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COMORBIDITY MEASURES AND MORTALITY IN INSTITUTIONALISED ELDERLY

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Abstract: *Background: Objectives:* The utility of comorbidity indices for the assessment of frail institutionalised elderly have not been fully explored. Such information may prove useful for individualized advanced care planning and healthcare resource allocation.We aimed to compare the predictive properties of four indices (CIRS-G total score, CIRS index, Charlson Score and Charlson age-adjusted) in the setting of a multi-racial Asian long term care facility. *Design and Setting:* We conducted a cross-sectional study with prospective collection of mortality data for 158 patients (mean age 76.6±12.3 years) at a nursing home in Singapore. *Measurements:* A multi-disciplinary team evaluated baseline demographics, disease number, medication burden, Mini Nutritional Assessment (MNA) score and modified Barthel Index (MBI). Correlations with baseline measures, univariate and multivariate regression analyses were performed to determine the impact of comorbidity indices on 2-year mortality. *Results:* Baseline correlations were significant but modest between the 4 indices and medication burden, MBI and MNA (Pearson's R range: 0.23-0.31, all p<0.05).Two year all-cause mortality was 25.8% (n=41). Upon univariate analyses, mortality was significantly associated with MBI (OR 0.99, P=0.016), MNA (OR 0.87, P=0.006), number of diseases (OR 1.21; P=0.048), CIRS-G total score (OR 1.14; P=0.010) and age-adjusted Charlson Score (OR 1.25; P=0.032). After accounting for age, gender, race, MBI and MNA, only CIRS-G total score significantly predicts mortality in the multivariate analysis (OR 1.14; P=0.02). *Conclusion:* Beyond its association with baseline demographics, nutritional and functional measures, the CIRS-G total score remained a significant predictor of mortality compared to indices derived from the Charlson Score. Inclusion of said comorbidity variable will be useful when interpreting mortality data of institutionalized elderly and planning of residential care resource allocation.

Key words: Comorbidity, instituionalised elderly, charlson comorbidity index, cumulative illness rating scale, mortality, nursing home.

Introduction

Co-morbidity or multi-morbidity has been defined as "the total burden of physiological dysfunction or the total burden of types of illnesses having an impact on an individual's physiologic reserve" (1). Its notoriety in delaying diagnosis, influencing treatment decision, altering survival and confounding analysis has led to many studies performed in the setting of the acutely hospitalised elderly (2-6). However, relatively few studies were performed examining its impact on long-term care residents, whose characteristics differ greatly from community dwellers. Previous studies have found institutionalized elderly to be older in age, poorer in health, having greater functional and cognitive impairment, less socially involved and reporting lower incomes with resultant higher mortality and morbidity rates when compared to their community dwelling counterparts (7-13).

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It has been commonly assumed that long-term care residents have greater co-morbidity burden, although few studies investigated its spectrum and characterisation. Given the inherent frailty of this population, the greater burden of diseases is likely to exert a significant influence on healthcare related outcomes although its magnitude should not be assumed. Furthermore, interactions between co-morbidities and co-variates such as age, gender, pill burden, functional status and nutrition are also not well understood.With an ageing population in many developed nations, the utilization and public expenditure on long-term care is expected to increase exponentially (14). This silver tsunami has fuelled the need to improve understanding of the role of co-morbidities in determining mortality outcomes in the frail institutionalised elderly. Such knowledge is essential for health-care providers in both individual disease management, as well as health-care resource allocation.

Several co-morbidity indices have been developed to effectively quantify and measure co-morbidities. These co-morbidity measures serve to indicate overall number

and severity of diseases, allow for inter-patient comparison, evaluate the confounding effects of illnesses on the index disease, establish the risk of disability, estimates prognosis, facilitate therapeutic decision-making and allow risk stratification in the field of healthcare research (15). Two of these indices, namely the Charlson Co-morbidity Index (CCI) (16, 17) and the Cumulative Illness rating Scale –Geriatrics (CIRS-G) (18), have been applied across a wide spectrum of clinical settings, including patients with malignancies, end stage renal failure, depression, pneumonia and surgical amputations (18-22). Their use in the long term care settings have also been previously documented but their impact in predicting clinical outcomes have not been consistent (23-25).

