

## Development of a Comorbidity Score Based on Institutionalization: Comparative Performance with a Comorbidity Score Modeled on Mortality

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### Abstract

**Background:** Comorbidity scores based on the prediction of 1-year mortality risk are used in pharmacoepidemiologic and pharmaco-economic research to control for unmeasured confounding. However, admission to a long-term care institution may be a more salient and discriminant outcome on which to base comorbidity scores.

**Objective:** To develop a prescription claims-based comorbidity score to predict institutionalization in the community-dwelling elderly population, and to compare its performance against existing mortality comorbidity scores.

**Methods:** A geriatric institutionalization comorbidity index was derived from data of a retrospective cohort of 61,172 community-dwelling older adults identified through the Quebec claims databases (2000-2009). Predictors of institutionalization were identified through clinical expertise and by nested case-control analysis. The Framingham Heart Study method was used to develop the score. The performance of the score was assessed through the c-statistic in a separate validation cohort of 26,216 persons and compared with the performance of a mortality score, the Geriatric Comorbidity Index. The robustness was assessed in a cohort of elderly individuals with dementia.

**Results:** Drugs associated with an increased risk of institutionalization were: antipsychotics, antidepressants, hypoglycaemic agents, statins, benzodiazepines and antihypertensives. The mean score assigned to cases was significantly different from that of controls. The c-statistic for the Institutionalization Comorbidity Index was 0.79 (95% CI: 0.77-0.83) compared to 0.75 (95% CI: 0.73-0.78) for the mortality index. The score was robust when in the dementia cohort Comorbidity Index was 0.81 95% CI: 0.78-0.84).

**Conclusion:** A score that predicts institutionalization in the community-dwelling elderly population offers improvement over existing comorbidity scores. It may therefore be used in research conducted in this population, especially for drug effectiveness and health economic studies which often involve institutionalization as the outcome of interest.

**Keywords:** Comorbidity score; Pharmacoepidemiology; Claims databases; Elderly; Unmeasured confounders; Mortality; Institutionalization; Performance

### Introduction

Accounting for a large portion of health care expenditures, institutionalization is considered to be an important patient outcome in real world studies conducted in the elderly population [1]. Furthermore, it is well known that institutionalization is associated with several adverse outcomes such as poor quality of life, loss of independence and even mortality [2]. Institutionalization and admission to long-term care represents an important outcome in clinical studies involving the elderly population, as well as a costly endpoint in health economic studies. As the numbers of older adults increase, the demand for long term care services will increase too.

Comorbidity scores have previously been developed in order to address unmeasured confounders in claims databases. Health care claims databases are a critical source of data from which to conduct health services and epidemiologic research. These databases are easy to obtain, relatively inexpensive and contain a large bank of population-based health information. Database linkage leads to the accumulation of longitudinal data on prescriptions and medical services as well as health outcomes in large populations. However, the advantages of these databases for their use in research are offset by the absence of clinical information which is often not recorded in claims data.

Among the most widely comorbidity score used are the von

Korff Chronic Disease Score (CDS), based on prescription claims [3], and the Charlson Index, based on medical services claims [4]. Both involve scores that predict the risk of mortality in the following year [5-9]. However, as shown by Mikaeloff et al. mortality may not be the most relevant outcome in certain sub-populations, such as that of the infant population, due to its very low frequency [10]. In contrast, in the elderly population a more salient outcome to mortality is disability-free survival or its corollary, admission to long-term care. Comorbidity indices published in the literature typically include asymptomatic medical conditions, such as hypertension, that predict mortality but exclude many diagnoses related to quality of life, such as urinary incontinence and depression. Schneeweiss et al. determined that the predictive performance of claims-based comorbidity scores

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depends on several factors, such as the choice of study outcome and the target population [11]. In the elderly population, a score based on mortality is most appropriate to address research questions related to survival as opposed to outcomes, such as disability-free survival, institutionalization, hospitalization, morbidity, quality of life and health care costs [12]. As such, institutionalization may be a more relevant outcome than death when constructing comorbidity scores for the elderly, for cost reasons as well as those related to patient preference. Older adults report fear of losing their autonomy, their dignity and to be abandoned by their family. Because of this, institutionalization is not really an option but more a must.

