT scale is feasible in countries outside of Canada.

Limitations

Use of the DIVERT Scale is limited to a predominantly frail population of community-dwelling older

adults who receive home care services. The current study was limited to the person-level variables available in the RAI-HC assessment and could not capture all relevant determinants, particularly primary care utilization. Further work is needed to understand what types and intensity of interventions are feasible and effective in the community. Future research should aim to replicate these findings in countries outside of Canada.

Conclusion

Our study provided external validity for the DIVERT scale, further demonstrating that the tool can accurately predict ED use and hospitalization in Canadian home care clients. More specifically, our study demonstrated that discriminative performance of this prognostic tool is consistent in a new cohort of clients from diverse regions, and during a different time period. Future research should aim to validate these findings in the United States and countries outside of North America, as the implementation and uptake of the DIVERT scale in new regions is feasible.

Abbreviations

AUC: Area Under the Receiver Operating Characteristic Curve

DIVERT: Detection of Indicators and Vulnerabilities for Emergency Room Trips

ED: Emergency Department

RAI-HC: Resident Assessment Instrument - Home Care

Declarations

Ethics Approval and Consent to Participate: Ethical approval was obtained for this study through the Hamilton Integrated Research Ethics Board (#2651).

Consent for Publication: Not applicable.

Availability of Data and Materials: The data analyzed in this study are not publicly available due to privacy and confidentiality restrictions pertaining to person-level health information, which contains personal identifiers, in Canada; however, the data set creation plan and underlying analytic code are available from the corresponding author on reasonable request.

Competing Interest: The authors declare that they have no competing interests

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Conflicts of Interest: There are no conflicts of interest to report.

Author Contributions: Fabrice Mowbray wrote the first draft of the article and additionally on all edits. Aaron Jones conducted the statistical analyses for this study. Dr. Connie Schumacher, Dr. John Hirdes, and Dr. Andrew Costa critically revised the article and made substantial contributions.

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Tables

Table 1: Sample Characteristics Across Canadian Provinces and Regions

Client Characteristics	Ontario	Alberta	Winnipeg	W
	n=877,696	n=80,427	n=42,583	
Demographic Characteristics				
Age (Mean)	78.2	79.4	78.8	
Sex (Female)	64%	64%	67%	
Health Characteristics				
Activities of Daily Living				
Independent	46%	59%	64%	
Supervision/Limited Assistance	31%	23%	24%	
Extensive Assistance/ Dependent	23%	18%	12%	
Cognitive Impairment				
Intact	28%	36%	42%	
Borderline / Mild impairment	53%	46%	46%	
Moderate/Severe impairment	19%	18%	12%	
Depression Rating Scale				
0	53%	59%	68%	
1-2	26%	23%	22%	
3+	21%	18%	10%	
Poor Self-Reported Health	22%	16%	20%	
Fall in last 90 Days	39%	31%	29%	
Dyspnea	28%	18%	24%	
Bladder Incontinence	29%	31%	30%	
Wandering	3%	6%	2%	
Aggressive Behaviour	11%	15%	6%	
Frailty Index	0.24	0.21	0.18	
Number of Medications (Mean)	7.4	7.5	6.8	
Informal Caregiver Status				
	51%	35%	38%	

Live-in caregiver	24%	10%	11%
Caregiver express distress	20.0	16.1	13.2
Informal care hours per day (Mean)			
DIVERT Scale			
1 (least risk)	16%	27%	25%
2	28%	22%	29%
3	18%	16%	19%
4	21%	17%	16%
5	11%	10%	7%
6 (most risk)	7%	8%	4%

