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Reduced functional independence and multimorbidity increases the risk of severe infection among older patients with Omicron: a multicenter retrospective cohort study

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Abstract

Background Multimorbidity and physical function in older adults have been identified as associated with coronavirus disease 2019 (COVID-19) outcomes. This study aimed to investigate whether multimorbidity affects the association of impaired functional independence (FI) with critical COVID-19 among older inpatients during the peak of Omicron infection in China.

Methods This is a multicentre, retrospective cohort study in northeastern China. Patients aged ≥ 60 years, who were diagnosed with COVID-19 at the time of admission or during hospitalisation. The Barthel index was used to assess FI. Patients were classified into independent, mildly dependent, moderately dependent, and severely dependent groups. Disease severity was classified as critical, severe, and non-severe and combined into severe or critical and non-severe. Binary logistic regression analysis was used to investigate any correlation between FI and disease severity. Patients were further stratified by presence or absence of multimorbidity.

Findings In this study, of 1598 patients, 530 (33.17%) developed severe or critical infections during the entire hospital stay. Patients with severe dependency had 7.39 times (95% CI: [4.60, 12.15]) higher risk of serious or critical infections than those without dependency. An interaction was noted between reduced FI and multimorbidity (p for interaction < 0.001). Compared to non-multimorbid patients (OR = 3.71, 95% CI: [1.58, 9.16]), multimorbid patients (OR = 10.04, 95% CI: [5.63, 18.57]) had a more pronounced risk of severe or critical infection.

Conclusions Our results provide further scientific evidence on the association between FI, multimorbidity, and disease severity in older COVID-19 patients, contributing to future health decision-making for COVID-19 and other infectious diseases.

Keywords Multimorbidity, Functional independence, Barthel index, Omicron, Older patients

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Background

Although the global incidence of coronavirus disease 2019 (COVID-19) continues to decline, the COVID-19 pandemic persists. The clinical symptoms and disease severity of COVID-19 may vary depending on the virus strain. Since it was first identified in South Africa in mid-November 2021 and recognised as a variant of concern (VOC) on November 26, 2021 [1, 2], the Omicron (B.1.1.529) variant of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has raised several concerns worldwide. Since Omicron was 3.3 times more transmissible than the Delta variant [3],the trend of increasing cases of infection in the former shows a higher and quicker peak [4]. As the current dominant global strain, 7,525,560 confirmed cases of the Omicron variant have been reported worldwide, as of February 15, 2023, [5] posing a clear threat to public health worldwide.

Recent studies have shown that older patients represent a vulnerable population in the outbreak of Omicron infection and account for the highest proportion of severe infections [6]. Comorbidity with two or more chronic diseases (also known as multimorbidity) is a common feature in older patients. This is probably related with age-related proinflammatory state,which can lead to higher vulnerability to chronic diseases development and faster disease progression [7]. Compared with patients with a single chronic disease, those with multimorbidity showing an acceleration in the accumulation of inflammatory factors [8], have been confirmed the association with multiple adverse health outcomes and disease burden [9–12]. Exacerbation of low-grade inflammation may produce an exaggerated response to COVID-19 acute infection [13]. During the COVID-19 pandemic, multimorbid patients were at greater risk of infection and adverse outcomes, including hospitalisation, and had higher mortality rates than patients with a single chronic disease, as confirmed by experimental studies and systematic meta-analyses [14, 15].

Functional independence (FI) is defined as 'functioning physically safe and independent from other persons, within one's own context' [16]. Impaired functional status serves as a marker of increased vulnerability and decreased biological reserve and is often considered a major but incomplete predictor of poor outcomes in older adults [17]. The Barthel index is a reliable, sensitive, and practical metric for assessing activities of daily living (ADL) in patients, reflecting the FI of patients in self-care and social activity; it is essential for guiding the allocation of inpatient and community care resources. In China, the Barthel index is routinely evaluated on the day of patient's admission as a foundation for grading inpatient care [18]. Clinical studies have demonstrated its significance in predicting common outcomes in older patients, [19–21] in-hospital burden such as in-hospital mortality and duration of hospital stay, [22, 23] and prognostic value in the emergency department [24]. Additionally, studies have reported its use as a prognostic factor for adverse outcomes in COVID-19 [25, 26].