Persons aged 65 years and older are expected to account for 30% of the population by the year 2050 [13]; hence costs associated with the aging population will continue to grow.

It is important to develop tools that are specific and relevant to elderly population since many pharmacoepidemiologic and pharmaco-economic studies will be performed in the next few years. In addition, the elderly have been identified by the FDA as a population vulnerable to drug-induced adverse effects [14]. Yet, they are rarely included in pre-approval randomized controlled trials. Consequently, at the present time, evidence on the benefits and harms of drugs in this population is mainly generated through real world studies

In a previous study, we have developed the Geriatric Comorbidity Score (GCS), which is based on the risk of mortality in the following year. This prescription claims-based score was developed using the Framingham Study methodology [15]. Potential predictors of mortality were initially selected through a comprehensive literature review and clinical expert opinions. A multivariable logistic regression analysis was then conducted to retain the final predictors to be included in the score. Our validation assessment has shown that the GCS yields higher performances than the von Korff CDS in the sub-population of community-dwelling elderly. We hypothesize that such performance may be further improved with the use of institutionalization as the outcome of interest instead of mortality. The objectives of our study were to develop a prescription claims-based comorbidity score to predict the risk of institutionalization in a community-dwelling elderly population, and to compare the performance of such score with that of the Geriatric Comorbidity Score, which is based on mortality. As secondary objective, we wanted to assess the factors associated with institutionalization.

## Methods

### Design Overview

The development of the score was based on a nested case-control analysis. This design was selected for its ability to control for confounding variables in a time window that is proximal to the occurrence of the outcome [16]. A cohort study design was not retained for the development stage since time dependent analyses of exposure variables may result in complex scores, which may not be suitable for use in most clinical health services or epidemiologic models. However, since our score will be used in many different designs, we tested the performance of our new institutionalization score using a cohort study design.

### Data sources

The public drug program of the province of Quebec (Canada) covers the great majority (>97%) of residents of the province age 65 and over. The program is administered by the Régie de l'assurance

maladie du Québec (RAMQ), and the resulting prescription claims database includes the following information on each dispensing: drug name, drug class (using the American Hospital Formulary Classification), dosage, number of units, prescribed duration (from which can be derived prescribed daily dosage), date of dispensing, prescriber's specialty. The program covers medications included in the drug formulary and dispensed in an outpatient setting; over-the-counter medication or those dispensed in-hospital are not recorded in the RAMQ prescription database.

Health coverage is universal in Quebec, i.e. all residents are covered regardless of age or income. The resulting database includes information on medical services that are billed on a fee-for-service basis whether they are rendered in outpatient clinics, emergency rooms, or hospitals. Among the variables included in the medical services database are: date of service, physician's specialty, diagnosis (according to the ICD-9 classification), type of service (medical act) and location of service. In addition, through the beneficiaries' databases, data on age and gender are available. Databases may be linked through the health insurance number which is unique for each patient and remains unchanged over time.

### Definition of the cohort

The study population consisted of a cohort of 87,392 community-dwelling elderly ages 66 and over who were randomly sampled from members of the public drug program from 1<sup>st</sup> January 2001 to 31<sup>st</sup> December 2009. Age 66 was chosen as the lower limit since a one-year prescription history was required for all patients. Patients who were users of cholinesterase inhibitors were excluded because, in Quebec, the reimbursement of these drugs is conditional on their effectiveness, i.e. criteria for reimbursement include assessment of cognitive status and decline. Inclusion of these drugs in the development of the score would have likely resulted in a protopathic bias. Also, it is important to note that dementia is one of the most important predictor of institutionalization. By including demented patients, the majority of the variance would have been taken by this variable.

