Derivation and Validation of the Detection of Indicators and Vulnerabilities for Emergency Room Trips Scale for Classifying the Risk of Emergency Department Use in Frail Community-Dwelling Older Adults

Andrew P. Costa, PhD,[ab] John P. Hirdes, PhD,[c] Chaim M. Bell, MD, PhD,[de] Susan E. Bronskill, PhD,[f] George A. Heckman, MD, MSc,[bc] Lori Mitchell, PhD,[g] Jeffery W. Poss, PhD,[c] Samir K. Sinha, MD, DPhil,[de] and Paul Stolee, PhD[c]

OBJECTIVES: To develop and validate a prognostic case finding tool that classifies the risk of emergency department (ED) use in an older home care population.

DESIGN: Population-based retrospective cohort study using routinely collected data from home care clinical assessments linked prospectively to ED records.

SETTING: Ontario and the Winnipeg Regional Health Authority, Canada.

PARTICIPANTS: Older adults living at home and expected to receive in-home services for at least 60 days (N = 361,942).

MEASUREMENTS: One or more ED visits within 6 months after an in-home clinical assessment was used as the main dependent measure. Ninety-five person-level risk measures from a clinical assessment instrument were selected as potential independent variables. The Detection of Indicators and Vulnerabilities for Emergency Room Trips (DIVERT) Scale was derived using recursive partitioning analyses informed by a multinational clinical panel.

RESULTS: Overall, 41.2% had one or more ED visits within 6 months of their in-home assessment. Previous ED use and cardiorespiratory symptoms, cardiac conditions, and specific geriatric syndromes were predictors within the six-level DIVERT Scale. The scale provided adequate risk differentiation for case finding, with an area under the receiver operating characteristic curve of 0.62 (95% confidence interval = 0.61–0.62) and distinct risk gradients between risk scores. The multilevel validation demonstrated consistent performance across geographic and participant clusters.

CONCLUSION: The DIVERT Scale is a valid case-finding tool for ED use in older home care clients. It may be suitable for preemptively and systematically risk-stratifying individuals or groups for additional assessment, case management, and preventative interventions. It may also be suitable for the stratification and adjustment of performance metrics. **J Am Geriatr Soc 63:763–769, 2015.**

Key words: emergency department; community care; home care; risk assessment; case finding

Emergency departments (EDs) are a common access point for older adults seeking care.[1] Older adults have higher rates of ED use than younger persons,[1] and their overall share of ED volumes has risen significantly.[2] The ongoing demographic shift in many societies has led to greater emphasis on improving community-based disease management and service integration to prevent avoidable ED use.[3]

Home health services occupy an increasingly prominent role in many healthcare systems.[4] In Canada, home care clients are a prevalent subgroup of community-dwelling older adults,[5] accounting for 6%, 15%, and 32% of the household population aged 65 to 74, 75 to 84, and 85 and older, respectively.[6] Sample estimates suggest that home care clients have an ED usage rate approximately double that of nursing home residents and older adults without publicly funded home care.[7] A prognostic tool to identify community-dwelling older adults at risk of ED use may improve case finding.[8,9] Studies show that the effec-

From the [a]Departments of Clinical Epidemiology and Biostatistics; [b]Medicine, McMaster University, Hamilton; [c]School of Public Health and Health Systems, University of Waterloo, Waterloo; [d]Department of Medicine, University of Toronto; [e]Department of Medicine, Mount Sinai Hospital; [f]Institute for Clinical Evaluative Sciences, Toronto, Ontario; and [g]Winnipeg Regional Health Authority, Winnipeg, Manitoba, Canada.

Address correspondence to Andrew P. Costa, Schlegel Chair in Clinical Epidemiology & Aging, Departments of Clinical Epidemiology & Biostatistics and Medicine, McMaster University, 1280 Main Street West, Hamilton, ON, Canada L8S4k1.
E-mail: acosta@mcmaster.ca

DOI: 10.1111/jgs.13336

© 2015, Copyright the Authors
Journal compilation © 2015, The American Geriatrics Society
0002-8614/15/$15.00

tiveness of home-based support can be enhanced with case-finding approaches.[10,11]

Risk prediction models for ED revisits have been described in the literature.[12,13] Similarly, some prognostic tools for ED and hospital admission have been proposed for the primary care setting.[14–16] To the knowledge of the authors of the current study, no published risk prediction models have been validated for ED or hospital use in predominantly frail populations of older adults living in the community, including those receiving in-home care.

