

Predicting the Risk of Hospital Admission in Older Persons—Validation of a Brief Self-Administered Questionnaire in Three European Countries

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OBJECTIVES: To validate the Probability of Repeated Admission (Pra) questionnaire, a widely used self-administered tool for predicting future healthcare use in older persons, in three European healthcare systems.

DESIGN: Prospective study with 1-year follow-up.

SETTING: Hamburg, Germany; London, United Kingdom; Canton of Solothurn, Switzerland.

PARTICIPANTS: Nine thousand seven hundred thirteen independently living community-dwelling people aged 65 and older.

MEASUREMENTS: Self-administered eight-item Pra questionnaire at baseline. Self-reported number of hospital admissions and physician visits during 1 year of follow-up.

RESULTS: In the combined sample, areas under the receiver operating characteristic curves (AUCs) were 0.64 (95% confidence interval (CI) = 0.62–0.66) for the prediction of one or more hospital admissions and 0.68 (95% CI = 0.66–0.69) for the prediction of more than six physician visits during the following year. AUCs were similar between sites. In comparison, prediction models based on a person's age and sex alone exhibited poor predictive validity (AUC \leq 0.57). High-risk individuals (Pra score \geq 0.5) were 2.3 times as likely (95% CI = 2.1–2.6) as low-risk individuals to have a hospital admission, and 2.1 times as likely (95% CI = 2.0–2.2) to have more than six physician visits.

CONCLUSION: The Pra instrument exhibits good validity for predicting future health service use on a population level in different healthcare settings. Administrative data have shown similar predictive validity, but in practice, such data are often not available. The Pra is likely of high interest to governments and health insurance companies worldwide as a basis for programs aimed at health risk management in older persons. *J Am Geriatr Soc* 54:1271–1276, 2006.

Key words: health service use; risk assessment; prediction; validity; questionnaire

Healthcare expenditures for older persons are concentrated in a small group of high-risk individuals.^{1,2} For example, in the United States, the costliest 5% of Medicare beneficiaries accounted for 48% of annual fee-for-service spending in 2003, whereas the least costly half of beneficiaries accounted for only 3%.² Of health service use, hospital admissions are particularly important, because they account for the majority of overall healthcare costs (e.g., in the United Kingdom, hospital expenditure accounted for 81% of costs for patient services)³ and are known to frequently constitute the starting point of further decline in health and mobility in older people.⁴ As a consequence, in the United States, a number of survey instruments have been developed to identify populations of community-dwelling older persons at high risk of future hospital admission.^{5–9}

The best validated and one of the most widely used self-administered instruments for prediction of future hospital admission in community-dwelling elderly populations is the Probability of Repeated Admission (Pra) questionnaire.⁵ This eight-item tool has been shown to have high test-retest reliability and validity for prediction of diverse health-related outcomes in different populations of older persons in North America.^{5,10–17} Historically, the Pra formula was derived from a logistic model that predicted more than one hospital admission in the following 4 years.⁴ A subsequent study found that the score is comparably accurate in

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DOI: 10.1111/j.1532-5415.2006.00829.x

predicting one or more hospital admissions during a 1-year follow-up period.¹⁷ It has also been used to target geriatric evaluation and management programs in Medicare/Medicaid and older veteran populations.^{18–22} In the United States, organizations typically involved in managed care, disease management, and case management have shown interest in use of the instrument. Currently, 16 U.S. organizations and one Puerto Rican organization hold active licenses to use the Pra.

Outside the United States, screening tools for outcomes such as functional decline have been developed²³ and validated²⁴ in older persons, but no instrument has specifically been designed for prediction of future hospital admission in a community-dwelling population.

Findings from North American studies might not be generalizable to settings outside of the United States, because the type of healthcare system or other factors related to the regional environment might influence the validity. Factors such as the availability of hospital beds, number and type of ambulatory physicians delivering primary and specialist care, hospital and physician payment system, or financial incentives related to healthcare use may strongly influence health resource utilization. Therefore, determinants of healthcare use of older people may differ between the United States and countries with different healthcare systems. The purpose of the present study was to determine the validity of the Pra instrument for predicting future health service use over a 12-month period in older populations from three countries with different health care systems: the United Kingdom, Germany, and Switzerland.