To optimize statistical efficiency, 70% of the cohort was used for the construction of the score and 30% for its validation.

### Follow-up

Cohort members were followed until the first of the following events: i) institutionalization; ii) end of their coverage in the public drug program due to discontinuation of residency; iii) mortality; iv) end of the study period (31<sup>st</sup> December 2009).

### Identification of cases and controls

Patients institutionalized during the follow-up period were retained as cases. Institutionalization was identified through the location of services billed by physicians. The date of occurrence was the first date for which a service was billed at an institution, and was retained as the index date. For each case, on the date of institutionalization, up to 4 controls were selected through risk set sampling. Controls were matched on the year of entry in the main cohort, age (65-74, 75-79, 80-84, 85 and over), and gender. The same index date as the case was assigned to the matched controls.

### Independent variables

Potential predictors of institutionalization were selected based on their clinical relevance and evidence from the literature concerning their association with institutionalization [17-21]. Some of those

factors cannot, however, be considered in a claims-based tool since several patient characteristics, such as marital status, social status, income, are not available in administrative databases. The following conditions were retained as potential predictors: diabetes, urinary incontinence, depression, anxiety, sleep disturbances, Parkinson's disease, hypercholesterolemia, pulmonary disease, chronic infection, hypertension and cardiovascular and cerebrovascular disease. For each of these conditions, drug classes used for treatment were identified and were considered as potential predictors of institutionalization. Drug dispensings were used as opposed to diagnoses in the medical services database since, in the Quebec claims databases, they have previously been shown to be more reliable to ascertain the presence of a medical condition than medical claims [22]. Also, in this context (comorbidity score), developing a score based on drug users would be of particular interest, as not all databases contain medical diagnostic information and as this is of inconstant validity, especially in elderly.

### Time window

Exposure to the selected drugs was assessed through the presence of at least one dispensing in the prescription database during the year prior to index date. A sensitivity analysis was conducted using a 3 month time window prior to the event which yielded similar results (data not shown). Since most comorbidity in this population consists of chronic diseases, drug dispensing received in a 3 month time window was highly correlated with drug dispensing in a one-year time window.

### Statistical analysis

**Development of the score:** Bivariate analyses were conducted to identify potential predictors of institutionalization in the construction cohort. Drugs that were significantly associated with institutionalization were considered as potential predictors and were retained for multivariable analyses at a significance level of 0.20. Multivariable conditional logistic regression analysis was then conducted, with independent variables identified through backward stepwise selection. To ensure the stability of the model, forward and bidirectional selection were also used, and the retained variables compared. However, in order to keep all important clinical variables, in the development of a score, it is important to use a level of significance which is higher than evaluation study. The final predictors were those variables which were significantly associated with an increase or decrease in the probability of institutionalization with the level of statistical significance set at 0.20. A weighted score was assigned to each predictor, using the Framingham Heart Study Method [15]. Weights correspond to a multiplication of the Beta coefficient obtained from the final multivariable logistic regression model with a constant in order to obtain an integer number. The constant consists of an arbitrary number that yields integers instead of decimals. In that case, the retained constant was 0.25 a risk factor is associated with a positive score while a protective factor is associated with a negative score. An overall risk score was then derived through summation of individual scores for each individual included in the construction cohort.

**Validation of the score: nested case-control design:** A nested case-control design was also used to assess the performance of the score in the validation cohort. The predictive accuracy of the institutionalization score was assessed through measures of calibration and discrimination of the multivariable logistic model and the point scoring system. Calibration and predictive accuracy were determined by comparing the predicted and observed number of patients institutionalized in the validation cohort. Discrimination was assessed using the area under the Receiver Operating Characteristic (ROC) curve in the validation

cohort. The c statistic was used as a measure of performance. The c statistic is the fraction of patients with the outcome among pairs of patients where one has the outcome and one not; the patient with the highest prediction being classified as the one with the outcome. Hence, when a model provides no information, the value of the c statistic is 0.5. Hosmer and Lemeshow suggest that a c statistic over 70 provides acceptable predictive validity [23]. Confidence interval on the c statistic was obtained using a bootstrap method.

