Vietnam Journal of Community Medicine, Vol. 66, English version No. 2, 307-312

PREVALENCE AND FACTORS ASSOCIATED WITH FRAILTY USING THE CLINICAL FRAILTY SCALE AMONG COMMUNITY-DWELLING OLDER ADULTS IN HO CHI MINH CITY

Pham Duy Quang*

Nguyen Tat Thanh University - 298A-300A Nguyen Tat Thanh, Xom Chieu Ward, Ho Chi Minh City, Vietnam

Received: 02/12/2025
Revised: 12/12/2025; Accepted: 19/12/2025

ABSTRACT

Background: Frailty is a prevalent geriatric syndrome characterized by increased vulnerability and an elevated risk of poor health consequences, including decline in functional capacity, falls, hospitalization, and mortality. However, little is known about the conditions associated with frailty in the elderly, which remain understudied and poorly known in Vietnam, and early community-based detection is critical for managing the complex medical and psychosocial needs of the elderly.

Objective: This study aimed to explore the prevalence of frailty and its associated factors among community-dwelling older adults in Ho Chi Minh City.

Method: In this cross-sectional study, a total of 317 older adults participated. Frailty was evaluated by utilising the CFS scale as a screening tool. This study was started in May 2025 and completed by November 2025.

Results: The overall prevalence of frailty was found to be 14.8%, using the CFS-VN version. Multimorbidity was present in 53.0% of participants, polypharmacy in 24.9%, and IADL disability in 13.9%. In the multivariate logistic regression model, multimorbidity (aOR = 3.13, 95% CI: 1.32-7.69), polypharmacy (aOR = 2.94, 95% CI: 1.39-6.25), and IADL disability (aOR = 2.70, 95% CI: 1.19-6.67) were independently associated with a higher likelihood of frailty. Older adults aged ≥ 80 years showed an elevated but non-significant increase in frailty risk (aOR = 2.19, 95% CI: 0.83-5.79). Gender, ethnicity, BMI category, marital status, and history of falls were not significantly associated with frailty after adjustment ($p > 0.05$).

Conclusion: In summary, multimorbidity, polypharmacy, and IADL impairment were the strongest independent correlates of frailty in this study. The CFS-VN proved to be a practical tool for initial frailty screening in community settings, particularly in urban areas of Vietnam.

Keywords: Community-dwelling, frailty; CFS; Vietnam.

1. INTRODUCTION

Frailty is physically characterised by declines in function and reserves across multiple physiological systems, accompanied by heightened vulnerability to stressors. Data from the Vietnam Association of Gerontology and Geriatrics projects that the elderly population will comprise 16.8% of the total by 2029[1]. The number of frail older adults in the Asia-Pacific region varies greatly, with rates between 7% and 65%[2]. In developing nations like Vietnam, where the elderly population is growing rapidly, understanding the prevalence and determinants of frailty is imperative, yet research on this topic remains limited. In primary care, the identification of frailty should be simple and require little time. Although this tool is well-established among the elderly (as the tool was used mainly in over 65 years) in developed nations, as well as based on functional disability and cognitive status, previous studies in Vietnam have primarily focused on hospitalized patients[3,4]. To address this gap, our study seeks to validate this instrument among Vietnamese older adults living in the community. Therefore, our objective is to investigate the prevalence of frailty among the older population, as well as identify relevant factors in Ho Chi Minh City.

2. SUBJECTS AND RESEARCH METHODS

2.1 Population characteristics, study design and time of implementation

This research was a cross-sectional study.

All subjects came from Cho Lon District, which is one of

*Corresponding author
Email: pdquang@ntt.edu.vn **Phone**: (+84) 973417748 **DOI:** 10.52163/yhc.v66i8.4079

the highest population-density urban districts in Ho Chi Minh City, Vietnam. The study duration was 06 months, from May 2025 to November 2025.

- **Inclusion criteria:** A group of Vietnamese people aged ≥ 60 years and recruited from the health check-up population of District 5 Health Center were eligible to be included in the study.

- **Exclusion criteria:** Included bedbound status, terminal illness, or a prognosis of less than six months. We also excluded any questionnaires that were incompletely answered.

- Sample Size: The formula for calculating sample size is as follows.

$$n = Z^2_{1-\alpha/2} \frac{p(1-p)}{d^2}$$

+ n = the desired sample size from a large population size.

+ α: level of significance, choose α = 0.05. Two-tailed

+ Z-score confidence level (1.96).

+ p = Population proportion (0.39). Sample size was calculated according to a study done at the Geriatric outpatient clinic at Gia-Dinh People's Hospital, by Nguyen Van Tri[5].

+ d = Absolute error (0.06).

Consequently, the study surveyed 317 participants who met the sampling criteria.

Sampling method: This study used a multistage sampling approach. First, six of the twelve wards in Cho Lon District were selected using stratified cluster random sampling. Then, older adults within these wards were recruited using convenience sampling.

2.2. Materials and data analysis

2.2.1. Data collection techniques

Relevant patient characteristics of the study included: demographic data (age, gender, ethnic group, marital status, education level), presence of comorbidity, body mass index (BMI) categories, history of falls and number of medications.

Data were collected during routine health check-up sessions at the local health station, with additional information obtained in approximately 10–15 minutes per participant.

