Depressive Symptoms and Malnutrition are Associated with Other Geriatric Syndromes and Increase Risk for 30-Day Readmission in Hospitalized Older Adults: A Prospective Cohort Study

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Abstract

Background: Readmission in older adults is typically complex with multiple contributing factors. We aim to examine how two prevalent and potentially modifiable geriatric conditions – depressive symptoms and malnutrition – relate to other geriatric syndromes and 30-day readmission in hospitalized older adults.

Methods: Consecutive admissions of patients \( \geq 65 \) years to a general medical department were recruited over 15 months. Patients were screened for depression, malnutrition, delirium, cognitive impairment, and frailty at admission. Medical records were reviewed for intermediary events including poor oral intake and functional decline during hospitalization. Unplanned readmission within 30-days of discharge was tracked through the hospital’s electronic health records and follow-up telephone interviews. We use directed acyclic graphs (DAGs) to depict the relationship of depressive symptoms and malnutrition with geriatric syndromes that constitute covariates of interest and 30-day readmission outcome. Multiple logistic regression was performed for the independent associations of depressive symptoms and malnutrition with 30-day readmission, adjusting for variables based on DAG-identified minimal adjustment set.

Results: We recruited 1619 consecutive admissions, with mean age 76.4 (7.9) years and 51.3% females. 30-day readmission occurred in 331 (22.0%) patients. Depressive symptoms (OR 1.55, 95% CI 1.15-2.07), malnutrition (OR 1.59, 95% CI 1.14-2.23), higher comorbidity burden, hospitalization in the one-year preceding index admission, frailty, delirium, as well as functional decline and poor oral intake during the index admission, were more commonly observed among patients who were readmitted within 30 days of discharge (P<0.05). Patients with active depressive symptoms were significantly more likely to be frail (OR=1.62, 95% CI 1.22-2.16), had poor oral intake (OR=1.35, 95% CI 1.02-1.79) and functional decline during admission (OR=1.58, 95% CI 1.11-2.23). Malnutrition at admission was significantly associated with frailty, delirium, cognitive impairment and poor oral intake during hospitalization (P<0.05). In minimal adjustment set identified by DAG, depressive symptoms (OR=1.38, 95% CI 1.02-1.86) remained significantly associated with 30-day readmission. The association of malnutrition with 30-day readmission was attenuated after adjusting for age, ethnicity and depressive symptoms in the minimal adjustment set (OR=1.40, 95% CI 0.99-1.98, P=0.06).

Conclusion: The observed causal associations support screening and targeted interventions for depressive symptoms and malnutrition during admission and in the post-acute period.

Background

Hospitalized older adults represent a medically complex population and are susceptible to unplanned early readmission (1, 2), exposing the vulnerable older person to recurrent hazards of hospitalization that negatively impact their prognosis (3). While readmissions have often been attributed to suboptimal transitional care, many hospital-initiated transition programs had little impact on readmission rate, and effective interventions are often resource- and personnel-intensive (4, 5). Thus, cost efficiency mandates
that such multi-modal transitional care interventions be targeted towards patients at highest risk for readmission.

Risk stratification tools designed to predict readmission in older adults have largely demonstrated poor discriminative ability (6–10). Most predictive models incorporate age, comorbidity and prior healthcare utilization which may not serve to further risk-stratify an already high-risk population of frail elderly with multi-morbidity. As such, identifying clinically actionable data to triage hospitalized seniors to specific foci of interventions should be considered to address the varying levels of needs. A recent study highlighted the association between geriatric syndromes and readmission within one year (11). The inclusion of geriatric syndromes in a predictive scoring system also yielded moderate discriminative ability for 30-day readmission in older adults (12). Geriatric syndromes are multifactorial conditions that often do not fit into discrete disease categories, share risk factors and commonly co-exist (13). These recent findings should support comprehensive geriatric assessment (CGA) in identifying older patients at risk for readmission. However, determining the causal pathways by which individual geriatric syndromes lead to readmission may allow for more targeted interventions to address the inciting trigger, especially in high acuity settings that may be constrained by time and manpower resources for a full CGA.