**Validation of the score: cohort design:** The new comorbidity score based on the prediction of institutionalization was also validated using a cohort study design. Subjects were considered exposed if they were using drugs of interest (the ones which are included in the calculation of the score) at the time of entry in the cohort. The retained time window is the same than in the nested-case control approach was 1-year. The score was then applied in the cohort and the c-statistic was calculated.

**Sensitivity analysis: assessment of the robustness of the score:** Since dementia is one of the most important predictors of institutionalization and it is not taken into account in the development of the score, it was decided to test the robustness of the score in a demented elderly population as sensitivity analysis. To be included in the cohort with dementia, elderly must be new users of cholinesterase inhibitors between 1999 and 2009. A cohort of 37,138 patients was constructed. The institutionalization score was then applied in that specific cohort and the c-statistic was used to assess the performance.

All data were analyzed using the SAS statistical packages (SAS 9.2 for Windows, SAS Institute Inc., Cary, NC, USA).

### Ethical Considerations

No patient or physician identifiers were provided to the researchers; only encrypted identifiers were used throughout the study. The study was approved by the Ethics Committee of the University of Montreal Hospital Center.

### Results

The development and validation cohorts were similar in terms of demographic characteristics (Table 1). The majority of patients was between the ages of 65 and 69 (55.85% and 56.51%, respectively) and was females (57% for both cohorts).

As shown in table 2, factors which significantly increased the risk of institutionalization were the use of antipsychotics, antidepressants, and hypoglycaemic agents. Protective factors included: use of statins, antihypertensives, and benzodiazepines. Finally, despite a plausible clinical association between some drugs and the risk of institutionalization, the effect of such variables were not statistically significant in the multivariable model (use of osteoporotic drugs, respiratory drugs, diuretics, glaucoma drugs, proton-pump inhibitors, cardiovascular drugs, antiparkinsonians, urinary incontinence drugs, anti-thrombotic agents). Table 3 presents the results of individual scores for each of predictors of institutionalization. Being the most important factors impacting on institutionalization, use of antipsychotics obtained the highest score with 5 points followed by antidiabetics with 2 points.

### Validation of the score

Results of the validation component of the study are presented in table 4. The score range between -19 and 8. The mean score for cases is statistically higher than that for controls, which indicates that the score discriminates between the two groups. When applied to the validation cohort, the c statistics is 0.79 (CI: 95% 0.77-0.83). Figure 1 show that

the area under the ROC curve for the institutionalization score is 0.736 and the null hypothesis was rejected.

### Comparison with the mortality score

The c statistics obtained using the GCS based on mortality, when applied in this validation cohort are presented in table 4. The c statistics is 0.75 (95% CI: 0.73-0.77), which statistically different than the 0.79 (95% CI: 0.78-0.83) obtained with the institutionalization score.

### Sensitivity analysis

The c statistic obtained by the institutionalization score in the demented elderly cohort is 0.81 (95% CI: 0.78-0.84) and is not statistically different than the score obtained in the general elderly population (Figure 2). When tested in a non-demented elderly cohort but using a cohort study design, the c-statistic of the model including age and gender is 0.81 (95% CI: 0.79-0.83). The odds ratio of the score is 1.22 which represents an increasing of institutionalization of 22% by point in the score scale (Figures 3 and 4).