METHODS

Context of the Study

The analysis was based on baseline and 1-year follow-up data collected in the PRevention in Older people—Assessment in GEneralists' practices (PRO-AGE) Trial (International Standard Randomised Controlled Trial Number 28458424), a multinational, randomized, controlled study designed to evaluate the effects of a health-risk appraisal-based intervention in community-dwelling older people using a health-risk appraisal system.²⁵ The local institutional ethical committees approved the study.

Study Population and Data Collection

For recruitment of participants, 84 general practitioners from Hamburg (Germany), London (United Kingdom), and Solothurn (Switzerland) were involved. In total, the participating physicians assessed 22,515 individuals, who were enrolled in their practices, for eligibility. Inclusion criteria for participation were independent community living and aged 65 (Hamburg: 60) and older. Based on a priori criteria, 3,583 persons were excluded, because they had cognitive impairment ($n = 1,153$), required human assistance in performing one or more basic activities of daily living (ADLs) or were residing in a nursing home ($n = 1,682$), had terminal disease ($n = 505$), or were not able to speak the native language ($n = 243$).

The remaining 18,932 individuals were sent a brief self-administered questionnaire containing the Pra questionnaire,⁵ an additional question on need for human help in basic ADLs,²⁶ and a consent form for participation in the

main study. The Pra questionnaire was administered, because stratified analyses of intervention effects were planned based on Pra risk scores. Nine thousand two hundred nineteen persons were not eligible for this study because of not returning the questionnaire ($n = 7,550$), returning an incompletely filled out questionnaire ($n = 404$), self-reported need for human assistance in basic ADLs ($n = 462$), or other reasons ($n = 4$). Also, persons younger than 65 ($n = 799$ from Hamburg sample) were excluded for the purpose of the present secondary analysis. Of the remaining 9,713 individuals, 428 were not eligible for follow-up, because they had died ($n = 192$), moved away ($n = 72$), entered a nursing home or were referred to nursing care ($n = 41$), or were lost to follow-up ($n = 123$). The remaining 9,285 seniors were sent a self-administered follow-up questionnaire one year after baseline. Two thousand twenty-six did not return it. Of those returning the questionnaire, 335 did not answer the question on hospital admission at follow-up, and 313 did not answer the question on physician visits at follow-up. For the present analyses, the denominator was 6,924 for the analyses of hospital admission outcome and 6,946 for the analyses of physician visit outcome.

Measures

The Pra instrument is based on eight items (age, sex, self-perceived health, number of hospital admissions in previous year, number of physician visits in previous year, presence of diabetes mellitus, presence of coronary heart disease, and availability of a caregiver), which are combined in a weighted score.^{5,12}

The outcome measures investigated were self-report of one or more overnight hospital stays (main outcome) and self-report of more than six physician visits (secondary outcome) during the 12 months of follow-up. Both outcomes were assessed using a categorical question with four (hospital admissions: 0, 1, 2, ≥ 3 within the previous year) and five (physician visits: 0, 1, 2–3, 4–6, > 6 within the previous year) answer categories.

Statistical Analyses

Baseline characteristics of study participants were tabulated using descriptive statistical methods. The areas under the receiver operating characteristic (ROC) curves (AUCs) were derived using nonparametric ROC curve analysis. AUCs were determined for each site separately and for the three sites combined. High- to low-risk ratios were calculated by classifying persons with a Pra score of 0.5 or higher as high-risk, according to previous trials.¹² To determine how age and sex alone would predict future hospital admission, AUCs were calculated based on logistic regression models that contained hospital admission as the dependent variable and age and sex as independent factors. Furthermore, relative risks for hospital admission were calculated using age 75 and 80 as cutoff values.

In addition, several sensitivity analyses were conducted. First, whether random allocation of study participants to intervention and control groups may have affected the findings was explored. For this purpose, logistic regression models containing only the Pra score as independent variable were compared with models also containing an indicator variable for random allocation of participants and an

interaction term between random allocation and different Pra score levels (75th or 95th percentile) using likelihood ratio statistics. Second, whether participating persons differed from those who did not participate at follow-up was investigated. Nonparticipating persons included persons who had not returned the questionnaire and persons who had returned the questionnaire but not answered the question on hospital use at follow-up (n = 2,361). Third, all analyses were repeated after exclusion of persons younger than 70, because the score has been developed in a U.S. population of persons aged 70 and older. All analyses were performed using the STATA 8.2 statistical software package (StataCorp, College Station, TX).