More than 50% of older adults aged > 60 years worldwide have multimorbidity [27]. In the Swedish Kungsholmen Project, multimorbid patients among individuals aged > 78 years had impaired FI for 81% of their remaining life, [28] suggesting a remarkably high prevalence of multimorbidity combined with reduced FI in older adults. Previous studies on risk factors for severe COVID-19 have focused on the independent effects of a single factor, which may interact through complex pathophysiological mechanisms and have unpredictable effects on the outcome of severe infections [29]. Thus, direct translation of the results of studies on possible independent factors into real-world decision-making remains difficult. Given that multiple health problems such as multimorbidity and reduced FI in older adults often coexist, no study to date has reported on their effects on COVID-19 among older patients. Therefore, this retrospective cohort study of COVID-19 inpatients was conducted during the peak of Omicron infection in China, aiming to investigate whether multimorbidity affects the association of impaired FI with critical COVID-19 among older adults. We also aimed to determine specific chronic conditions that play significant roles in increasing the risk of severe Omicron infection in older adults with reduced FI.

Methods

Study design and setting

In this multicentre, retrospective cohort study, we have chosen five tertiary teaching hospitals in Liaoning Province with independent geriatric specialized wards, including Shengjing Hospital of China Medical University, the Affiliated Central Hospital of Shenyang Medical College, the Second Affiliated Hospital of Shenyang Medical College, Liaoning Jinqiu Hospital, and the Fourth People's Hospital of Shenyang. These hospitals have very comprehensive conditions for diagnosis and treatment of geriatric diseases, and among them, Jinqiu Hospital is a provincial-level geriatric disease diagnosis and treatment centre. Therefore, the participants from these hospitals have good representativeness. The research group consists of 20 members, including 8 professors or chief physicians, 2 intermediate physicians, and 10 public health graduate students majoring in geriatric epidemiology. Besides, before the start of the study, we provided strict training to the researchers to understand the research purpose, significance, and content, and required them to collect data with unified standards, methods, techniques, and a scientific attitude. We included older adult patients

hospitalised in northeastern China due to COVID-19 from December 1, 2022, to January 31, 2023. And data were obtained from the above five medical centres in northeastern China.

Study participants

Patients aged ≥ 60 years and who were diagnosed with COVID-19 at the time of admission or during hospitalisation were included. Specifically, patients who had the following pathogenic and serological findings for diagnosis, were included: positive nucleic acid and antigen test finding for SARS-CoV-2, positive isolation and culture results for SARS-CoV-2, and elevated levels (four or more times) of SARS-CoV-2-specific IgG antibodies during the recovery period compared with the acute period. In addition, we included patients who lacked a positive pathogenic diagnosis but met the clinical diagnostic criteria for SARS-CoV-2 infection based on a combination of epidemiological history, clinical presentation, and other laboratory findings. Patients were excluded if they were transferred from another hospital, or died with 24 h, baseline data could not be collected, and with missing data on any covariates.

Since we did not retrieve the incidence of critical infection in hospitalized elderly patients with COVID-19 who suffered from multimorbidity or impaired FI, we conducted a pilot investigation in the early stage in Shengjing Hospital.

In the pilot investigation, we collected data from 200 patients, with a 36% incidence of severe infection in patients with multimorbidity (p1) and a 24% incidence of severe infection in patients without multimorbidity (p0).

According to sample size calculation formula:

$$n = \frac{\left(Z_{\frac{1-\alpha}{2}}\sqrt{2\overline{pq}} + Z_{\beta}\sqrt{p_0q_0 + p_1q_1}\right)^2}{(p_1 - p_0)^2}$$

$\alpha = 0.05$, $\beta = 0.1$;

$n = 304.47$, considering the loss of follow-up, we will increase the sample size by 10%. Finally, we need at least 336 participants in each of the exposure and control groups.

Data collection

Data for all patients were obtained from the electronic medical record system, including sex, age, smoke, history of long-term medication (angiotension-converting enzyme inhibitior or angiotension receptor blocker (ACE-i/ARB) medications, steroids, non-steroidal anti-inflammatory drugs (NSAIDs), anticoagulants/antiplatelets, chemotherapy agents, or targeted biologics), and medications used for clinical treatment (antivirals and/or steroids). Moreover, we performed laboratory tests within 3 days of admission or diagnosis of COVID-19, including peripheral blood lymphocyte count, neutrophil count, D-dimer, serum albumin, Neutrophil–lymphocyte ratio (NLR) was calculated based on peripheral blood lymphocyte and neutrophil counts.

Data on the history of the 16 most common or significant chronic diseases, [30] including hypertension, diabetes, dyslipidaemia, stroke, heart disease, cancer or malignancy, chronic lung disease, liver disease, kidney disease, gastrointestinal disease, mood, neurological, or psychiatric disorders, memory-related disorders, arthritis or rheumatism, asthma, prostate disease, and glaucoma or cataracts, were also collected. Patients were classified as multimorbid if they had ≥ two chronic diseases [31].