The current study sought to develop and validate a case-finding tool to estimate the risk of ED use in home care clients. It was hypothesized that symptoms of chronic illness and functional impairment, falls, and informal care distress would be associated with future ED use in this predominantly frail population of community-dwelling older adults.

METHODS

Population, Design, and Settings

This was a retrospective cohort study using home care clinical assessment records linked prospectively to ED records in Ontario from April 1, 2007, to September 29, 2010, and the Winnipeg Regional Health Authority (WRHA) from January 1, 2006, to September 29, 2009. All home care clients living in a noninstitutional setting and expected to receive home care services for at least 60 days were included. Chronological age was not used as an exclusion criterion given that the effect of home care eligibility yields similar functional and frailty profiles in younger and older home care clients, as well as to maximize utility in home care practice. More than 80% of home care clients were aged 65 and older, and more than 95% were aged 50 and older. Each home care assessment was used as the unit of analysis to maximize external validity. Ontario is Canada's most-populous province, and the WRHA accounts for more than half of the population in the province of Manitoba.

Ethics approval was granted through the University of Waterloo Office of Research Ethics (17045).

Measurement

Population-level Resident Assessment Instrument Home Care (RAI-HC) records were used as the source of independent variables. The RAI-HC, a standardized comprehensive assessment containing approximately 200 items,[17] has been found to document major domains of health reliably.[18] A comparison of the RAI-HC with the International Classification of Functioning, Disability, and Health showed substantial overlap in content.[19] The RAI-HC is used for clinical home care assessment in most Canadian provinces and territories, as well as Estonia, Finland, Hong Kong, Iceland, Ireland, Italy, Japan, the Netherlands, New Zealand, Singapore, Spain, Switzerland, and some U.S. states. Home care case managers, who are usually registered nurses, receive assessment training in all relevant jurisdictions. RAI-HC assessment data have been used in previous clinical and epidemiological research.[20]

Outcome Measurement

Emergency department visits were prospectively identified through the National Ambulatory Care Reporting System, which provides population-based ED episode data that have been used previously in large investigations.[21] The records were restricted to unscheduled ED visits using administrative visit codes to remove the bias of low-acuity scheduled visits from more-rural regions. A 6-month follow-up period was chosen to reflect the contemporary home care assessment intervals.

One or more ED visits within 183 days (6 months) after a RAI-HC assessment date was chosen as the primary dependent variable. Two or more ED visits within 6 months after a RAI-HC assessment was chosen as a secondary dependent variable based on the distribution of ED visits. Time from the home care assessment to first ED visit was chosen as a tertiary, ad hoc, dependent measure for validation. Deaths within 6 months of the assessment were censored at date of death.

Scale Derivation

Two regionally stratified client samples were randomly partitioned for model derivation and calibration (75%) and for validation (25%). A six-member, five-country clinical panel of geriatric and emergency medical specialists was recruited to rank the presumed clinical relevance of all potential variables. In addition, the unadjusted odds of any ED visit within 6 months of assessment was calculated for each selected RAI-HC variable to evaluate the validity of the clinical panel's rankings. This approach was used to support face validity and the inclusion of clinically meaningful risk factors.

Chi-squared Automatic Interaction Detection (CHAID), a recursive partitioning method,[22] was used to derive the DIVERT Scale with a random sample of 10,000 records from the derivation sample. Recursive partitioning may be more intuitive and useful to support pattern recognition than other multivariable methods that require additive calculations. SAS Enterprise Miner 6.2 was used to perform CHAID analysis (SAS Institute, Inc., Cary, NC) using methods suggested previously.[23] Input was gathered from the clinical panel to support decision-making where pertinent. Sensitivity analyses were performed to establish the most-parsimonious and -discriminatory variable combinations within the classification. Scalar risk scores were established by combining discrete classification termini with similar effect sizes. A sensitivity analysis was conducted to establish the most discriminatory and coherent scoring scheme based on the precision of the classification risk scores and overall discriminatory power.