Table 2: Outcome Proportion and Discriminative Ability of the DIVERT Scale

DIVERT	Ontario	Alberta	Winnipeg	Whitehorse
Outcome: Any ED visit within 6 months				
1	31%	35%	28%	34%
2	39%	42%	38%	46%
3	45%	48%	42%	46%
4	51%	52%	49%	62%
5	59%	61%	59%	66%
6	67%	66%	68%	75%
AUC	0.614	0.611	0.618	0.647
Outcome: Any ED visit within 6 months of Hospital Admission				
1	14%	16%	11%	4%
2	19%	22%	18%	20%
3	24%	27%	21%	20%
4	29%	31%	26%	27%
5	36%	36%	34%	27%
6	42%	41%	39%	37%
AUC	0.624	0.617	0.624	0.664
Outcome: Two or more ED visits within six months of home care assessment				
1	12%	15%	10%	16%
2	16%	19%	14%	18%
3	20%	23%	18%	19%
4	25%	27%	23%	33%
5	33%	36%	30%	39%
6	42%	43%	41%	40%
AUC	0.629	0.628	0.634	0.633

Figures

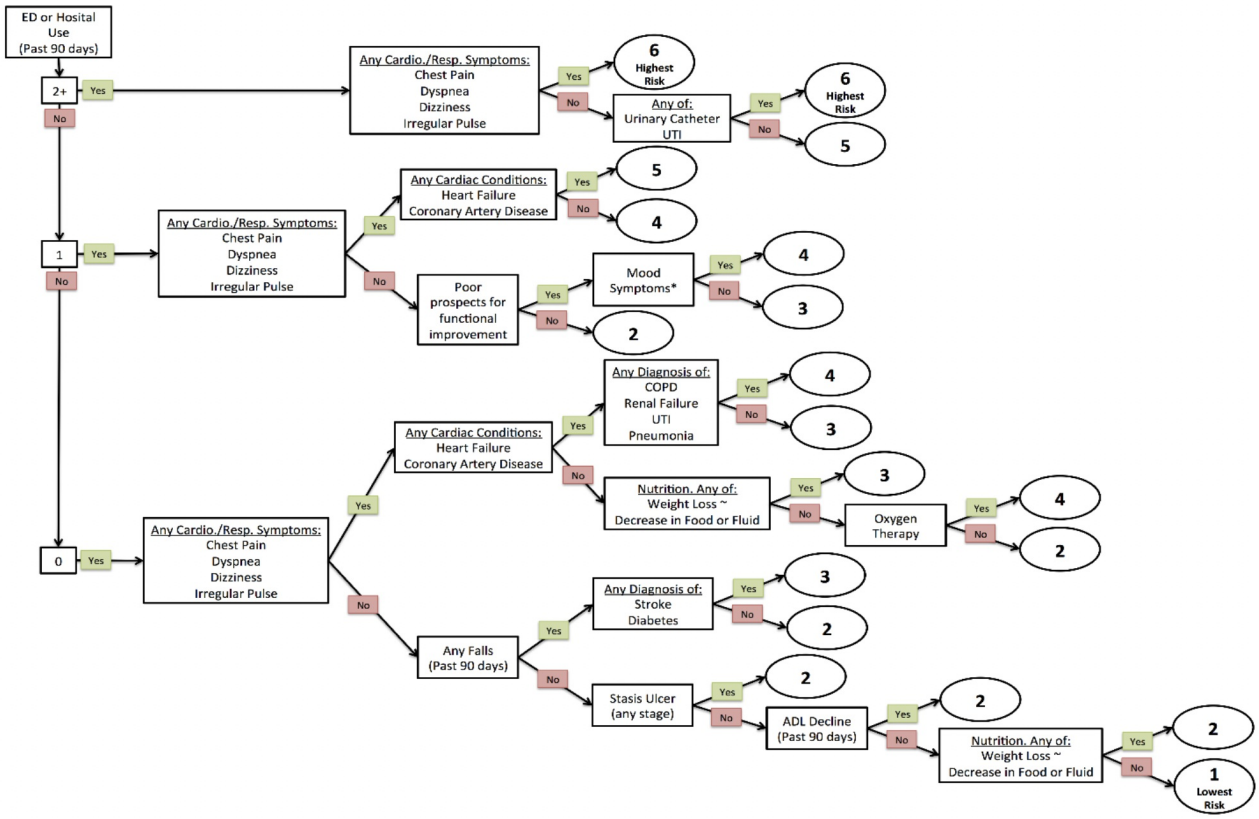

Figure 1

The DIVERT Scale