The Barthel index [32] was used to assess the FI of patients at the time of admission. This index comprises 10 items (feeding, moving from wheelchair to bed and back, grooming, toilet use, bathing self, mobility on level surfaces, ascending and descending stairs, dressing, controlling bowels, and controlling bladder) and is scored from 0 to 100 points, with lower Barthel index indicating worse FI. Based on Barthel index, we also classified the patients into independent (100 points), mildly dependent (60–99 points), moderately dependent (41–59 points), and severely dependent (≤ 40 points) groups.

Outcome events were determined using the World Health Organization's definitions of disease severity for COVID-19 [33]: critical, severe, and non-severe. Critical COVID-19 is defined using the criteria for acute respiratory distress syndrome, sepsis, septic shock, or other conditions that would normally require the provision of life-sustaining therapies such as mechanical ventilation (invasive or non-invasive) or vasopressor therapy. Severe COVID-19 is defined by any of the following conditions: oxygen saturation < 90% of room air, signs of pneumonia, signs of severe respiratory distress (accessory muscle use, inability to complete full sentences, respiratory rate > 30 bpm). Meanwhile, non-severe COVID-19 is defined as the absence of any criteria for severe or critical COVID-19. Outcome data were collected for the most severe level of disease observed throughout the hospitalisation period, and the severity of disease was combined into a binary classification (non-severe and severe or critical) for subsequent analysis.

Statistical analysis

Median and interquartile range (IQR) and frequency and percentage are used for descriptive statistics of continuous and categorical variables, respectively. The Kolmogorov–Smirnov test was used to determine whether continuous variables conformed to the normal distribution. The Kruskal–Wallis test and chi-square or Fisher's exact test were used for comparing two sets of continuous

and categorical variables, respectively. Binary logistic regression analysis was used to estimate the odds ratio (OR) and 95% CI of the association between multimorbidity and Barthel index and severe or critical infection. Subsequently, we performed an analysis stratified by the presence or absence of multimorbidity and constructed plots to determine whether multimorbidity influenced the association. We used the Wald test to assess whether the observed relationship was linear or nonlinear and constructed spline plots to describe the dose–response relationship between the Barthel index and the risk of severe or critical infection. Since the smallest unit of variation in the Barthel index is 5, we also assessed the association between every 5-unit decrease in the Barthel index and severe or critical infection. A multivariate regression model was developed and the following independent variables were adjusted: age (whether ≥ 80 or not), sex, smoke, biochemical indicators (D-dimer level ≥ 500 μg/L, albumin level < 35 g/L, NLR ≥ 2.973), and clinical medication use (antivirals, steroids). Additional sensitivity analysis was performed to exclude potential bias due to long-term patient medication use (ACE-i/ARB medications, steroids, NSAIDs, anticoagulants/antiplatelets, chemotherapy agents, or targeted biologics).

All statistical analyses were performed using R software (version 4.2.0). Differences with a two-sided $p < 0.05$ were considered statistically significant.

Results

A total of 1614 patients aged ≥ 60 years and diagnosed with COVID-19 in one of the five hospitals were included in the study, of whom, 16 patients who were transferred from other hospitals were excluded. Finally, 1598 patients were included in baseline analysis. Of these, 1246 patients underwent follow-up analysis due to missing covariates in 352 patients (S1 Figure). S1 Table shows the overall baseline and missing data for the 1598 patients.

Table 1 shows the baseline characteristics of the overall population based on COVID-19 severity. A total of 530 patients (33.17%) had severe or critical COVID-19. Compared with those with other severity, patients with severe or critical COVID-19 were more likely to be male and older (aged ≥ 80 years); have a lower Barthel index (higher severity); higher neutrophil count, CRP, lactate dehydrogenase, D-dimer, and NLR; lower peripheral blood lymphocyte count and albumin; and higher risk of multimorbidity ($p < 0.05$). No significant intra-group differences were noted in any of the other indicators.

Multimorbid patients had 1.67 times higher risk of developing severe or critical COVID-19 than non-multimorbid patients (OR = 1.67, 95% CI: [1.23, 2.28]) (S2 Table), and this risk increased by 21% with increasing number of comorbidities in multimorbid patients (OR = 1.21, 95% CI: [1.12, 1.30]).