Depression and malnutrition represent modifiable factors to address readmission risk, having been associated across studies with readmission outcomes although their causal pathways were not always explicitly described (12, 14–16). Additionally, both are common risk factors for other geriatric syndromes such as frailty and cognitive impairment (17, 18), and potentially predispose to intermediary events including functional decline and poor oral intake during the index admission, all of which may further contribute to the patient’s risk for readmission. Thus, with hospital readmissions in older adults being typically complex and multifactorial, we propose the use of graphical representations of exposure-outcome relationship to facilitate analysis for a less biased estimate of the total causal effect of depression and malnutrition. Directed acyclic graphs (DAGs) have permeated epidemiology and raised awareness of the inadequacy of conventional criteria for identifying or adjusting for confounders (19). We construct DAGs to depict how depression and malnutrition relate to each other as well as other geriatric syndromes, in their relationship with 30-day readmission outcome.

The objectives of this study were to examine (i) association between depressive symptoms and malnutrition with other geriatric syndromes, and (ii) association between depressive symptoms and malnutrition with unplanned 30-day readmission in hospitalized older adults. DAGs were applied to identify a minimally sufficient adjustment set for quantitative analyses for the magnitude of effects. We also compared the results from DAG-driven approach with the results from traditional methods of selecting variables for adjustment in multiple regression models.

**Methods**

**Study Setting and Participants**
This prospective cohort study recruited community-dwelling older adults aged ≥65 years who were admitted to the Department of General Medicine, Sengkang General Hospital (SKH), Singapore, over a 15-month period. All consecutive admissions during the recruitment period were screened for study eligibility. We excluded patients who were admitted from sheltered or nursing homes, direct admissions to high dependency or intensive care units at presentation, demised during hospitalization, admissions to non-medical departments, and patients who were transferred to other acute hospitals or discharged against medical advice. The first admission of unique patients to SKH between October 2018 and January 2020 was defined as the index admission.

Ethics approval for conduct of this study was obtained from SingHealth Institutional Review Board. Informed consent was obtained from all participants, or their legally acceptable representative in cases when the participant was unable to provide informed decision.

Defining Outcome

An unplanned hospital readmission was defined as at least an overnight stay in any acute hospital up to 30 days from the index discharge, irrespective of the admitting department, and that had not been previously scheduled. Observations within the Emergency Department for which an admission was not actualized were excluded, and only the first readmission was counted. Readmission data was tracked through the hospital's electronic health records and follow-up telephone interviews were conducted to facilitate capture of readmissions to other acute hospitals that did not share the index hospital's electronic platform.

Clinical Assessment and Data Collection

Screening for depression was performed within 48 hours of admission using the Patient Health Questionnaire-2 (PHQ-2), asking patients “Over the past 2 weeks, (i) have you felt down, depressed, or hopeless? and (ii) have you felt little interest or pleasure in doing things?” A positive response to either question was considered as presence of depressive symptomatology (20). Medical records as well as medication list were reviewed to clarify any diagnosis of depression that had been established prior to the index admission. Patients were categorized in one of 4 groups: (i) No depressive symptoms and no history of depression (PHQ2- / History-), (ii) No depressive symptoms but positive history of depression (PHQ2- / History+), (iii) Depressive symptoms regardless of history (PHQ2+ / History±), (iv) Inability to communicate symptoms (due to reasons such as advanced dementia or hypoactive delirium).

Malnutrition was identified using the locally validated 3-minute Nutrition Screen, which was routinely administered by a trained nurse upon admission. A score ≥3 (range 0-9) is indicative of malnutrition risk in acute hospital patients (21).

Delirium diagnosis within 48 hours of admission was established using the Confusion Assessment Method (CAM) (22). The CAM diagnostic algorithm requires the presence of (a) acute onset or fluctuating course), (b) inattention, along with either (c) disturbed consciousness or (d) disorganised thinking.
Patients exhibiting two CAM features without meeting CAM diagnostic criteria were diagnosed as having subsyndromal delirium.