Validation

Class-level effect sizes, area under the receiver operating characteristic curve (AUC), and Hosmer-Lemeshow goodness-of-fit were calculated to establish model fit and performance. Kaplan–Meier survival curves for time to first ED visit from baseline were used to confirm temporal validity. Given that home care clients' risk of ED use could be clustered according to home care agency or health

region and according to client (given multiple assessments), multi-level effect sizes were compared with that of standard logistic regression using a validation subsample to determine the effect of clustering. Such clustering could negatively influence generalizability and internal validity. The exchangeable correlation structure was used according to methods previously suggested.[24] Analyses were performed using SAS version 9.2 (SAS Institute, Inc.). The reporting is based on the STrengthening the Reporting of OBservational studies in Epidemiology statement.[25]

RESULTS

Sample Characteristics and Variable Selection

A total of 617,035 assessments were used for the analyses, representing 361,942 home care clients in Ontario and the WRHA (566,418 from Ontario, 50,617 from the WRHA). Overall, 41.2 ± 0.1% of home care clients had one or more ED visits and 17.6 ± 0.3% had multiple ED visits within 6 months of their in-home assessment.

The derivation cohort is described in Table 1. Home care clients were elderly, the majority were female, and approximately one-quarter lived alone. One in three had no co-residing informal caregiver, whereas one in six had a caregiver who expressed distress. Activity of daily living (ADL) impairment and decline, falls, and mood symptoms occurred in more than one-third of clients. Musculoskeletal conditions were common, as were cardiovascular illness and diabetes mellitus. Dementia, emphysema, mental illness, and cancer had an approximately 15% prevalence. Past ED and hospital use was common.

Derivation

Overall, 462,773 assessments were partitioned for classification tree derivation and 154,262 for validation, representing 242,651 and 119,291 clients, respectively. The clinical panel generally rated variables related to demographic characteristics, communication, vision, social functioning, dental status, and the client's environment lower than other domains, particularly diseases, conditions, and previous hospital use. Criteria for variable consideration was based on a mean ranking of more than 2 or at least two of six panel members assigning the top rank to the variable. Ninety-five RAI-HC assessment variables were selected as potential independent variables (see Appendix S1). The effect sizes of candidate variables were broadly consistent with clinical panel rankings.

The raw DIVERT classification contained 19 discrete termini that were collapsed into six levels of risk differentiation and scored hierarchically from the lowest level (Figure 1). The amount of previous ED or hospital usage had the highest discriminatory power, as well as the best ability to organize the proceeding classification branches. Clients with only one ED visit and two or more ED visits in the previous 90 days were approximately 1.5 and 2 times as likely to have a future ED visit as clients with no previous ED or hospital use, respectively. Beyond previous use, cardiorespiratory symptoms provided the most optimal discrimination of future ED use. The presence of a heart condition best differentiated the likelihood of future ED use when there was adequate power to distinguish risk between clients with cardiorespiratory symptoms. The presence of other complex diagnoses differentiated risk among clients with a heart condition. Those with symptoms, but without a diagnosed heart condition, were best differentiated according to nutritional insufficiency and receipt of oxygen therapy, sequentially. In participants without cardiorespiratory symptoms, prospects for improvement and mood symptoms that those with poor prospects experienced best determined the likelihood of future ED use. In clients without previous use or cardiorespiratory symptoms, any previous fall best differentiated ED risk. A recent stroke or diabetes mellitus best differentiated the risk of ED use in clients with previous falls. The presence of a stasis ulcer, recent ADL decline, and nutritional insufficiency best differentiated those without previous falls sequentially.

Validation

The class-level odds ratios for each score increased significantly through the range of the DIVERT Scale for one or more ED visits and multiple ED visits and demonstrated enhanced performance when predicting multiple ED visits (Table 2). A Kaplan-Meier survival curve for number of days to first ED visit showed clear differentiation between DIVERT Scale scores (Appendix S2). The distribution of clients on the DIVERT Scale was positively skewed. Class-level odds ratios between the conventional logistic and multilevel logistic models were consistent (Appendix S3). Despite some variation in the distribution, the predictive performance of the DIVERT Scale across disease diagnoses was consistent.