Table 1 Baseline characteristics of the participants based on COVID-19 severity

	Non-severe *N = 1068*	Severe or critical *N = 530*	*p*
Sex:			0.004
Male	629(58.9%)	352(66.4%)	
Female	439(41.1%)	178(33.6%)	
Age:			< 0.001
60–80	621(58.1%)	213(40.2%)	
≥ 80	447(41.9%)	317(59.8%)	
Smoking:			0.234
No	882(82.6%)	424(80.0%)	
Yes	186(17.4%)	106(20.0%)	
Barthel index	80.0[60.0;100]	45.0[20.0;70.0]	< 0.001
Barthel index:			< 0.001
Independent	289(27.1%)	35(6.60%)	
Mildly dependent	437(40.9%)	138(26.0%)	
Moderately dependent	195(18.3%)	111(20.9%)	
Severely dependent	147(13.8%)	246(46.4%)	
Peripheral blood lymphocyte count (10^9/L)	1.00[0.64;1.40]	0.70[0.48;1.04]	< 0.001
Neutrophil count (10^9/L)	3.90[2.79;5.70]	5.40[3.70;8.00]	< 0.001
D-dimer (ug/L)	450[214;969]	892[335;2198]	< 0.001
Serum albumin (g/L)	34.5[31.5;38.0]	31.0[27.7;33.4]	< 0.001
NLR	4.01[2.39;7.42]	7.60[4.25;14.2]	< 0.001
Multimorbidity:			< 0.001
No	365(34.2%)	120(22.6%)	
Yes	703(65.8%)	410(77.4%)	

Abbreviations: *NLR* Neutrophil–lymphocyte ratio

Table 2 and Figs. 1 and 2, and S2 Fig show the risk of severe or critical COVID-19 at different levels of the Barthel index. During hospitalisation, the risk of severe or critical COVID-19 was 7.39 times higher in heavily dependent patients than in non-dependent patients (OR = 7.39, 95% CI: [4.60, 12.15]). For every 5-point increase in the Barthel index, the risk of severe or critical COVID-19 was increased by 12% (OR = 1.12, 95% CI: [1.10, 1.15]). Moreover, we observed a linear correlation between reduced FI and the risk of severe or critical COVID-19 (Fig. 2, $p < 0.001$). We also observed a significant interaction between multimorbidity and reduced FI ($p < 0.001$). Compared with non-multimorbid patients ($OR_{\text{mildly dependent vs independent}} = 2.08$, 95% CI: [0.97, 4.74]; $OR_{\text{moderately dependent vs independent}} = 2.74$, 95% CI: [1.13, 6.90]; $OR_{\text{severely dependent vs independent}} = 3.71$, 95% CI: [1.58, 9.16]), multimorbid patients ($OR_{\text{mildly dependent vs independent}} = 2.13$, 95% CI: [1.23, 3.84]; $OR_{\text{moderately dependent vs independent}} = 3.45$, 95% CI: [1.94, 6.34]; $OR_{\text{severely dependent}}$

Table 2 Association between the Barthel index and the risks of severe or critical infection, stratified by multimorbidity

	Number of severe or critical	Number of risk	Barthel index	
			Range	OR (95%CI)
All participants				
Barthel index				
Independent	31	264	100	Ref
Mildly dependent	108	432	60–99	2.10(1.34,3.37)
Moderately dependent	90	247	40–60	3.10(1.92,5.10)
Severely dependent	188	303	0–40	7.39(4.60,12.15)
Per 5 decrease in the Barthel index	417	1246		1.12(1.10,1.15)
Stratified by comorbidity				
Multimorbidity: yes				
Barthel index				
Independent	20	160	100	Ref
Mildly dependent	76	294	60–99	2.13(1.23,3.84)
Moderately dependent	70	179	40–60	3.45(1.94,6.34)
Severely dependent	156	229	0–40	10.04(5.63,18.57)
Per 5 decrease in the Barthel index	322	862		1.15(1.12,1.19)
Multimorbidity: no				
Barthel index				
Independent	11	104	100	Ref
Mildly dependent	32	138	60–99	2.08(0.97,4.74)
Moderately dependent	20	68	40–60	2.74(1.13,6.90)
Severely dependent	32	74	0–40	3.71(1.58,9.16)
Per 5 decrease in the Barthel index	95	384		1.06(1.01,1.11)