Baseline cognitive performance was assessed using the locally validated Abbreviated Mental Test (AMT, range 0-10) (23). Medical records were reviewed for a prior diagnosis of established dementia. Patients were categorized as cognitively impaired if they scored less than 8 on the AMT or had a known diagnosis of dementia.

Premorbid (defined as performance in the period up to 2 weeks prior to onset of acute illness) functional performance was assessed through interview with the patient or caregiver, to determine whether patients were independent, requiring assistance or dependent in activities of daily living (ADLs) and instrumental ADLs. We defined functional decline during hospitalization as incremental assistance in ADLs at the time of discharge compared with premorbid function.

Daily intake-output charts were reviewed for adequacy of oral intake during the admission, which was categorized as optimal if the patient consumed at least three-quarter share of each meal provided at least 50% of the time throughout the hospital stay (24).

Frailty status was assessed using the Clinical Frailty Scale (CFS) (range 1-9), with CFS scores assigned based on information on premorbid functional performance, comorbidities, cognition and symptoms of exhaustion. Patients with CFS scores of 1-3 were categorized as non-frail, 4 as pre-frail, and 5-9 as frail (with increasing frailty ranging from mild, moderate, severe, very severe and terminal) (25).

Comorbidity burden was scored using the Charlson Comorbidity Index, and severity of illness at admission was assessed using the modified Severity of Illness Index (26, 27). The primary and additional diagnoses during admission were recorded, and hospital admissions in the year preceding index admission were captured through the electronic health records. Medication reconciliation was performed routinely at admission, with polypharmacy defined as the use of at least 5 prescription medicines.

Socio-demographic data included age, gender, ethnicity, marital status and living arrangement. Information pertaining to patient’s need for a caregiver was obtained through interview with the patient or caregiver. Caregiver burden was assessed using a single question “Do you feel strained by the caregiving situation?”, with responses of “not at all” and “not particularly” being defined as low strain and responses of “to some extent”, “much so” and “very much so” being defined as high strain (28).

**Statistical Analysis**

**Directed Acyclic Graphs**

We constructed DAGs based on a priori knowledge from literature review to derive the most plausible causal diagrams for the effects of depression and malnutrition, respectively, on 30-day readmission. DAGs comprise nodes representing variables of interest and arrows representing causal associations between variables. The DAGs provide a clear conceptualization of confounding and enable derivation of
a minimal adjustment set that blocks all backdoor paths without inadvertently opening closed pathways by conditioning on colliders, and avoid bias that may be introduced through erroneous adjustment for mediating variables (29, 30). We used the programme DAGitty (31, 32), which facilitated identification of causal and biasing paths in the DAGs to determine the minimal sufficient adjustment sets (Fig. 1A and 1B) for estimating the total causal effects of depression and malnutrition on the outcome of 30-day readmission. These minimal adjustment sets consist of the smallest number of variables necessary to account for confounding.

### Univariate Analysis and Multiple Logistic Regression

Summary measures of baseline characteristics are presented as means (± standard deviations) and proportions. We performed univariate analyses comparing participants with and without 30-day readmission, using Pearson's Chi square test for categorical variables and independent sample t-test for continuous variables. The association between depressive symptoms and malnutrition with other geriatric syndromes was examined using logistic regression. Multiple logistic regression was used to examine the independent risk of depressive symptoms and malnutrition on 30-day readmission, adjusted for the potential confounders identified in the minimal adjustment sets.