Using these two co-morbidity indices, we aimed to i) evaluate the co-morbidity burden amongst elderly in residential facilities; ii) investigate the relationship between co-morbidity and co-variates such as age, functional and nutritional status; iii) compare the predictive properties of co-morbidity indices for medium term mortality.

Methods

Subject

The details of the study method have been previously described in an earlier paper examining nutritional assessment and mortality in institutionalised elderly (26). In brief, we conducted a cross-sectional observational study with prospective collection of mortality data at a 180-bedded voluntary welfare nursing home (Thong Teck Home for Senior Citizens) in Singapore, during the period commencing from 1 August 2005 to 31 July 2007. All residents staying in the home for at least 1 month were considered for enrolment in the study. Patients who have clinical evidence of acute febrile illnesses during the period of assessment were excluded, so that we may evaluate a more homogeneous population of frail elderly with concurrent chronic illnesses. A total of 180 patients were screened, out of which 158 patients or their legal guardian provided informed consent to participate in this study. The study had gained approval from the Institutional Review Board.

Data Collection

Patients were assessed by a multi-disciplinary team headed by a geriatrician (medical assessment) and consisting of a dietician (nutritional assessment), a physiotherapist and an occupational therapist (functional assessment). Patients enrolled were assessed on separate occasions by individual members of the team and assessors were blinded to the results of other team members' findings. Cause and timing of death were obtained from nursing home records at the end of the two years follow up period.

Assessment of Co-morbidity Burden

The geriatrician scored all 158 patients for their co-morbidity burden using the CIRS-G and the CCI after reviewing all available medical records and clinical assessment including history taking and physical examination. These 2 indices were selected for their relatively wide spread clinical applications and their previous validation in the long-term care setting.

The CCI was developed as a multi-item disease specific co-morbidity index that considers the presence or absence of 19 different conditions, weighted with a score of 1, 2, 3 or 6 according to their association with 1-year mortality. Scoring a subject using the CCI would yield 2 co-morbidity scores, namely CCI Total Score (summation of all weighted CCI diseases recorded) and the Age-adjusted CCI scores (from age 50-99, a score of 1 is added to the summation score for each additional decade in age) (16).

The CIRS-G, on the other hand, provides a comprehensive review of impairments in 13 organ systems, with severity grading scored on a scale of 0-4. From these items the CIRS-G Total Score (summation of scores from all CIRS categories recorded) and the CIRS Severity Index (summary score based on the average of all CIRS items recorded) were calculated (18). All 4 co-morbidity scores were collated from all subjects for analysis.

Assessment of Co-variates

Baseline demographic data including, age, gender, ethnicity and date of admission to nursing home were obtained from retrospective review of the medical records. As part of the medical assessment, the geriatrician reviewed the medical records of all 158 patients and collected data on disease number and medication burden (number of medications listed as active in the charts).

The occupational therapist assessed the patients and scored their functional status using the Modified Barthel Index (MBI), which is a validated activity of daily living (ADL) scale in widespread clinical use, comprising 10 activities of daily living, each with five levels of dependency; the maximum score is 100 points, representing independence in daily living (27). A dietician performed all anthropometric measurements and clinical interviews necessary for the assessment of nutritional status. A MNA score was calculated for all participants who underwent nutritional assessment. Participants were classified as well nourished (MNA ≥24), at risk of malnutrition (MNA = 17-23.5) or malnourished (MNA <17) according to the MNA score (maximum=30) (28).

Statistical Analysis

Data collected were analysed using STATA V10.0 (STAT Corp, College Station, Texas, USA) and all tests were conducted at the 5% level of significance. Baseline differences were compared for those who died versus those who survived after 2 years using t-tests for continuous variables and chi-square for categorical variables.

The relationship between co-morbidity burden and significant co-variates identified a-priori were examined through a Pearson correlation test performed between co-morbidity indices and age, MBI, MNA score, pill burden and disease burden. To further test their influence on 2-year mortality, we used the logistic regression model to assess these significant variables in the univariate analysis. Multivariate regression analysis was also performed to examine the impact of comorbidity on 2 year mortality, and the odds ratios were adjusted for age, gender, race, MBI and MNA.

Receiver-Operator Characteristic (ROC) curve analyses for survival were also plotted for 2 of the most viable co-morbidity scores identified during regression analysis, and their most clinically efficacious cut-off values for predicting 2-year mortality were then determined. Subjects were subsequently stratified into 2 groups based on optimum cut-off values and the Kaplan Meier plots of survival were constructed. Log-rank tests were further performed to evaluate their significance.