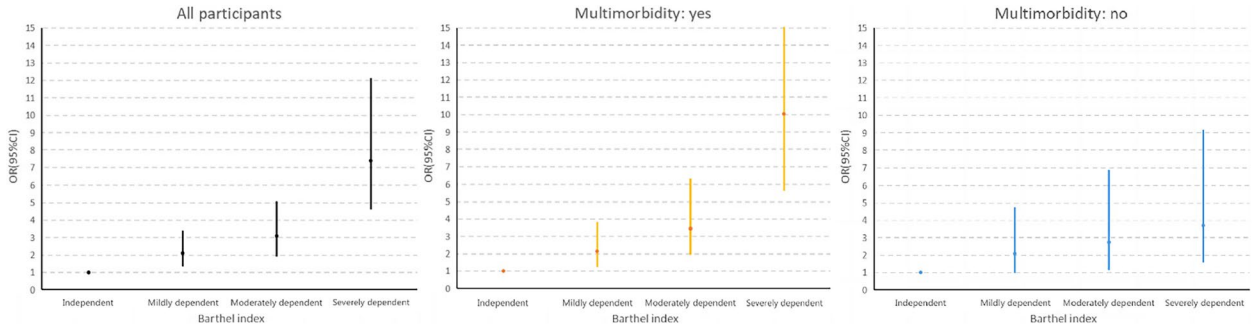

Fig. 1 Odds ratios (95% CI) of severe or critical infection according to the Barthel index, stratified by multimorbidity

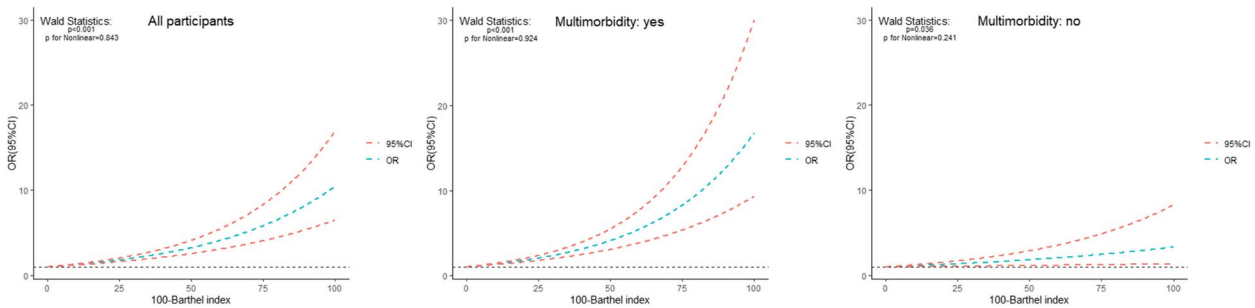

Fig. 2 Dose–response relationship between the Barthel index and the risks of severe or critical infection, stratified by multimorbidity

$_{\text{vs independent}}$ = 10.04, 95% CI: [5.63, 18.57]) had a more pronounced risk of severe or critical infection. After additional correction of the model for history of long-term medication, the results of the sensitivity analysis were consistent with those of the principal analysis (S3 Table).

Figure 3 and S3 Fig report the risk of severe or critical infection for each 5-point decrease in the Barthel index stratified by 16 diseases. Among them, hypertension, stroke, heart disease, chronic lung disease, liver disease, kidney disease, and prostate disease exacerbated the risk