Complete-case analysis was restricted to participants with 30-day follow-up data. Potential selection bias arising from loss to follow up was subsequently addressed through sensitivity analyses (assuming that all losses to follow up were readmitted and non-readmitted respectively) and multiple imputation while holding the assumption of missing at random (MAR). Multivariate normal regression was used for multiple imputation with 20 data sets created. We performed alternative analyses to contrast the approach of DAG-derived minimal adjustment sets with conventional variable selection strategies that included all covariates significantly associated with both exposure (depressive symptoms or malnutrition) and outcome (30-day readmission) as confounding variables in the multiple regression model. Age, gender and ethnicity were adjusted for a priori, irrespective of the univariate associations, in these models.

Statistical analysis was performed using STATA 15.0. All statistical tests were 2-tailed, with p-value ≤ 0.05 considered statistically significant.

### Results

We recruited 1619 consecutive admissions, with mean age 76.4 (7.9) years and 51.3% females. 112 (6.9%) patients had missing 30-day follow-up data. Complete case analysis was performed for 1507 patients, of whom 331 (22.0%) were re-admitted within 30-days of discharge. Depressive symptomatology was reported by 352 (21.8%) participants, while 44 (2.7%) participants had a history of established depression but were asymptomatic at time of admission. Malnutrition was prevalent in 13.4% participants at admission. Factors associated with 30-day readmission Table 1 compares the characteristics of patients with and without 30-day readmission. Patients with 30-day readmission were more likely to report depressive symptoms (26.1% vs 20.4%, P<0.001) compared with patients who were
not readmitted. Malnutrition at admission was more prevalent among patients who were readmitted within 30-days compared with those without readmission (17.4% vs 11.6%, P<0.01). Patients who were readmitted within 30 days had significantly longer length of stay during the index admission compared with those who were not readmitted, with observed differences in patterns of admission diagnoses but not severity of illness. Patients with 30-day readmission had higher comorbidity burden, were more likely to have been admitted to hospital in the one-year preceding index admission, more often cognitively impaired and had more severe frailty at baseline. Delirium, functional decline and poor oral intake during the index admission were all significantly more commonly observed among patients who were readmitted within 30 days of discharge.

Table 1

Baseline and hospitalization characteristics for patients with and without 30-day readmission
Association of depressive symptoms and malnutrition with other geriatric syndromes

The presence of active depressive symptoms was significantly associated with frailty (CFS >5, OR=1.62, 95% CI 1.22-2.16, P=0.039), poor oral intake during hospitalization (OR=1.35, 95% CI 1.02-1.79, P=0.037), and inpatient functional decline (OR=1.58, 95% CI 1.11-2.23, P=0.011), when referenced against patients...
with neither depressive symptoms nor history of depression (Table 2). Prior depression diagnosis even in the absence of active depressive symptoms, as well as inability to communicate symptoms, were significantly associated with frailty, poor oral intake, functional decline, delirium and cognitive impairment. Malnutrition was significantly associated with all geriatric syndromes examined, with the exception of functional decline during hospitalization (P=0.076).

Table 2

Logistic regression for depressive symptoms and malnutrition with other geriatric syndromes

| Depressive symptoms (CFS≥5) | Delirium (≥3) | Cognitive impairment (≥3) | Poor oral intake | Functional decline |
|-----------------------------|---------------|---------------------------|------------------|-------------------|
| PHQ2- / History -          | Ref           | Ref                       | Ref              | Ref              |
| PHQ2- / History +          | 2.36* (1.04-5.35) | 4.73* (2.24-10.00) | 2.07* (1.11-3.87) | 2.18* (1.16-4.11) | 2.22* (1.04-4.74) |
| PHQ2+ / History -          | 1.62* (1.22-2.16) | 1.18 (0.73-1.91) | 0.85 (0.64-1.13) | 1.35* (1.02-1.79) | 1.58* (1.11-2.23) |
| Uncommunicative            | 27.72* (6.82-112.74) | 35.45* (22.50-55.88) | 73.56* (23.06-234.82) | 10.76* (7.00-16.53) | 3.45* (2.24-5.33) |
| Malnutrition               | 1.53* (1.07-2.19) | 2.33* (1.60-3.39) | 1.88* (1.39-2.54) | 2.70* (2.01-3.64) | 1.43 (0.96-2.11) |