Results

Baseline Characteristic

All 180 residents of the nursing home were screened, of which 158 consented for participation. All 158 (100%) participants underwent nutritional assessment, while 152 (96.2%) participants completed the initial medical review and the functional assessment. Only 2 patients were lost to follow up due to their premature discharge from the facility. The study population consists largely of elderly residents, with mean age of study subjects as 76.6 ± 12.3 years and 55.6% of them were female. The majority (96.8%) of the subjects were Chinese. The frailty of the study population is reflected by its low average score for the modified Barthel Index of 40 ± 34.8, indicating a highly dependant population of elderly. A high co-morbidity burden was demonstrated by an average CCI Total Score of 2.4 ± 1.7 and an average CIRS-G Total Score of 9.8 ± 3.7. The majority of residents were at risk of malnutrition, with a mean MNA score of 17.4 ± 3.9, in fact 39.9% of residents have a MNA score of <17.

The two year all-cause mortality was 25.8% (n=41). The commonest cause of demise amongst subjects with known causes of death is pneumonia. Other diagnoses include ischemic heart disease, stroke, lower limb gangrene and urosepsis. Comparing subjects who were alive after 2 years follow up and those who passed away, subjects who passed away were more elderly in age, of poorer functional and nutritional status and have higher disease burdens as measured using both CCI and CIRS-G. Selected characteristics of the 2 groups are presented in Table 1.

Table 1
Baseline characteristics of study population

	Overall n=158	Alive n=117 (74.2%)	Deceased n=41 (25.8%)
Age,years	76.6 (12.3)	75.2 (12.4)	80.6 (11.3)
Gender			
Female	85 (53.8%)	60 (51.3%)	25 (61.0%)
Male	73 (46.2%)	57 (48.7%)	16 (39.0%)
Race			
Chinese	153 (96.8%)	114 (97.4%)	39 (95.1%)
Malay	4 (2.5%)	2 (1.7%)	2 (4.9%)
Indian	1 (0.6%)	1 (0.9%)	0 (0%)
Duration of stay, days	55.4 (33.2)	57.3 (33.1)	50 (33.3)
Modified Barthel Index	40.0 (34.9)	44.2 (35)	28.2 (32.1)
CCI Total Score	2.4 (1.67)	2.25(1.75)	2.82 (1.34)
Age Adjusted CCI	5.5 (1.96)	5.31 (2.05)	6.10 (1.54)
CIRS-G Total Score	9.8 (3.70)	9.33 (3.69)	11.15 (3.49)
CIRS-G Severity Index	2.46 (0.45)	2.49 (0.48)	2.39 (0.37)
MNA (total)			
Total MNA <17	17.4 (3.9)	17.89 (3.87)	15.89 (3.61)

CCI, Charson Comorbidity Index; CIRS-G, Cumulative Illness Rating Scale – Geriatrics; MNA, Mini-Nutritional Assessment.

Baseline Correlations

Pearson's correlation test showed a modest but statistically significant association between co-morbidity indices, pill burden, MBI and MNA score. Significant correlations are presented in Table 2.

Univariate and Multivariate Regression Analysis

Univariate analysis shows that mortality was significantly associated with MBI (OR 0.99, 95% CI: 0.975-0.997; p=0.016), MNA (OR 0.87, 95% CI: 0.79-0.96; p=0.006), number of diseases (OR 1.21; 95% CI: 1.00 – 1.47, p=0.048), CIRS-G total score (OR 1.14; 95% CI: 1.03-1.27; p=0.010) and Age-adjusted CCI (OR 1.25;95% CI: 1.02-1.53; p=0.032).