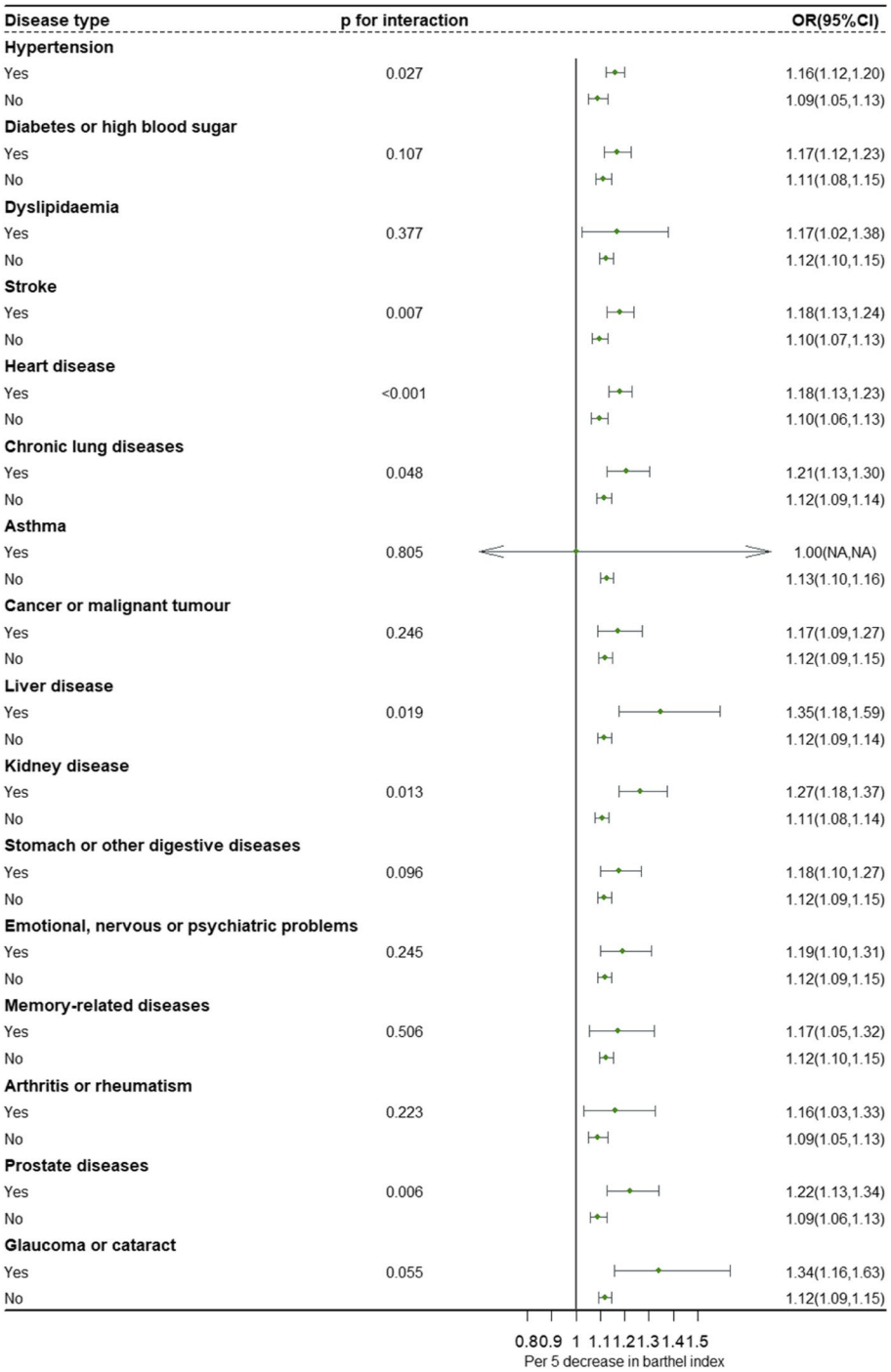

Fig. 3 Odds ratios (95% CI) of severe or critical infection by per 5 decrease in the Barthel index, stratified by single disease

of severe or critical infection in patients due to diminished FI (p for interaction < 0.05).

Discussion

In this multicentre, retrospective cohort study conducted simultaneously at five medical centres in northeastern China, older adults with reduced FI on the day of hospital admission (or the day of COVID-19 diagnosis in the case of patients infected during hospitalisation), as determined by the Barthel index, were at higher risk of presenting with severe and critical COVID-19 due to the Omicron variant. This association was significantly enhanced by pre-hospitalisation multimorbidity. In addition, in the subgroup analysis of chronic diseases, we confirmed the interaction of pre-hospitalisation hypertension, stroke, heart disease, chronic lung disease, liver disease, kidney disease, and prostate disease with reduced FI in terms of the risk of severe COVID-19 in older adults. The interaction between reduced FI and multimorbidity in terms of severe Omicron infection among older patients was significant. To our knowledge, this study is the first to report this finding in the field.

Among baseline characteristics of enrolled patients, we observed that men aged ≥ 80 years had higher rates of severe and critical COVID-19 ($p < 0.05$) than men of 60–80; this trend of sex dimorphism and age stratification of risk was consistent with previously reported results [34, 35]. The significant differences in the Barthel index, FI stratification, presence of multimorbidity, and number of morbidities between the two groups also validate the results of previous studies of independent factors, [35, 36] namely that both multimorbidity and decreased FI have predictive value for outcomes among older COVID-19 patients.

During the first 3 years of the COVID-19 pandemic, numerous studies have analysed the association of multimorbidity and the Barthel index with disease progression or prognosis of COVID-19 [14, 15, 25, 26, 37]; however, each parameter has been limited to being an independent risk factor predicting adverse outcomes of severe disease or death. Multimorbidity tends to be more associated with long-term prognosis, whereas the Barthel index provides a convenient and immediate functional status of patients and is more readily available as a routine assessment at admission in many hospitals. Given the independent and intertwined roles of health factors such as multimorbidity and FI among older adult population, few studies have begun to focus on the association between these two factors. Previous studies demonstrated an association effect between multimorbidity and altered functional status, which has predictive power for some health outcomes among older adult population [38, 39]. However, validation of the synergistic effects between the two has been limited to the overlapping results of the two independent factors [40, 41] or mediation of causal pathways, [42] and the criteria of the instruments reflecting functional status in these studies are variable. Moreover, the use of the Barthel index, which has been validated by clinical studies as a prognostic factor for COVID-19, has not been found to reflect reduced FI among older patients.