DISCUSSION

Important Findings

The DIVERT Scale illustrates that previous ED use, cardiorespiratory symptoms, cardiac conditions, and specific geriatric syndromes are prominent drivers of future ED use in home care clients. It is likely that cardiorespiratory symptoms represent immediate and, often, distressing precursors. That the presence of cardiac conditions differentiated risk of ED use between individuals with different cardiorespiratory symptoms suggests that cardiac conditions are markers for the real or perceived severity of cardiorespiratory symptoms. It is likely that the interaction between cardiac conditions and other diagnoses represents the detrimental influence of cardiac-related syndromes and acute decompensation. These results also indicate that mood moderates the influence of functional decline. The observed interaction between previous falls and diabetes mellitus or a recent stroke may represent greater risk of injurious falls due to peripheral neuropathy. It is likely that the effect of falls, ADL decline, and nutritional status for those with no previous ED use or cardiorespiratory symptoms reflects more-generalized risk from unstable geriatric syndromes.

Table 1. Characteristics of the Derivation Sample According to Emergency Department (ED) Use within 6-Months of an In-Home Assessment

Characteristic	All, N = 242,651	Number of ED Visits within 6 Months After Home Care Assessment	
		≥1, n = 99,842 (41.2%)	0, n = 142,809 (58.8%)
Demographic			
Age at assessment, mean ± standard deviation	76.2 ± 14.1	76.1 ± 14.0	76.3 ± 14.3
Female, % (n)	64.2 (155,708)	60.8 (60,730)	66.5 (94,978)
Living alone, % (n)	26.9 (65,159)	26.6 (26,546)	27.0 (38,613)
No co-residing informal caregiver, % (n)	32.0 (77,640)	32.1 (32,037)	31.9 (45,603)
Caregiver expresses distress, % (n)[a]	15.6 (37,928)	16.9 (16,837)	14.8 (21,091)
Clinical, % (n)			
ADL decline (previous 90 days)	42.8 (103,729)	46.9 (46,882)	39.8 (56,847)
Any mood symptoms[b]	36.3 (88,073)	39.5 (39,427)	34.1 (48,646)
Any ADL impairment[c]	31.1 (75,335)	32.6 (32,559)	30.0 (42,776)
Any falls (previous 90 days)	31.3 (75,897)	34.3 (34,280)	29.1 (41,617)
Dyspnea[d]	23.8 (57,841)	28.9 (28,801)	20.3 (29,040)
Poor self-reported health[e]	18.1 (43,884)	21.7 (21,651)	15.6 (22,233)
Cognitive impairment[f]	9.1 (22,161)	8.8 (8,791)	9.4 (13,370)
Weight loss[g]	8.2 (19,949)	10.3 (10,266)	6.8 (9,683)
Any behaviors[h]	4.6 (11,178)	4.8 (4,822)	4.5 (6,356)
Decrease in food or fluids[i]	2.6 (6,247)	3.3 (3,304)	2.1 (2,943)
Diagnosis			
Musculoskeletal[j]	59.2 (143,739)	57.7 (57,578)	60.3 (86,161)
Cardiovascular[k]	42.0 (101,842)	46.7 (46,638)	38.7 (55,204)
Diabetes mellitus	24.5 (59,544)	27.0 (26,942)	22.8 (32,602)
Dementia	17.5 (42,444)	16.5 (16,458)	18.2 (25,986)
Emphysema, chronic obstructive pulmonary disease, asthma	16.5 (40,099)	20.1 (20,024)	14.1 (20,075)
Psychiatric[l]	13.0 (31,545)	13.8 (13,738)	12.5 (17,807)
Cancer	15.8 (38,370)	18.4 (18,412)	14.0 (19,958)
Neurological (not including dementia)[m]	6.0 (14,538)	5.9 (5,872)	6.1 (8,666)
Infection[n]	7.3 (17,704)	8.9 (8,893)	6.2 (8,811)
Renal failure	5.8 (14,077)	7.5 (7,503)	4.6 (6,574)
Hospital use in prior 90 days, % (n)[o]			
Any outpatient ED visits	19.3 (46,846)	24.5 (24,471)	15.7 (22,375)
Hospitalized	31.4 (76,213)	37.7 (37,631)	27.0 (38,582)
ED visits in next 6 months, % (n)[o]			
≥1 (primary outcome)	41.2 (99,842)	100.0 (99,842)	–
≥2 (secondary outcome)	17.5 (42,463)	42.5 (42,463)	–