PHQ: Patient Health Questionnaire
*P<0.05

**DAG-derived adjustment for the causal association of depressive symptoms and malnutrition with 30-day readmission**

For the effect of depression on 30-day readmission with 15 co-variates, 29 causal paths were identified and the minimal adjustment set included age, comorbidity, gender, ethnicity, living alone and having an admission in the preceding one year (Fig. 1A). After adjusting for the confounding variables in the minimal adjustment set, patients reporting depressive symptoms had significantly increased risk for 30-day readmission (OR=1.38, 95% confidence interval 1.02-1.86, P=0.039) when referenced against patients with neither depressive symptoms nor history of depression (Table 3). Patients with an established depression diagnosis but not experiencing active depressive symptoms were not at risk for 30-day readmission. Patients who were unable to communicate their symptoms were also at increased risk for 30-day readmission. Patients who were unable to communicate their symptoms remained significant risk factors for 30-day readmission in multiple imputation and sensitivity analyses.
Table 3

Estimated odds ratios for depressive symptoms on 30-day readmission

| Depressive symptoms | Model 1, Odds Ratio (95% CI) | Model 2, Odds Ratio (95% CI) | Model 3, Odds Ratio (95% CI) |
|---------------------|-----------------------------|-----------------------------|-----------------------------|
| PHQ2-/ History -    | Ref                         | Ref                         | Ref                         |
| 1.55 (1.15-2.07),   | 1.38 (1.02-1.86),           | 1.30 (0.95-1.76),           |
| P=0.003             | P=0.039                     | P=0.099                     |
| PHQ2+/ History +    | 1.24 (0.58-2.65)            | 1.03 (0.47-2.24),           | 0.97 (0.43-2.20),           |
| P=0.576             | P=0.947                     | P=0.949                     |
| Non-communicative   | 2.47 (1.63-3.74),           | 2.11 (1.35-3.28),           | 1.95 (1.02-3.72),           |
| P<0.001             | P=0.001                     | P=0.044                     |

PHQ: Patient Health Questionnaire
Model 1: unadjusted
Model 2: DAG-based minimal adjustment set including age, gender, ethnicity, comorbidity burden, living alone and admission in preceding one year
Model 3: conventional variable selection, adjusted for age, gender, ethnicity, comorbidity burden, admission in preceding one year, frailty, cognitive impairment, malnutrition, admission diagnosis, poor oral intake and functional decline during admission

The DAG for malnutrition on 30-day readmission included 14 causal paths and age, depression and ethnicity were identified as potential confounders in the minimal adjustment set (Fig. 1B). Malnutrition at admission was significantly associated with 30-day readmission in the unadjusted model (OR=1.59, 95% confidence interval 1.14-2.23, P=0.007). In the minimal adjustment set to account for confounding by age, ethnicity and depressive symptoms, malnutrition retained association with 30-day readmission, although no longer statistically significant (OR=1.40, 95% confidence interval 0.99-1.98, P=0.058) (Table 4). Malnutrition remained significantly associated with 30-day readmission in multiple imputation analysis (OR=1.48, 95% CI 1.08-2.02, P=0.014), and in sensitivity analyses for which all patients with missing 30-day follow up were assumed as having been readmitted (OR=1.46, 95% confidence interval 1.08-2.06-1.99, P=0.018). The association between malnutrition and 30-day readmission was no longer statistically significant (P=0.075) in sensitivity analyses that assumed missing follow-up data as not having been readmitted.

Table 4

Estimated odds ratios for malnutrition on 30-day readmission
Using the conventional approach of including all variables with univariate P<0.05 in their association with depressive symptomatology and 30-day readmission – comorbidity burden, admission diagnosis, previous hospitalization, frailty status, cognitive impairment, malnutrition, poor oral intake and functional decline during admission - alongside a priori adjustment for age, gender and ethnicity, depressive symptomatology was no longer associated with readmission risk, although patients who were unable to communicate symptoms remained at increased risk for 30-day readmission (Table 3). Comorbidity burden, previous hospitalization, frailty status, depressive symptomatology, cognitive impairment and poor oral intake during admission were associated with both malnutrition and 30-day readmission on univariate analyses. In multiple logistic regression with a priori adjustment for age, gender, ethnicity, and all significant univariate covariates, malnutrition was not associated with readmission risk (Table 4).