Based on these findings, we proposed an interaction between reduced FI assessed by the Barthel index and multimorbidity on the prognosis of Omicron infection among older adults and successfully tested this hypothesis. Recent advances have shown that cellular senescence, a switch associated with ageing in the cellular state, is a key regulator of SARS-CoV-2-induced hyperinflammation [43]. Pre-existing senescent cells among older patients and in those with underlying diseases as well as secondary senescent cells induced by the senescence-associated secretory phenotype (SASP) seem to play a key role in the development of severe COVID-19 [44]. In addition, senescence-associated cell type-specific pathophysiological immune responses exacerbate disease severity in older COVID-19 patients [45]. We hypothesise that multimorbidity and reduced FI exacerbate COVID-19 among older patients precisely through the interaction of excessive inflammation induced by SARS-CoV-2 and mediated by SASP activation. In addition to biological factors, medication-related factors associated with chronic disease as well as other factors, including access to health care, socioeconomic status, and other social adversity factors, may underlie the complex interplay between multimorbidity, reduced FI, and negative outcomes of Omicron infection in older adults [46–48].

We tabulated 16 chronic diseases with the highest prevalence in older Chinese adults to define multimorbidity; some of which had been shown to be high-risk comorbidities for COVID-19 in previous studies [49, 50]. Seven of these chronic diseases were found to interact with reduced FI (Fig. 3). Broadly, the primary effects of most comorbidities in the acute viral disease phase of COVID-19 cannot escape the general consequences of frailty and reduced physiological reserve [51]. For instance, early suggestions that both hypertension and chronic lung disease mediated the increased risk of death in COVID-19 patients through increased expression of the viral receptor angiotensin-converting enzyme 2 (ACE2) was questioned and subsequently rejected in later studies, [52] suggesting that phenotypes associated with frailty are more likely to be comorbidities or multiple morbidities mediating the relationship with COVID-19. During the inflammatory lung injury phase, the general effects of comorbidities and/or frailty may also interact to constitute a potential mechanism for

the development of organ damage among older patients by reducing tolerance to hypoxemic respiratory failure, or by mediating some systemic inflammatory responses [51]. These theories may explain the significance of the interaction observed between partial single disease and reduced FI. Interestingly, (non-cancerous) prostate disease was previously considered to be independent of susceptibility to COVID-19, [53] and our single-disease analysis found an interaction between (non-cancerous) prostate disease and reduced FI in severe COVID-19 among older patients (p for interaction = 0.006). Previous studies have reported that SARS-CoV-2 may damage the prostate through ACE2 signalling, androgen receptor-related mechanisms, inflammation, and metabolic disturbances, worsening BPH and its associated lower urinary tract symptoms (LUTS) [54]; the severity of which is associated with ADL limitation in older men [55]. LUTS is associated with a frail phenotype, which is a risk factor for reduced FI. We hypothesise that the observed interaction is related to exacerbated LUTS after Omicron infection in older men with prostate disease and that inflammation is the key mechanism connecting the two factors.

Although some aspects of multimorbidity and FI among older adults have been studied, only few studies have treated these two as coexisting and interacting outcomes [38–41], with even fewer studies of geriatric susceptibility as applied to epidemic infectious diseases such as COVID-19. In addition, there is a lack of understanding of common risk factors for which interventions can be developed, which needs to be based on deeper understanding of the biological mechanisms of ageing; these may be addressed through integrated multi-omics analysis in the future. In addition, the assessment of multimorbidity and functional status, which underlies clinical decision-making, still lacks consistency and does not facilitate the development of a good evidence-based foundation. Although such assessments are routinely incorporated into medical records in most geriatric wards, their significance in decision-making remains overlooked by health care professionals, and the results are not reflected in subsequent actions. With respect to health policy, systematic reinforcement of primary care to optimise management systems for patients with multimorbidity and reduced FI (e.g., physical activity interventions) [56] may be equally important as vaccines for older adults to deal with future waves of infectious diseases.