[a] Primary caregiver expresses feelings of distress, anger, or depression.
[b] Based on interRAI Depression Rating Scale level ≥1.[26]
[c] Based on interRAI activity of daily living (ADL) Hierarchy Scale level ≥1.[27]
[d] Dyspnea at rest or when performing normal day-to-day activities.
[e] When asked, "In general, how would you rate your health?" person responds, "Poor."
[f] Based on interRAI Cognitive Performance Scale level ≥3. Equivalent to between 1 and 15 on the Mini-Mental State Examination.[28]
[g] Weight loss of ≥5% o in last 30 days or ≥10% in last 180 days.
[h] Abusive (physically or verbally), disruptive (including socially inappropriate), wandering, or resisting care.
[i] Noticeable decrease in the amount of food usually eaten or fluids usually consumed.
[j] Arthritis, fracture, or osteoporosis.
[k] Stroke, congestive heart failure, coronary artery disease, or peripheral vascular disease.
[l] Any diagnosed psychiatric disease.
[m] Head trauma, multiple sclerosis, or parkinsonism.
[n] Pneumonia, tuberculosis, or urinary tract infection.
[o] Reference date = home care assessment.

Comparison with Similar Prediction Models and Literature

The DIVERT Scale achieved an AUC of 0.62 (95% confidence interval = 0.61–0.62) and not less than 0.60 in any identified client subgroup. This level of performance is similar to that of prediction tools for ED and hospital admission or readmission,[12,14–16] although precise comparisons of performance with that of similar tools are illusory given that they cannot be compared within the study sample or against the same outcome measure (e.g., type and timeframe). Similarly, conventions for evaluating the discrimination of diagnostic tests may not be appropriate for evaluating case finding tools given that they differ in their purpose, target population, the testing methods used, ideal thresholds of accuracy, cost, and the clinical