### Discussion

Through this study, we have developed a comorbidity score based

Characteristics	Development cohort (n=61172)		Validation cohort (n=26217)	
	n	%	n	%
Age (years)				
65-69	34188	55.89	14814	56.51
70-74	11176	18.27	4667	17.8
75-79	7989	13.06	3390	12.93
80-84	4512	7.38	1901	7.25
85 and over	3297	5.39	1442	5.5
Gender				
Female	34 819	56.92	14 899	56.83
Male	26 393	43.08	11 318	43.17

**Table 1:** Baseline characteristics of the patients in development and validation cohorts.

Drugs	Institutionalization			
	Bivariate analysis		Multivariate analysis	
	Odds Ratio	95% CI	Odds Ratio	95% CI
Drugs for osteoporosis	0.77	0.61-0.99	0.93	0.71-1.21
Respiratory drugs	0.83	0.70-1.00	0.99	0.86-1.14
Diuretics	0.91	0.76-1.08	0.87	0.76-1.00
Antipsychotics	4.05	3.02-5.43	3.45	2.91-4.08
Statins	0.39	0.30-0.50	0.64	0.53-0.78
Antidepressants	1.33	1.09-1.61	1.45	1.25-1.68
Benzodiazepines	1.02	0.85-1.21	0.83	0.73-0.95
Glaucoma drugs	0.89	0.45-1.75	0.63	0.37-1.07
Proton-pump inhibitors	0.50	0.36-0.71	0.96	0.74-1.24
Antidiabetics	1.34	1.05-1.69	1.63	1.38-1.92
Cardiovascular drugs	0.80	0.67-0.96	0.94	0.82-1.08
Antihypertensives	0.73	0.61-0.87	0.72	0.63-0.83
Antiparkinsonian	5.03	1.39-18.18	0.93	0.38-2.31
Urinary incontinence	1.79	1.39-2.30	1.09	0.46-2.36
Anti-thrombotics	1.17	0.82-1.48	1.01	0.93-1.09
Cephalosporin	0.45	0.40-0.53	0.54	0.45-0.65
Macrolide	0.51	0.45-0.61	0.37	0.31-0.44
Penicillin	0.48	0.41-0.50	0.44	0.37-0.52
Quinolone	0.87	0.73-1.05	0.99	0.70-1.40

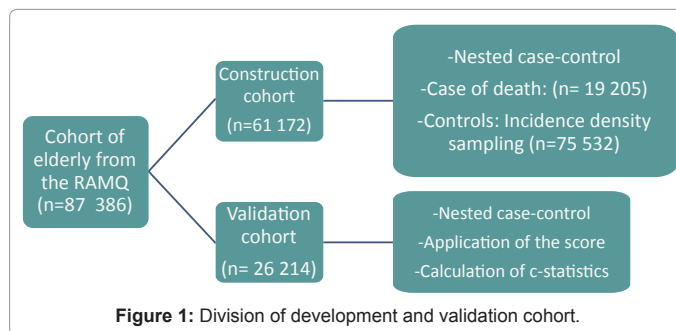
**Table 2:** Bivariate and multivariate analysis of potential factors associated with institutionalization.

Risk factor	Score
Drugs for osteoporosis	0
Urinary incontinence drugs	0
Cardiovascular drugs	0
Respiratory drugs	0
Diuretics	-1
Antipsychotics	5
Statin	-2
Antihypertensive	-1
Cephalosporin	-2
Macrolide	-4
Penicillin	-3
Tetracycline	-3
Antithrombotics	0
Quinolone	0
Proton-pump inhibitors	0
Antiparkinsonian	0
Glaucoma drugs	-2
Benzodiazepines	-1
Antidepressant	1
Antidiabetic	2

**Table 3:** Score associated with each risk factor for institutionalization.

	Institutionalization			Death		
	Cases (n=607)	Controls (n= 368)	t-test	Cases (n=7 977)	Controls (n= 31 038)	t-test
Mean score	-1	-4	30.08; p<0.001	-1	-3	95.12; p<0.001
Mean Risk	0.46	0.31	30.08; p<0.001	0.45	0.33	95.12; p<0.001
c-statistic	0.79 (0.78-0.83)			0.75 (0.73-0.77)		