Strengths and limitations

This is the first study to focus on the interaction between multimorbidity and FI in COVID-19 among older adults. We collected data from five hospitals, including both academic and teaching hospitals, to form a representative sample of older patients with Omicron infection in northeastern China. Demographic data, physiological parameters, disease severity, multimorbidity, geriatric parameters, and functional impairment of Omicron infection were combined, providing novel evidence to the growing field of research on COVID-19. The Barthel index, which estimates 10 functional status items, is a simple and widely used tool to assess FI and, in combination with multimorbidity, to predict the severity of Omicron infection in hospitalised older patients. The use of existing content adds dimensionality and predictive accuracy to the assessment, providing additional considerations for resource allocation and treatment decisions without increasing the workload of frontline clinicians. Besides, the information on exposure and outcome did not depend on patient self-recall, resulting in a reliable source of information with minimal information bias.

However, this study also has several limitations. First, most patient data were collected retrospectively, which may introduce selection bias. However, all hospitals registered COVID-19 inpatients, suggesting that we did not miss a large number of patients. Second, baseline data on transferred patients were incomplete; however, this process was random, and the proportion of missing patients was small (0.99%) and unlikely to have affected our findings. Third, this study used functional status on the day of hospitalization, but the Barthel Index may begin to decline from the onset of the disease. Thus, the Barthel index should be evaluated before onset, at onset, and after rehabilitation to achieve dynamic results, which can get a more comprehensive understanding of the disease. Fourth, data on COVID-19 vaccination could not collected through the electronic medical record system. However, according to the National Health Commission of China, the number of vaccinated older individuals aged ≥ 60 years was 239.4 million, and 228.165 million individuals were fully vaccinated, accounting for 90.68% and 86.42% respectively [57]. The difference in protective factors due to different vaccination coverages should have a minimal impact on our findings, although the coverage rate of the COVID-19 vaccine among older adults in China is high. Finally, due to sample size limitations, we could not complete the subgroup analysis of sex and age. This prevented us from further identifying the characteristics of the high-risk population. Future large prospective studies could further investigate and identify high-risk populations to facilitate more precise allocation of clinical resources.

Conclusion

In summary, our results provide further scientific evidence on the association between FI, multimorbidity, and disease severity in older COVID-19 patients. Besides,

the interaction of pre-hospitalisation hypertension, stroke, heart disease, chronic lung disease, liver disease, kidney disease, and prostate disease with reduced functional independence was confirmed in terms of the risk of severe COVID-19 in older patients. And these findings can help in future health decision-making for COVID-19 and other infectious diseases.

Abbreviations

COVID-19	Coronavirus disease 2019
FI	Functional independence
ACE-i/ARB	Angiotension-converting enzyme inhibitior or angiotension receptor blocker
NSAIDs	Non-steroidal anti-inflammatory drugs
CRP	C-reactive protein
NLR	Neutrophil–lymphocyte ratio
OR	Odds ratio
CI	Confidence interval
ACE2	Angiotensin-converting enzyme 2
LUTS	Lower urinary tract symptoms

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12877-025-05739-6.

Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

Supplementary Material 4.

Supplementary Material 5.

Supplementary Material 6.

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Authors' contributions

WY†: conceptualization, investigation, resources, data curation, writing-original draft, writing-review & editing, supervision, project administration. RH†: conceptualization, methodology, software, formal analysis, investigation, data curation, writing-original draft, writing-review & editing, visualization. SS, LB, XC, YD, SL, QL, YY, XY, WW, RR, LX, RZ, YL, XL, TH, ZN: investigation, resources. Yang Peng*: conceptualization, resources, data curation, writing-review & editing, supervision, project administration, funding acquisition. Difei Wang*: conceptualization, resources, data curation, writing-review & editing, supervision, project administration, funding acquisition. † These authors contributed equally and were co-first authors. * These authors contributed equally and were corresponding authors. All authors reviewed the manuscript.

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Data availability

The datasets generated and/or analysed during the current study are not publicly available due to ethical restrictions but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Review Board of the Affiliated Central Hospital of Shenyang Medical College, the Second Affiliated Hospital of Shenyang Medical College, Liaoning Jinqiu Hospital, the Fourth People's Hospital of Shenyang and Shengjing Hospital of China Medical University (2023PS376K), and was conducted according to the principles of the Declaration of Helsinki. Due to its retrospective nature, all ethics committees (Medical Ethics Committee of Shengjing Hospital of China Medical University, Medical Ethics Committee of Central Hospital Affiliated to Shenyang Medical College, Ethics Committee of Liaoning Jinqiu Hospital, Ethics Committee of the Second Affiliated Hospital of Shenyang Medical College, and Ethics Committee of the Fourth People's Hospital of Shenyang) have waived the request for informed consent of the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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