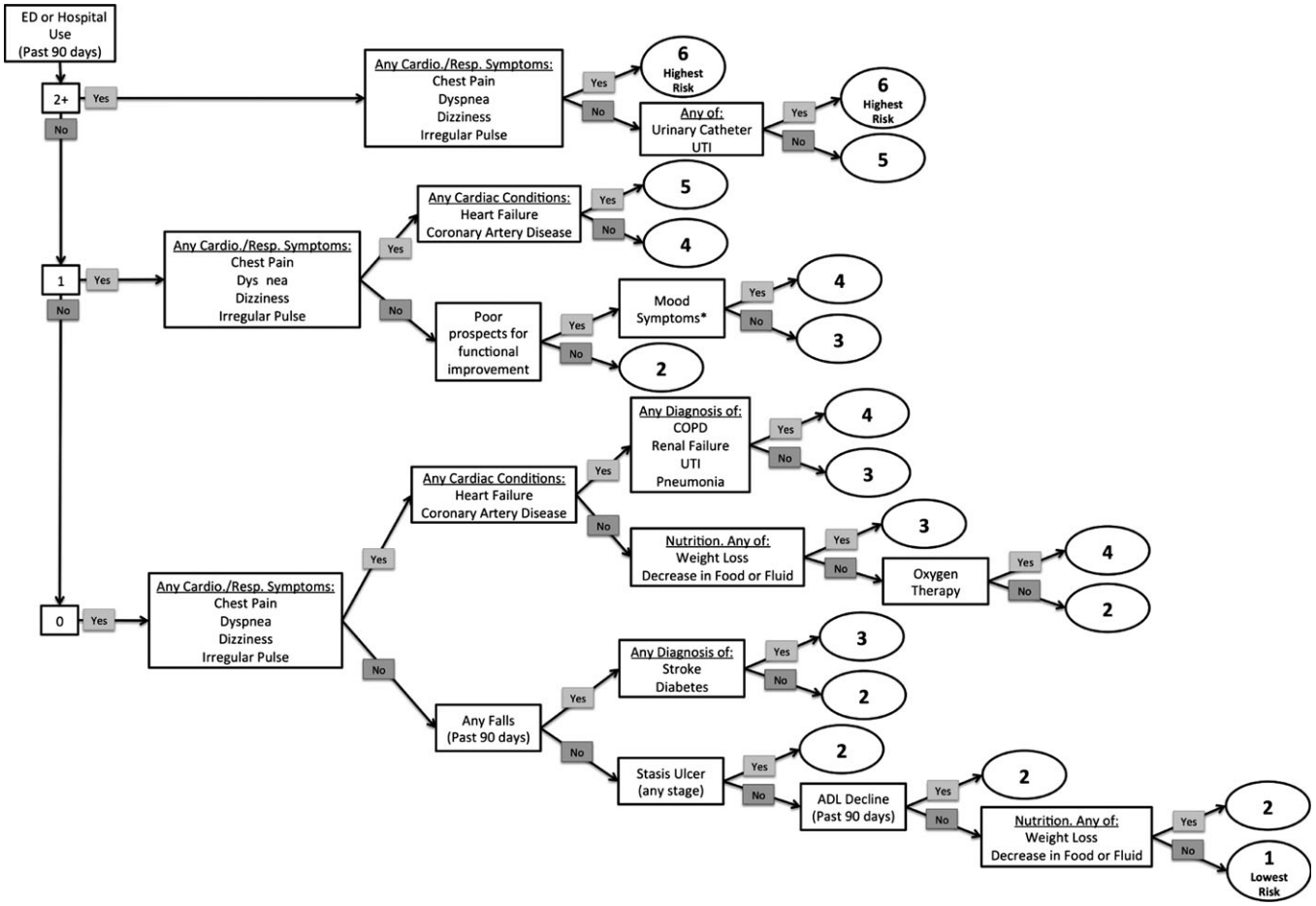

Figure 1. Detection of Indicators and Vulnerabilities for Emergency Room Trips "(DIVERT)" Scale. *Negative statements; persistent anger; expressions of unrealistic fears; repetitive health complaints, repetitive anxious complaints; sad, pained, worried facial expression; or tearfulness.[25] Approximately ≥5% in last 30 days or ≥10% in last 180 days.

Table 2. Distribution, Absolute Risk, Sensitivity, Specificity, and Odds Ratio (OR) of the Detection of Indicators and Vulnerabilities for Emergency Room Trips (DIVERT) Scale for Emergency Department (ED) Visits 6 Months After an In-Home Clinical Assessment, Validation Sample

DIVERT Score Cutpoint	Proportion of Population, %	Proportion with Outcome, %	Sensitivity at Cutpoint	Specificity at Cutpoint	ED Visits within 6 Months After an In-Home Clinical Assessment, OR	
					Any	≥2
1 (reference)	23.8	29.4	–	–	1.0	1.0
2	28.3	36.2	0.83	0.29	1.4	1.3
3	18.3	43.0	0.58	0.59	1.9	1.9
4	16.5	49.3	0.39	0.77	2.4	2.5
5	8.7	57.6	0.19	0.91	3.3	3.7
6	4.4	67.2	0.07	0.98	5.1	5.7
Area under the receiver operating characteristic curve					0.62	0.63

interpretation of a "positive" result. Further inquiry is needed into acceptable standards of discrimination for case finding tools.

The major features of the DIVERT Scale are similar to tools that predict ED and hospital admission or readmission. Consistent with similar studies of community-dwelling older

adults, the current study found that previous use was a strong risk factor.[13,16] The DIVERT Scale was designed for preemptive case finding, rather than postacute risk assessment from the perspective of the hospital episode. As such, it elaborates on predictive factors for persons who have not recently had an acute hospital stay. Also, risk factors related to functional and informal care characteristics were not empirically viable. Their poor predictive validity suggests that informal care strain and functional status may not be sufficient risk factors for ED use in home care clients.

Clinical Implications

Applying intensive preventative efforts to all home care clients is rarely feasible. Therefore there is clinical relevance in systematically identifying clients who are at highest risk of ED use to target enhanced risk assessment or preventative action. Some studies have suggested that case finding tools for similar purposes and with similar discrimination are useful to stratify individuals into clinically meaningful risk gradients and can improve the cost-effectiveness of interventions.[29,30] In addition, prognostic tools are particularly useful when risk is diverse and when many factors contribute to risk.[31] The DIVERT Scale incorporates information that can be acted on that, in addition to risk estimation, can be used to initially target clients into different prevention schemes. For example, clients with unstable cardiorespiratory symptoms and associated cardiac conditions might be considered for referral to a specialist for advanced monitoring, whereas those without associated cardiac conditions may be considered more appropriate for preclinical diagnosis and secondary prevention in primary care.