**Table 4:** Mean score and mean risk for institutionalization and mortality and c-statistics.



**Figure 1:** Division of development and validation cohort.

on institutionalization in the community-dwelling elderly population. It was shown that very few prescribed medications are significantly associated with institutionalization. Although institutionalization is a relevant outcome in this population, it remains fairly rare (only 2180 events or 2.5% of the study population were identified). Despite the relatively large sample size, some drugs were not associated with a statistically significant effect, even though they were clinically relevant. This is probably due to the relatively low frequency of use of these drugs in this population. This is the case for drugs used to treat urinary incontinence, for example. In the literature, it is well known that urinary incontinence is one of the major factors which lead to institutionalization [21]. However, our study was unable to confirm

this in a large population of community-dwelling elderly, since few elderly receive prescribed treatment for this condition (3% of cases and 2.1% of controls).

Comorbidity scores to control for prescription channelling are often used in pharmacoepidemiology [24]. Iezzoni stated that the predictive performance of comorbidity scores depends on several factors such as the clinical conditions included in a score and their relative weights, the distribution of comorbidity in the source population, the study outcome, and the accuracy of the administrative data. Our study focused on the impact of the choice of the outcome [25].

The institutionalization score that we have developed yields adequate performances, comparable to those of other scores that predict mortality that are found in the literature. Comparability of performances between the institutionalization and mortality scores may be explained by the fact that, in the literature, it was shown that the most important factors that predict both institutionalization and mortality are age and gender [11,24]. In the elderly population alone,

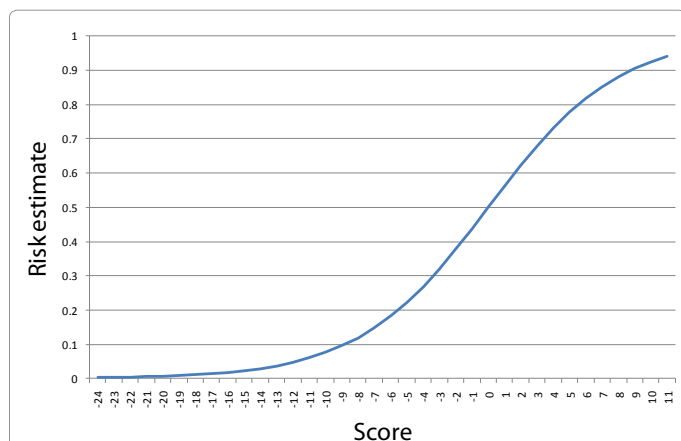


Figure 2: Estimate of the risk of death associated with each score calculated from the multivariate logistic regression equation.

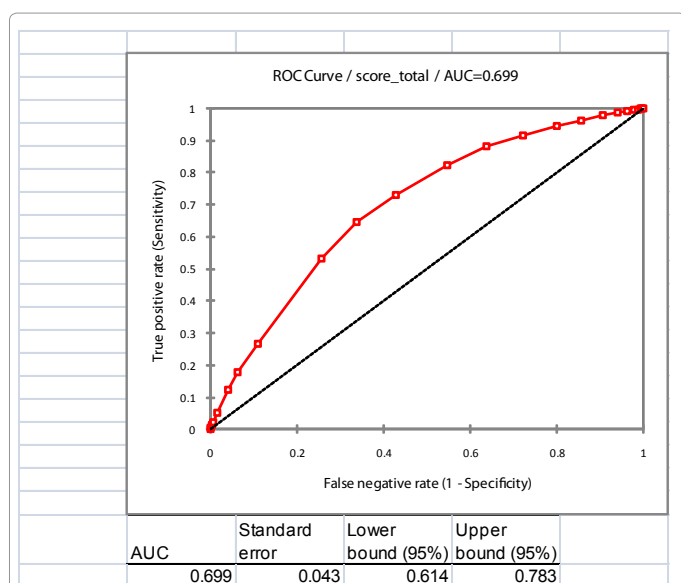


Figure 3: Area under the receiver operating curve the newly developed Geriatric Disease Score (GDS) elderly death score.