Table 2
Pearson correlations between comorbidity indices and age, no. of diseases, pill burden, functional status and nutrition

	Charlson Comorbidity Index (Total)	Charlson Comorbidity Index (Age-Adjusted)	CIRS(G) Total Score	CIRS Severity Index
Age	-0.03	0.55*	-0.04	-0.15
No. of Diseases	0.55*	0.49*	0.71*	0.38*
No. of Medications	0.23*	0.03	0.24*	-0.01
Modified Barthel Index (MBI)	-0.31*	-0.26*	-0.28*	-0.09
Mini Nutritional Assessment Score (MNA)	-0.16	-0.28*	-0.23*	-0.08

*Differences significant at p value < 0.005; CIRS-G = Cumulative Illness Rating Scale – Geriatrics; CIRS = Cumulative Illness Rating Scale

In the subsequent multivariate model, after controlling for age, gender, race, MBI and MNA, we find that the CIRS-G Total Score is the only index that remains statistically significant (OR 1.14; 95% CI: 1.02-1.28; p=0.02) in its association with 2 year mortality (Table 3). Translated clinically, this would mean that for every 1 point increase in the CIRS-G Total Score, the odds ratio for 2 year mortality increases by 14.3%. Odds ratio for mortality of covariate risk factors in forward regression analysis of CIRS-G Total Score are presented in Table 4.

Table 4
Comparison of odds ratio of mortality for comorbidity scores, after controlling for age, gender, race, MBI and MNA

2-year Mortality	Odds Ratio	95% Confidence Interval	P value
CCI	1.23	0.95 – 1.60	0.12
Age-Adjusted CCI	1.08	0.83 – 1.41	0.56
CIRS-G Total	*1.14	1.02 - 1.28	*0.02
CIRS Severity Index	0.56	0.22 - 1.40	0.22

* p<0.05; MBI = Modified Barthel Index; MNA = Mini-Nutritional Assessment; CCI = Charlson Comorbidity Index; CIRS-G = Cumulative Illness Rating Scale – Geriatrics; CIRS = Cumulative Illness Rating Scale

Survival Analysis (Figures 1 & 2)

Receiver-Operator Characteristic (ROC) curve analysis for survival at 2 years identified CIRS-G Total Score ≥11 as most predictive of 2 year mortality, yielding a sensitivity of 61.52% and a specificity of 65.18% (AUC = 0.64). A Kaplan Meier plot of subject survival was constructed after stratifying the subjects into 2 groups using this cut-off (see Figure 1). A subsequent log-rank test performed clearly indicated a statistically significant reduction in survival time for subjects with a CIRS-G Total Score >11 (p=0.002). In comparison, a CCI value of ≥5 was found to be most predictive of 2 year mortality for this index, but this was not statistically significant (AUC= 0.606, p= 0.073).

Table 4
Multi-variate regression analysis of CIRS-G Total Score and 2-year mortality, after controlling for age, gender, race, MBI and MNA

2-year Mortality	Odds Ratio	95% Confidence Interval	P value
Age	1.05	1.00 – 1.09	*0.03
Gender	0.81	0.33 – 2.01	0.65
Race	0.24	0.03 – 1.79	0.16
MBI	0.99	0.98 – 1.01	0.32
MNA	0.96	0.85 – 1.09	0.55
CIRS-G Total	*1.14	1.02 - 1.28	*0.02

* p<0.05; MBI = Modified Barthel Index; MNA = Mini-Nutritional Assessment; CCI = Charlson Comorbidity Index; CIRS-G = Cumulative Illness Rating Scale – Geriatrics; CIRS = Cumulative Illness Rating Scale

Figure 1
Kaplan Meier survival curve of elderly subjects with CIRS-G Total Score ≥11 and < 11

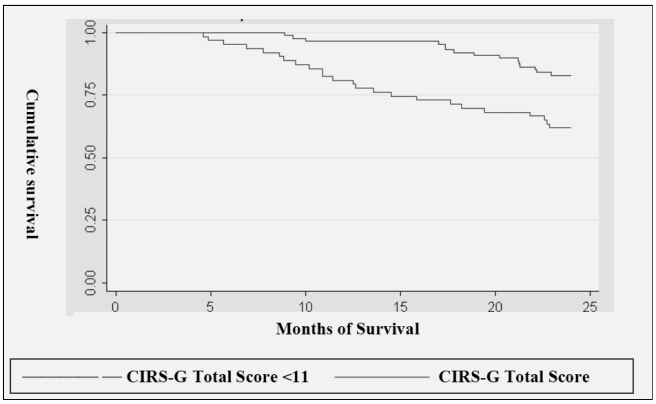
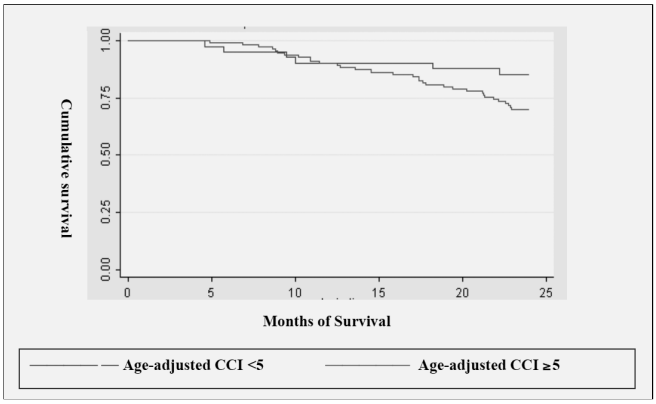