Although derivation was comprehensive, the use of the DIVERT Scale would be a simple exercise in practice. It can be automatically derived in real time from electronic records based on the RAI-HC standardized assessment used in many countries. It can also be used ad hoc to stratify existing home care clients and review cases at highest risk. 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.

Limitations

Use of the DIVERT Scale is limited to a predominantly frail population of community-dwelling older adults who receive home care services. Country-specific validations should be conducted before widespread use. 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. Although an external sample was not used for validation, the existing validation is robust given the population sample and the use of regional and diagnostic subvalidations.

The DIVERT Scale holds promise as a preemptive case finding tool for home care clinicians, although the preventability of ED visits in the community is understudied and remains unclear. Further work is needed to understand what types and intensity of interventions are feasible and effective in the community. Experimental studies are needed to determine the effectiveness of targeted preventative interventions used in conjunction with the DIVERT Scale.

ACKNOWLEDGMENTS

We gratefully acknowledge the clinical input of Drs. Christophe Bula (Switzerland), Ellen Burkett (Australia), Barry Goldlist (Canada), Len Gray (Australia), Heather Keller (Canada), Marie-Jeanne Kergoat (Canada), Don Melady (Canada), and Fredrik Sjostrand (Sweden).

Findings were presented at the World Congress of Gerontology and Geriatrics, Seoul, South Korea, June 26, 2013, and the Canadian Association for Health Services and Policy Research Annual Conference, Vancouver, British Columbia, May 28, 2013.

This study was funded by a grant from the Public Health Agency of Canada and with collaboration from the Canadian Institute for Health Information.

Conflict of Interest: Andrew P. Costa is supported by the Canadian Institutes of Health Research; Andrew P. Costa, John P. Hirdes, George A. Heckman, and Samir K. Sinha are members of interRAI, a not-for-profit network of researchers in more than 30 countries that produce assessment instruments. This work and any views expressed within it are solely those of the authors. The funders and collaborating organizations had no role in the study design, analysis, interpretation, or writing of the manuscript. No other relationships or activities that could appear to have influenced the submitted work.

Author Contributions: Costa, Hirdes: study concept and design in consultation with the authors. All authors: data interpretation, critical revision of manuscript for important intellectual content, approval of final version submitted for publication. All authors take responsibility for the integrity of the data and the accuracy of the data analysis. Andrew P. Costa is guarantor of the paper.

Sponsor's Role: None.

REFERENCES

1. Aminzadeh F, Dalziel WB. Older adults in the emergency department: A systematic review of patterns of use, adverse outcomes, and effectiveness of interventions. Ann Emerg Med 2002;39:238–247.
2. Pines JM, Mullins PM, Cooper JK et al. National trends in emergency department use, care patterns, and quality of care of older adults in the United States. J Am Geriatr Soc 2013;61:12–17.
3. Kellermann AL, Martinez R. The ER, 50 years on. N Engl J Med 2011;364:2278–2279.
4. Langa KM, Chernew ME, Kabeto MU et al. The explosion in paid home health care in the 1990s: Who received the additional services? Med Care 2001;39:147–157.
5. Health Council of Canada. Seniors in Need, Caregivers in Distress: What Are the Home Care Priorities for Seniors in Canada? Toronto: Health Council of Canada, 2012.
6. Carrière G. Seniors' Use of Home Care. Ottawa: Health Statistics Division, Statistics Canada, 2006.
7. Wilson D, Truman C. Comparing the health services utilization of long-term-care residents, home-care recipients, and the well elderly. Can J Nurs Res 2005;37:138–154.
8. Alessi CA, Stuck AE, Aronow HU et al. The process of care in preventive in-home comprehensive geriatric assessment. J Am Geriatr Soc 1997;45:1044–1050.
9. Stuck AE, Aronow HU, Steiner A et al. A trial of annual in-home comprehensive geriatric assessments for elderly people living in the community. N Engl J Med 1995;333:1184–1189.