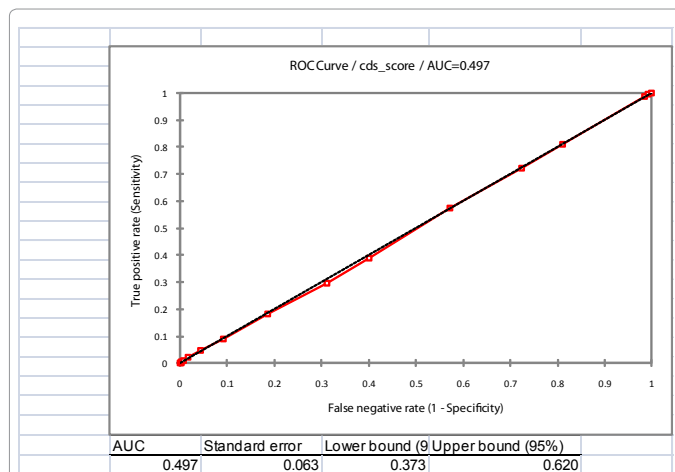


Figure 4: Area under the receiver operating curve the CDS score (idem).

this fact may be emphasizing by the interaction between age and gender.

Our results showed really good performances of the institutionalization score in the demented elderly population. This fact may be explained by the higher prevalence of both institutionalization and exposures. Also, since the demented population is older than general population, the high performances may be explained by the variances explained by age.

One of the strengths of our study is that the same method was used to develop scores of mortality and institutionalization. Our study is the first to demonstrate that a score based on institutionalization may be a reliable predictor of overall health status in the elderly population. The study population was very large (10.9% of the Quebec elderly) and very representative of the community-dwelling elderly population of Quebec. Also, it is the first study to derive a score using a nested case-control approach; all others used a cohort design. This design allowed us to ensure that drug exposure preceded the occurrence of institutionalization. Another major strength of the study was the fact that the initial predictive model was based on clinical relevance using a geriatrician's expertise, and was supported by a comprehensive literature review. Most other scores are data-driven only or used only clinician's opinions. A limitation of our study is the fact that we used a proxy to ascertain institutionalization. However, misclassification is probably minimal given that the observed rate in our study (2.5%) is similar to that of the community-dwelling Quebec elderly population (3%) [26]. Also, our score is based on prescription claims instead of diagnostic or procedure codes. However, knowing that this is a chronic disease score, one can believe that the majority of patients are treated. Also, this allowed controlling for the contribution of the treatment. It is the reason why some variables are protectors.

In conclusion, a comorbidity score to predict institutionalization that performs as well as a comorbidity score that predicts mortality was developed. Depending on the outcome in a original research, this tool may therefore be helpful to support pharmacoepidemiologic research conducted in this population. As example, if the outcome of interest is a clinical outcome like hospitalization, a score based on institutionalization may be more representative of the state of illness of patients.