Figure 2
Kaplan Meier survival curve of elderly subjects with CCI Score ≥5 and < 5



Discussion

This study provided further insights into the characteristics of the institutionalised elderly in a multi-ethnic Asian society, highlighting their high co-morbidity

burden (mean CCI Total Score 2.4 ± 1.67, mean CIRS-G Total Score 9.8 ± 3.7), greater functional limitations (mean MBI = 40 ± 34.84), increased risks of malnutrition (mean MNA score 17.4 ± 3.9) and high two year all-cause mortality of 25.8%. Similar demographic patterns were demonstrated in previous studies in European and American populations (29-34).

Our uni-variate analysis identified MBI, MNA and number of comorbid diseases as statistically significant predictors of 2-year mortality amongst institutionalized subjects. While existing literature has individually linked functional status, nutrition and co-morbidity load with increased mortality, few studies examines their interactions with one another in the frail elderly admitted to nursing home facilities. We identified positive but modest associations between co-morbidity burden with functional status, nutrition and pill burden. This suggests an interplay of these factors that together contributes to undermining the delicate physiologic balance in an institutionalised elderly. Nonetheless, we have also shown that co-morbidity burden alone (as reflected by the CIRS-G Total Score), can be used to reasonably predict medium term mortality in this population independent of these other interacting risk factors.

Previous population-based studies have found physical functional performance to strongly predict for mortality independent of co-morbidity in community dwelling elderly (35). Our study performed in the long term care setting similarly revealed functional status to be a statistically significant predictor., However the OR of 0.99 indicates a weaker association. This is likely due to the high prevalence of disability in our institutionalised subjects exerting a strong ceiling effect on this variable while further highlighting the utility of comorbidity measurement in outcome prediction.

The influence of gender on mortality and comorbidity was also explored. Female residents were more elderly (mean age 80.90 years vs 71.53 years; p <0.001), have poorer nutrition (mean MNA 16.73 vs 18.11; p= 0.03) and lower functional status (mean MBI 33.90 vs 46.79; p= 0.02). This was associated with greater rates of 2-year mortality compared to their male counterparts (29.41% vs 21.92% p = 0.29), although this did not reach statistical significance as a result of our modest sample size. It is surprising that despite the above, female subjects have statistically less co-morbidities than male subjects (mean CIRS-G Total Score 9.17 vs 10.50; p =0.03). Future studies may wish to examine the differential impact of comorbidity on mortality between the two genders.

In our current study we noted that the CIRS-G Total Score is superior to the CCI in predicting 2 year mortality. For every 1 point increase in the CIRS-G Total Score, the odds ratio for 2 year mortality increases by 14.3%. A cut-off score of ≥11 was identified as the optimal value that can be applied in the clinical setting to predict 2 year mortality amongst nursing home residents. The multidimensional nature of health means that no index of co-morbidity will be complete in its assessment. Two principal problems exist in any measure constructed to quantify co-morbidity burden. They relate to the effect of the presence or severity of a given disease on physiologic impairment and their additive or sometimes synergistic interactions to compromise function and influence mortality (36). These two issues are of particular relevance to the elderly, who are often disabled due to a range of different conditions, varying in their individual severity.