10. Stuck AE, Elkuch P, Dapp U et al. Feasibility and yield of a self-administered questionnaire for health risk appraisal in older people in three European countries. Age Ageing 2002;31:463–467.
11. van Rossum E, Frederiks CM, Philipsen H et al. Effects of preventive home visits to elderly people. BMJ 1993;307:27–32.
12. Buurman BM, van den Berg W, Korevaar JC et al. Risk for poor outcomes in older patients discharged from an emergency department: Feasibility of four screening instruments. Eur J Emerg Med 2011;18:215–220.
13. Salvi F, Morichi V, Dessì-Fulgheri P. The "Silver Code" and the frail elder in the emergency department. J Gerontol A Biol Sci Med Sci 2010;65A:159–164.
14. Crane SJ, Tung EE, Hanson GJ et al. Use of an electronic administrative database to identify older community dwelling adults at high-risk for hospitalization or emergency department visits: The Elders Risk Assessment Index. BMC Health Serv Res 2010;10:338.
15. Boult C, Dowd B, McCaffrey D et al. Screening elders for risk of hospital admission. J Am Geriatr Soc 1993;41:811–817.
16. Shelton P, Sager MA, Schraeder C. The Community Assessment Risk Screen (CARS): Identifying elderly persons at risk for hospitalization or emergency department visit. Am J Manag Care 2000;6:925–933.
17. Landi F, Tua E, Onder G et al. Minimum Data Set for home care: A valid instrument to assess frail older people living in the community. Med Care 2000;38:1184–1190.
18. Hirdes JP, Ljunggren G, Morris JN et al. Reliability of the interRAI suite of assessment instruments: A 12-country study of an integrated health information system. BMC Health Serv Res 2008;8:277.
19. Berg K, Finne-Soveri H, Gray L et al. Relationship between interRAI HC and the ICF: Opportunity for operationalizing the ICF. BMC Health Serv Res 2009;9:47.
20. Fialová D, Topinková E, Gambassi G et al. Potentially inappropriate medication use among elderly home care patients in Europe. JAMA 2005;293:1348–1358.
21. Guttmann A, Schull MJ, Vermeulen MJ et al. Association between waiting times and short term mortality and hospital admission after departure from emergency department: Population based cohort study from Ontario, Canada. BMJ 2011;342:d2983.
22. Kass GV. An exploratory technique for investigating large quantities of categorical data. Appl Stat 1980;29:119–127.
23. Breiman L, Friedman JH, Olshen RA et al. Classification and Regression Trees. Monterey, CA: Cole Advanced Books & Software, 1984.
24. Westgate PM. A bias correction for covariance estimators to improve inference with generalized estimating equations that use an unstructured correlation matrix. Stat Med 2013;32:2850–2858.
25. von Elm E, Altman DG, Egger M et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for reporting observational studies. BMJ 2007;335:806–808.
26. Burrows AB, Morris JN, Simon SE et al. Development of a Minimum Data Set-based depression rating scale for use in nursing homes. Age Ageing 2000;29:165–172.
27. Morris JN, Fries BE, Morris SA. Scaling ADLs within the MDS. J Gerontol A Biol Sci Med Sci 1999;54A:M546–M553.
28. Hartmaier SL, Sloane PD, Guess HA et al. The MDS Cognition Scale: A valid instrument for identifying and staging nursing home residents with dementia using the Minimum Data Set. J Am Geriatr Soc 1994;42:1173–1179.
29. Billings J, Dixon J, Mijanovich T et al. Case finding for patients at risk of readmission to hospital: Development of algorithm to identify high risk patients. BMJ 2006;333:327.
30. Mukamel DB, Chou CC, Zimmer JG et al. The effect of accurate patient screening on the cost-effectiveness of case management programs. Gerontologist 1997;37:777–784.
31. Manuel DG, Rosella LC, Hennessy D et al. Predictive risk algorithms in a population setting: An overview. J Epidemiol Community Health 2012;66:859–865.

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Variables for classification tree analyses by clinical domain and mean panel ranking, derivation sample.

Appendix S2. Kaplan–Meier curve for days to first ED visit within 6 months of an in-home assessment, by DIVERT scale, validation sample.

Appendix S3. Comparison of conventional logistic and multilevel generalized models for the clustering of home care agency/health region and patient, random validation subsample (N = 77,131).

Please note: Wiley-Blackwell is not responsible for the content, accuracy, errors, or functionality of any supporting materials supplied by the authors. Any queries (other than missing material) should be directed to the corresponding author for the article.