RESULTS

Baseline Characteristics

Baseline characteristics are summarized in Table 1. The highest mean Pra score was measured in Hamburg (0.301), followed by Solothurn (0.287) and London (0.270). The proportion of participants at high risk (Pra score ≥ 0.5) was 7%, 5%, and 4%, respectively. Differences between sites were most evident for fair or poor self-rated health (38% in Hamburg, 24% in London, and 21% in Solothurn), one or more hospital admissions in the 12 months before baseline (23%, 14%, and 19%), and more than six physician visits in the 12 months before baseline (51%, 23%, and 25%).

In addition, Table 1 depicts the corresponding baseline data of the U.S. study population that was used for developing the original Pra score. This sample included 5,876 noninstitutionalized U.S. civilians aged 70 and older. As a result, the age distribution of the U.S. population differs from the three European populations, although most baseline factors were similar between the U.S. and European samples. For example, the proportion of high-risk persons (Pra score ≥ 0.5) was 7% in the U.S. population, compared with 4% to 7% in the three European samples.

Performance of the Pra Score

Table 2 displays the accuracy of the Pra score for predicting one or more hospital admissions and more than six physician visits in the following year for the three study sites and for all sites combined. The AUCs were 0.64 (95% confidence interval (CI) = 0.62–0.66) for the main and 0.68 (95% CI = 0.66–0.69) for the secondary outcome in the combined study sample. AUCs were similar in the three study sites.

Based on the pooled results across the three study sites, high-risk individuals (Pra score ≥ 0.5) were 2.3 times as likely (95% CI = 2.1–2.6) as low-risk individuals (Pra score < 0.5) to be admitted to a hospital in the following year. Similarly, they were 2.1 times as likely (95% CI = 2.0–2.2) as low-risk individuals to reporting more than six physician visits in the following year. These high- to low-risk ratios showed notable differences between the study sites, ranging from 1.7 (95% CI = 1.6–2.0; Solothurn) to 3.6 (95% CI = 2.7–4.9; London) for the main outcome and from 1.6 (95% CI = 1.6–1.7; Hamburg) to 2.7 (95% CI = 2.3–3.1; Solothurn) for the secondary outcome.

ROC curve analysis for prediction of the main outcome based on age and sex alone resulted in AUCs of 0.57 or less (Hamburg, 0.56; London, 0.57; Solothurn, 0.54). Persons aged 75 and older were 1.3 times as likely (95% CI = 1.1–1.5) as persons younger than 75 of being admitted to a hospital in the following year. The results were similar when using a cutoff of 80.

Sensitivity Analyses

Sensitivity analyses revealed that the results for the main outcome were independent of group assignment of study participants. For the secondary outcome, in London, likelihood ratio comparison revealed a statistically significant difference between the study groups (P = .03); 26% of

Table 1. Baseline Characteristics of Study Participants with Complete Data for Hospital Admissions During Follow-Up from Hamburg (N = 1,820), London (N = 2,441), and Solothurn (N = 2,663) and Participants in the Probability of Repeated Admission (P_{ra}) Score Derivation Study⁵ (N = 5,876)

Baseline Characteristic	Hamburg	London	Solothurn	Boult 93
P_{ra} score				
Mean ± standard deviation	0.301 ± 0.117	0.270 ± 0.105	0.287 ± 0.107	—
Range	0.099–0.712	0.073–0.712	0.093–0.707	—
≥0.5, n (%)	132 (7)	94 (4)	137 (5)	(7)*
Male, n (%)	670 (37)	1,105 (45)	1,160 (44)	(43)
Caregiver available, n (%)	1,472 (81)	2,048 (84)	2,372 (89)	(93)
Age, n (%)				
65–69	577 (32)	692 (28)	799 (30)	—
70–74	522 (29)	708 (29)	778 (29)	(43)
75–79	397 (22)	565 (23)	608 (23)	(31)
80–84	209 (11)	327 (14)	338 (13)	(16)
≥85	115 (6)	149 (6)	140 (5)	(10)
Fair or poor self-rated health, n (%)	696 (38)	591 (24)	551 (21)	(32)
≥1 hospital admissions in previous year, n (%)	413 (23)	339 (14)	501 (19)	(21)
> 6 physician visits in the previous year, n (%)	936 (51)	551 (23)	669 (25)	(21)
Coronary heart disease, n (%)	370 (20)	406 (17)	588 (22)	(17)
Diabetes mellitus, n (%)	196 (11)	186 (8)	288 (11)	(10)

* N = 2,943; random split sample of total study population.