## References

1. Prouty R, Coucouvanis K, Lakin KC (2005) Fiscal year 2004 institution

- populations, movement, and expenditures by state with national comparisons to earlier years. *Ment Retard* 43: 149-151.
2. Wolinsky FD, Callahan CM, Fitzgerald JF, Johnson RJ (1992) The risk of nursing home placement and subsequent death among older adults. *J Gerontol* 47: S173-S182.
  3. Von Korff M, Wagner EH, Saunders K (1992) A chronic disease score from automated pharmacy data. *J Clin Epidemiol* 45: 197-203.
  4. Charlson ME, Pompei P, Ales KL, MacKenzie CR (1987) A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 40: 373-383.
  5. Roos LL, Stranc L, James RC, Li J (1997) Complications, comorbidities, and mortality: improving classification and prediction. *Health Serv Res* 32: 229-238.
  6. Linn BS, Linn MW, Gurel L (1968) Cumulative illness rating scale. *J Am Geriatr Soc* 16: 622-626.
  7. Deyo RA, Cherkin DC, Ciol MA (1992) Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. *J Clin Epidemiol* 45: 613-619.
  8. Rozzini R, Frisoni GB, Ferrucci L, Barbisoni P, Sabatini T, et al. (2002) Geriatric Index of Comorbidity: validation and comparison with other measures of comorbidity. *Age Ageing* 31: 277-285.
  9. Romano PS, Roos LL, Jollis JG (1993) Adapting a clinical comorbidity index for use with ICD-9-CM administrative data: differing perspectives. *J Clin Epidemiol* 46: 1075-1079.
  10. Mikaeloff Y, Moride Y, Khoshnood B, Weill A, Bréart G (2007) Infant and toddler disease score was useful for risk of hospitalization based on data from administrative claims. *J Clin Epidemiol* 60: 680-685.
  11. Schneeweiss S, Seeger JD, Maclure M, Wang PS, Avorn J, et al. (2001) Performance of comorbidity scores to control for confounding in epidemiologic studies using claims data. *Am J Epidemiol* 154: 854-864.
  12. de Groot V, Beckerman H, Lankhorst GJ, Bouter LM (2003) How to measure comorbidity. a critical review of available methods. *J Clin Epidemiol* 56: 221-229.
  13. Gauthier H (2004) Vie des générations et des personnes âgées : aujourd'hui et demain. *Institut de la Statistique du Québec* 1: 43-90.
  14. Administration F.a.d (2011).
  15. Dawber TR, Meadors GF, Moore FE Jr (1951) Epidemiological approaches to heart disease: the Framingham Study. *Am J Public Health Nations Health* 41: 279-281.
  16. Etminan M (2004) Pharmacoepidemiology II: the nested case-control study - a novel approach in pharmacoepidemiologic research. *Pharmacotherapy* 24: 1105-1109.
  17. Matsumoto M, Inoue K (2007) Predictors of institutionalization in elderly people living at home: the impact of incontinence and commode use in rural Japan. *J Cross Cult Gerontol* 22: 421-432.
  18. Luppá M, Luck T, Weyerer S, König HH, Brähler E, et al. (2010) Prediction of institutionalization in the elderly. A systematic review. *Age Ageing* 39: 31-38.
  19. Weissert WG, Cready CM (1989) Toward a model for improved targeting of aged at risk of institutionalization. *Health Serv Res* 24: 485-510.
  20. Gaugler JE, Pot AM, Zarit SH (2007) Long-term adaptation to institutionalization in dementia caregivers. *Gerontologist* 47: 730-740.
  21. Luk JK, Chiu PK, Chu LW (2009) Factors affecting institutionalization in older Hong Kong Chinese patients after recovery from acute medical illnesses. *Arch Gerontol Geriatr* 49: e110-e114.
  22. Tamblyn R, Lavoie G, Petrella L, Monette J (1995) The use of prescription claims databases in pharmacoepidemiological research: the accuracy and comprehensiveness of the prescription claims database in Quebec. *J Clin Epidemiol* 48: 999-1009.
  23. Hosmer D, Lemeshow S (2000) *Applied logistic regression*, (2nd edn), United States: Wiley Series in probability statistics.
  24. Schneeweiss S, Maclure M (2000) Use of comorbidity scores for control of confounding in studies using administrative databases. *Int J Epidemiol* 29: 891-898.
  25. Iezzoni LI (1997) The risks of risk adjustment. *JAMA* 278: 1600-1607.
  26. Sociaux (2010) M.d.I.S.e.d.S Info-Hébergement, Québec.