**Discussion**

Our study identified a 30-day readmission rate of 22%, and established the causal associations of depressive symptoms and malnutrition with 30-day readmission among community-dwelling older adults. Additionally, both depressive symptoms and malnutrition at admission were associated with other geriatric syndromes, including delirium, cognitive impairment, frailty, poor oral intake and functional decline during hospitalization.

Our working DAGs and associations between variables of interest were guided by a priori knowledge from literature review. As illustrated in Fig. 1A and Fig. 1B, frailty (17, 18), cognitive impairment (33), functional decline (34) and poor oral intake during admission would have been descendants of depressive symptoms and malnutrition, and thereby considered mediators in the causal paths between depressive symptoms or malnutrition and 30-day readmission. The adjustment for mediators in conventional analyses would have introduced rather than mitigated bias, attenuating the total causal effect of depressive symptoms and malnutrition on 30-day readmission (30). This is evident by the failure to observe a significant association between 30-day readmission and depressive symptoms, and the almost completely obliterated association between readmission and malnutrition, using conventional variable selection strategies.

| Model 1 | Model 2 | Model 3 |
|---------|---------|---------|
| Odds Ratio (95% CI) | Odds Ratio (95% CI) | Odds Ratio (95% CI) |
| Mainnutrition | 1.59 (1.14-2.23), P=0.007 | 1.40 (0.99-1.98), P=0.058 | 1.06 (0.72-1.55), P=0.766 |

**Model 1**: unadjusted

**Model 2**: DAG-based minimal adjustment set including age, ethnicity and depressive symptoms

**Model 3**: conventional variable selection, adjusted for age, gender, ethnicity, comorbidity burden, admission in preceding year, depressive symptoms, frailty, cognitive impairment and poor oral intake during admission
Earlier studies that reported association of depression with readmission risk had operationalized depression based on documentation in patient’s record of a diagnosis, history of depression using International Classification of Diseases (ICD-10) diagnosis codes, psychiatric diagnosis or filling of antidepressant prescription (35, 36). Using quick screening questions for depressive symptoms in the PHQ-2 (20), and further categorization based on established depression diagnosis, our findings suggest that active symptomatology may provide greater clinical relevance in identifying older adults at risk for readmission, compared with the mere dependence on historical diagnosis of depression. Indeed, subsyndromal depression is common in older adults, and imposes the same clinical significance and health impact as syndromal depression, and should be accorded due attention and intervention (37). Contrary to an earlier study which reported no significant association between depressive symptoms and 30-day readmission in hospitalized older adults (38), cognitive impairment did not preclude study participation in our cohort. Indeed, depressive symptoms are common in patients with dementia and contribute to excess morbidity and mortality, yet are often poorly recognized as patients with dementia may be unable to verbalize feelings of sadness (39). The increased risk for readmission among patients who were unable to communicate symptoms was notably higher than that for patients reporting depressive symptoms. Our approach of differentiating patients who were unable to communicate symptoms contrasts with a recent study classifying aphasic patients as being positive for depression which was also linked to increased risk for readmission (12). The inability to communicate can be a manifestation of severity of underlying dementia or delirium, which may be driving the readmission risk, as observed in our examined associations between depressive symptoms and the various geriatric syndromes. However, depression remains highly prevalent across dementia stages, and may present as behavioural disturbance such as agitation, sleep disturbance, decreased appetite or withdrawal in persons with advanced dementia who are unable to verbalize symptoms (40, 41). Owing to the inconsistent documentation practices of such behavioural manifestations, we were unable to confidently ascertain the potential for depression amongst our less communicative patients.