Table 2. Prediction of ≥ 1 Hospital Admissions and > 6 Physician Visits During 1 Year of Follow-Up in Older Persons Living in Hamburg (N = 1,820), London (N = 2,441), and Solothurn (N = 2,663): Area Under the Receiver Operating Characteristic Curves (AUCs), Observed Outcome, and High- to Low-Risk Ratio

	Hamburg	London	Solothurn	Combined Sites
Prediction of ≥ 1 hospital admissions, AUC (95% CI)	0.62 (0.59–0.65)	0.67 (0.64–0.70)	0.62 (0.59–0.65)	0.64 (0.62–0.66)
Persons with ≥ 1 hospital admissions, n (%)	463 (25)	377 (15)	623 (23)	1,463 (21)
High-risk subjects with ≥ 1 hospital admissions (P_{ra} score ≥ 0.5), n (%)	63 (48)	48 (51)	54 (39)	165 (45)
Low-risk subjects with ≥ 1 hospital admissions (P_{ra} score < 0.5), n (%)	400 (24)	329 (14)	569 (23)	1,298 (20)
Prediction of ≥ 1 hospital admissions: high- to low-risk ratio (95% CI)	2.0 (1.8–2.3)	3.6 (2.7–4.9)	1.7 (1.6–2.0)	2.3 (2.1–2.6)
Prediction of > 6 physician visits, AUC (95% CI)	0.63 (0.61–0.66)	0.68 (0.65–0.70)	0.70 (0.68–0.73)	0.68 (0.66–0.69)
Persons with > 6 physician visits, n (%)	907 (50)	613 (25)	706 (26)	2,226 (32)
High-risk subjects with > 6 physician visits (P_{ra} score ≥ 0.5) – n (%)	98 (76)	43 (45)	93 (65)	234 (64)
Low-risk subjects with > 6 physician visits (P_{ra} score < 0.5) – n (%)	809 (48)	570 (24)	613 (24)	1,992 (30)
Prediction of > 6 physician visits: high- to low-risk ratio (95% CI)	1.6 (1.6–1.7)	1.9 (1.6–2.2)	2.7 (2.3–3.1)	2.1 (2.0–2.2)

CI = confidence interval; P_{ra} = probability of repeated admission.

seniors in the control group versus 22% in the intervention group had more than six physician visits during follow-up.

The comparison between participating and nonparticipating persons revealed that the distribution of P_{ra} scores did not differ between the two groups (mean P_{ra} score \pm standard deviation in both groups 0.29 ± 0.11). Similarly, the proportion of persons with P_{ra} scores of 0.5 or higher was comparable between the two groups (5.2% in participating persons; 5.9% in nonparticipating persons; $P = .19$). There were statistically significant but numerically minor differences in age (participating persons 74.2 ± 6.1 ; nonparticipating persons 75.3 ± 6.5 ; $P < .001$) and sex (proportion of men among participating persons 42.4%; among nonparticipating persons 38.3%; $P < .001$) between the two groups.

Finally, the sensitivity analyses based on subjects aged 70 and older (after exclusion of persons < 70) gave similar results, except for larger CIs because of a smaller sample size.

DISCUSSION

This is, to the authors' knowledge, the first validation of the P_{ra} instrument in healthcare systems outside of the United States. In all three study sites and for both outcomes, the AUCs varied between 0.62 and 0.70, indicating an acceptable level of accuracy. The predictive accuracy of the P_{ra} score was substantially greater than prediction based on age and sex alone, which yielded AUCs not higher than 0.57. The score performance in prediction of future hospital admission was in good agreement with that found in former studies of the P_{ra} instrument^{5,11–14,17} and other scoring systems derived in Northern American populations.^{6–9} The P_{ra} was comparably accurate in predicting a high number of physician visits in the following year, an outcome that

has not been evaluated in previous U.S. studies. Although there were not significant differences in AUCs between study sites, the high- to low-risk ratios varied substantially according to site and outcome (between 1.6 and 3.6, as depicted in Tables 2 and 3). The inverse relationship between risk ratios and outcome incidences, which varied markedly between sites, partially explains this.