Comparing the CCI and the CIRS-G, the CCI is limited by its specific list of conditions that is unlikely to cover the full spectrum of illnesses in the frail elderly. Furthermore common afflictions in the institutionalised elderly such as dementia were awarded lower weightings compared to HIV and AIDS which though increasing in prevalence in the community elderly are less frequently encountered in this population. The score also does not take into account the severity of each individual illness but only focuses on their presence or absence. There is existing evidence that measuring co-morbidity by simply counting the number of co-existing illnesses would lead to differing conclusions, than correcting for co-morbidity by weighted indexes with severity ratings (37). More importantly, the CCI was designed based on patients admitted to an acute medical service, thus differential weights would have to be adjusted to allow for meaningful interpretation (38-40). These limitations could have accounted for its inferior performance to CIRS-G in predicting mortality in the long-term care setting.

The CIRS-G scale overcomes many of the above difficulties by quantifying both the presence and severity of identified impairments according to clinically relevant body systems. This method more closely resembles common clinical practice and may be more compatible in the setting of long term care where residents are often afflicted with a wide range of different ailments across various organ systems, and varying in their intensity and ability to compromise physiologic well being.

As compared to other comorbidity indices such as CCI, Index of Co-existent Diseases, Disease Count and Kaplan-Feinstein Index, that focuses purely on the presence or absence of diseases, it is noteworthy that CIRS-G scale not only rates co-morbid disease by the level of organ system impairment, but also by its impact on functional status. The value of physical performance in predicting mortality and nursing home admissions in the elderly has been validated in previous studies (41, 42). Our analysis also identified MBI (p = 0.02) as a statistically significant index of prognostication for institutionalised elderly. While incorporating functional rating into its assessment for disease severity may account for CIRS-G's superiority over other indices, it also created potential confounding during analysis as CIRS-G encompasses both clinical and functional assessments. However, subjects in our study

are institutionalised elderly with homogeneously high baseline level of functional disability (mean MBI 40.0). The resultant ceiling effect in this frail population likely undermined the predictive value of functional status, leading to a modest OR of 0.99 for MBI. Furthermore, after controlling for MBI, CIRS-G remains statistically significant in predicting 2-year mortality, thus highlighting its value as a prognostic tool, independent of functional status.

However, CIRS-G is not without short-comings. Several concurrent medical conditions may still fall under a similar body system category, thus undermining the overall measurement. It would also be physiologically incompatible to assume different organ system impairments carries comparable impact on mortality. Differential weighting of organ systems may thus be necessary to better reflect the influence of diseases on an individual's overall physiologic reserves.

The strengths of our current study include a fairly large sample size and its comprehensive assessment of almost all participants by a multi-disciplinary team, using instruments validated in the long-term care setting. Almost all the subjects were evaluated for both the presence and the severity of individual illnesses, thus enabling a more detailed measure of disease burden in the elderly. We acknowledge the limitation that its population having been derived from a single nursing home facility in Singapore, limiting its generalizability. Additionally given that a single geriatrician scored subjects using both scales, the study is unable to provide insight into the inter-rater reliabilities of the CCI and CIRS-G in this care setting. However, the inter-rater reliabilities of these 2 scales have been separately validated in previous studies (43, 44).

Conclusion

In conclusion, the institutionalised elderly has high co-morbidity burden, significant functional impairment and are at increased risks of malnutrition. Modest interactions exist between co-morbidity burden and age, functional and nutritional status. Beyond its association with baseline demographics, nutritional and functional measures, the CIRS-G Total Score remained a significant predictor of mortality compared to indices derived from the CCI. A CIRS-G Total Score of ≥11 significantly predicts 2 year mortality amongst frail institutionalised elderly. The CIRS-G Total Score can thus be considered for integration as a component of a wider, standardised geriatric clinical assessment protocol. Such an assessment can prove useful to healthcare providers, when interpreting mortality data of institutionalized elderly and planning of residential care resource allocation.

Key Points

- Institutionalised elderly often have significant co-morbidity burden as well as functional limitations and are at risk of malnutrition.
- Co-morbidity burden is associated with increased medium term mortality in the institutionalised elderly.
- There exists modest correlation between CCI and CIRS-G with functional disability, nutritional status, disease number and medication burden
- Beyond their association with baseline demographics, nutritional and functional measures, CIRS-G Total Score out performs CCI in predicting 2 year mortality amongst elderly patients in nursing homes.
- Incorporation of the CIRS-G Total Score as an integrated component of a wider, standardised geriatric clinical assessment protocol will be useful when interpreting mortality data of institutionalized elderly and planning of residential care resource allocation.

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