Recent studies highlighted malnutrition among the geriatric syndromes contributing to readmission risk in older adults, and nutritional problem was the strongest predictor identified from a Comprehensive Geriatric Assessment (11, 12). Our observed association between malnutrition and 30-day readmission justify efforts at targeted nutritional interventions for malnourished hospitalized older adults. Malnutrition was also associated with other geriatric syndromes and perpetuated poor oral intake during hospitalization. Thus, early identification and supportive dietary strategies will be paramount to address a potential vicious cycle driving readmission risk. With literature evidence suggesting depression as a contributing cause of malnutrition (42), possibly owing to reasons such as inappetence, loss of interest in self-care and apathy, our working DAG specified depression as a parent of malnutrition, and subsequently addressed as a confounding variable in the relationship between malnutrition and 30-day readmission. In DAG-based analysis, the effect of malnutrition on 30-day readmission was attenuated once depressive symptoms were adjusted for, although significant association was maintained in multiple imputation and sensitivity analyses. Comparatively, we hypothesized that the observed associations between comorbidity burden and malnutrition in many cross-sectional studies are driven through depression,
thereby guiding the direction of arrows in our working DAG. This was supported by the results from a study in frail older adults, in which depression rather than comorbidity index was associated with malnutrition in multiple regression analyses (43). This contrasts with earlier approaches which typically adjusted for comorbidities, admission diagnoses and length of hospital stay in examining the association between nutritional status and readmission, which in alternative analyses using the traditional approach for selection of variables would have nullified the association between malnutrition and 30-day readmission in our cohort.

A review of existing literature suggests that this is the first study adopting DAGs to examine the relationship between modifiable risk factors and 30-day readmission in older adults. Utilizing DAGs allows visualization and analysis of complex causal situations, such as in the case of unplanned hospital readmissions. Readmissions are typically multifactorial and complex events, with socioeconomic, medical and psychological factors typically being implicated. The DAG offers transparency in the representation of causal relations between variables based on knowledge, theories or assumptions. This provides a valid model for the identification of an implied adjustment set to accurately estimate a causal effect through inspection or algorithmically, depending on the DAG’s structure and complexity. However, we acknowledge several limitations in our study, in particular the exclusion of patients who were unable to provide informed consent and had no legally acceptable representative who could be approached for this study, leading to possible selection bias and generalizability of our study findings to all hospitalized older adults. We would like to highlight that cognitively impaired patients were still represented and accounted for approximately 30% of our cohort, although only 3% were severely impaired and unable to communicate. While our analysis was restricted to patients with complete follow-up data at 30-days, subsequent sensitivity and multiple imputation analyses supported the results of the complete-case analysis.

Conclusion

In conclusion, depressive symptoms and malnutrition are associated with other geriatric syndromes, and represent potentially modifiable risk factors for 30-day readmission in hospitalized older adults. The results support efforts to improve screening and identification of active depressive symptoms and malnutrition for targeted interventions during admission and in the post-acute period.

Declarations

Ethics approval and consent to participate:

All methods were carried out in accordance with relevant guidelines and regulations. The study protocol had been reviewed with ethics approval by SingHealth Institutional Review Board (CIRB Ref No 2018/2584). Written informed consent for study participation was provided by all participants before recruitment, or their legally acceptable representative for patients who were unable to provide informed decision.
Consent for publication:

Not applicable.

Availability of data:

All data analysed during this study are included in this published article.

Competing interests:

The authors have no conflict of interest to declare.

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Authors’ contributions:

Tay L contributed to study design, conduct of study, analysis and main manuscript writing; Chua M contributed to study design and manuscript review; Ding YY contributed to study design, analysis and manuscript writing. All authors reviewed the manuscript.

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Figures

Figure 1

A: DAG for the effect of depression on 30-day readmission. Backdoor paths and confounders are bolded.
B: DAG for the effect of malnutrition on 30-day readmission. Backdoor paths and confounders are bolded.