A limitation of this study is that it is based on populations that are not representative of older noninstitutionalized persons in the three countries. Only persons registered with general practitioners in selected regions of each country were invited to participate, and persons with functional or cognitive impairment were excluded from study participation. Although the present study cannot be generalized to older persons with disability or dementia for this reason, there is sufficient evidence to indicate that the P_{ra} instrument has a good predictive validity in older subpopulations including older persons with cognitive impairment and functional limitations.¹² There is a concern that population selection might have resulted in a subgroup of healthy older persons with a low level of healthcare utilization, although the findings of the present study do not support this concern. In fact, healthcare utilization rates found in the selected populations as reported in this study are comparable with the corresponding rates in the three countries.^{27,28}

There are additional potential limitations. First, outcome variables relied on self-report, which may have affected the validity of the analyses. Nevertheless, although some studies found that older persons tend to underreport health service use,²⁹ most studies confirm that self-reported information gives acceptable estimates of actual hospital use.^{14,30} In addition, the fact that rates of hospital admissions and physician visits in the present study are in good agreement with corresponding national rates^{27,28} supports

the assumption that the present self-reported data do not introduce bias. Second, analyses are based on data derived from a randomized, controlled trial, and potential confounding of results due to the intervention must be considered. The purpose of the intervention was related to health promotion and preventive care in the primary practice setting and not to hospital care. The analyses confirmed that the intervention did not have an effect on hospital use, thus supporting that there was no confounding effect of the intervention on the prediction of hospital admissions. Furthermore, it is unlikely that the intervention resulted in confounding of findings related to physician use, because the intervention had no effect on this outcome in Solothurn and Hamburg and only a minor effect in London. Finally, 25% of persons with available baseline information had missing information for hospital use, although the similarity in baseline Pra scores between persons responding at follow-up and those with missing information at follow-up makes it unlikely that this had an effect on the estimates.

The study has practical implications. Together with earlier evidence from previous U.S.-based studies, the present findings support use of the Pra instrument in countries other than the United States. The tool has potential clinical use, because previous studies have shown that older persons at risk of future hospital admission identified by the Pra may benefit from targeted geriatric evaluation and management.^{18,21} Additionally, on a population level, the Pra could be considerably better at risk adjustment than systems based on age and sex alone, which are in common use in Europe. In the past, organizations typically involved in risk assessment or risk management have shown interest in use of the Pra. In Europe, increasing healthcare costs of older persons directly affect health insurance companies and governments, which to some extent use managed care, disease management, case management, and other risk management approaches to influence this risk. Administrative data have shown similar predictive validity,³¹ but in practice, there are often subgroups of older persons for whom such data might not be available. Therefore, the Pra instrument is likely to be of great interest to governments and health insurance companies worldwide as a basis for programs aimed at health risk management in older persons. The promising results of the present study supporting the validity of the Pra in different healthcare systems may encourage governments and health insurance companies to consider using this approach.

ACKNOWLEDGMENTS

Financial disclosure: The PRO-AGE trial was supported by grants of the European Union (QLK6-CT-1999-02205), the Federal Education and Science Ministry (Bern, Switzerland, BBW 990311.1), the Swiss National Science Foundation (32-52804.97), the Swiss Foundation for Health Promotion (Project no. 398), and the Velux Foundation. The trial has been assigned the International Standard Randomized Controlled Trial Number ISRCTN 28458424. The intervention program in Hamburg was supported by the Bundesministerium für Familie, Senioren, Frauen und Jugend and the Max und Ingeburg Herz Foundation. Jan Wagner was supported by a Fellowship Grant from the

Robert Bosch Foundation. Lucas Bachmann's work (grants no. 3233B0-103182 and 3200B0-103183) was supported by the Swiss National Science Foundation. Ulrike Dapp (Hamburg) and Kalpa Kharicha (London) contributed to the conduct of the study and to data collection, and Gerhard Gillmann (Bern) and Eva Blozik (Bern) contributed to data analysis. The authors have no conflicts of interest to declare.

Author Contributions: Jan Wagner and Lucas M. Bachmann: study design, data analysis, data interpretation, preparation of manuscript. Chad Boulton, Matthias Egger, and John Beck: study design, data interpretation, preparation of manuscript. Danielle Harari and Wolfgang von Renteln-Kruse: conduct of the study, data collection, preparation of manuscript. Andreas Stuck: study design, conduct of the study, data collection, data interpretation, preparation of manuscript.

Sponsor's Role: The sponsors had no role in the design, methods, subject recruitment, data collection, analysis, or manuscript preparation.

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