2.2.2. Research tools and measurement methods

For frailty assessment, the Clinical Frailty Scale (CFS) was performed. The CFS is a judgment-based tool to screen for frailty. It takes less than five minutes to administer the CFS. We used a 9-score version of the original CFS (version 2.0), which was translated into Vietnamese (CFS-VN). Studies have shown the content validity of the frailty spectrum in these translated versions. It has a minimum total score of zero and a maximum score of 9, with the aid of a visual chart by an experienced family physician. Level 1 indicates very fit; level 2 fit; level 3 managing well; level 4 living with very mild frailty; level 5 living with mild frailty; level 6 living with moderate frailty; level 7 living with severe frailty; level 8 living with very severe frailty; and level 9 terminally ill. The most recent research on the CFS-VN in ambulatory older adults determined that a CFS score ≥ 5 indicates a frail state[5–7].

Functional ability was assessed using the Katz Index of Activities of Daily Living (ADL) and the Lawton Instrumental Activities of Daily Living (IADL) scale. The ADL scale has a maximum score of 6, with scores < 6 indicating impaired basic functional performance. The IADL scale has a maximum score of 8, and scores < 8 reflect diminished ability to perform instrumental daily tasks[8,9].

Collected data were processed using the Google Forms platform and analyzed with Stata 17.0 (StataCorp, College Station, TX, USA). Descriptive statistics were used to summarize participant characteristics. Chi-square or Fisher's exact tests were applied to assess bivariate associations. Multivariate logistic regression was performed to identify independent factors associated with frailty. A p-value < 0.05 was considered statistically significant.

2.3. Ethics Statement

The present study was reviewed and approved by the Ethics Council for Biomedical Research, Nguyen Tat Thanh University (No. 51/GCN-NTT). The study only collected data with the approval of the participants. Participants' personal information is kept confidential.

3. RESULTS

Table 1. Demographic characteristics of the study population (n=317)

Variables	Categories	n	%
Age in years, (mean ± SD)		71.3 ± 6.5 (Minimum 60 - Maximum 95)	
Age category	60-69 years	148	46.7
	70-79 years	130	41.0
	≥ 80 years	39	12.3
Gender	Male	96	30.3
	Female	221	69.7
Ethnicity	Kinh	186	58.7
	Chinese	131	41.3
Educational status	Illiterate	18	5.7
	Primary and Secondary	163	51.4
	Tertiary or higher	136	42.9
Marital status	Married	262	82.6
	Single/ divorced/ widowed	55	17.4

Table 1 describes data about the study, which included 317 community-dwelling older adults with a mean age of 71.3 ± 6.5 years (range: 60-95 years). Nearly half of the participants were aged 60-69 years (46.7%), followed by 41.0% in the 70-79 age group, and 12.3% aged 80 years or older. Females accounted for 69.7% of the sample, whereas males represented 30.3%. Regarding ethnicity, 58.7% were Kinh and 41.3% were Chinese. Educational levels varied: 5.7% were illiterate, 51.4% had completed primary or secondary education, and 42.9% had attained tertiary education or higher. In terms of marital status, the majority were married (82.6%), while 17.4% were unmarried, divorced, or widowed.

Table 2. Frailty characteristics (n = 317)

Variables	Categories	n	%
Chronic diseases	Hypertension	145	45.7
	Diabetes	45	14.2
	Osteoarthritis	38	12.0
Number of chronic conditions	2 or more	168	53.0
	Less than 2	149	47.0
Number of daily medications	Less than 5	238	75.1
	5 or more	79	24.9
IADL disability	Yes	44	13.9
	No	273	86.1
ADL disability	Yes	34	10.7
	No	283	89.3
Falls in the previous 1 year	Yes	27	8.5
	No	290	91.5
Body mass index (kg/m^2)	Underweight (< 18.5)	26	8.2
	Normal weight (18.5-24.9)	193	60.9
	Overweight/ Obesity (≥ 25.0)	98	30.9
Clinical Frailty Scale, n (%)	Frail (≥ 5)	47	14.8
	Non-frail (< 5)	270	85.2

Among the 317 older adults surveyed, hypertension was the most common chronic condition (45.7%), followed by diabetes (14.2%) and osteoarthritis (12.0%). More than half of the participants (53.0%) had multimorbidity, defined as two or more chronic conditions. Polypharmacy was also prevalent, with 24.9% reporting the use of five or more daily medications. Functional limitations were present in a smaller proportion of participants, with 13.9% experiencing IADL disability and 10.7% reporting ADL disability. Falls in the previous year occurred in 8.5% of respondents. Regarding nutritional status, 8.2% were underweight, while 30.9% were classified as overweight/obese. Based on the CFS-VN, 14.8% of participants were identified as frail.

Table 3. The associates of frailty (univariate analyses)

Variables	Frail				OR (95% CI)	p-value*
	Yes		No			
	n	%	n	%		
Gender						
Female	35	15.8	186	84.2	1.32 (0.65-2.66)	0.443
Male	12	12.5	84	87.5		
Ethnicity						
Kinh	32	17.2	154	82.8	1.55 (0.80-3.01)	0.156
Chinese	15	11.5	116	88.5		
Age category						
60-69 years	15	10.1	133	89.9	Reference	
70-79 years	20	15.4	110	84.6	1.61 (0.79-3.30)	0.189
≥ 80 years	12	30.8	27	69.2	3.94 (1.66-9.35)	0.001
Body mass index (kg/m^2)						
Normal weight	23	11.9	170	88.1	Reference	
Under-weight	3	11.5	23	88.5	0.96 (0.27-3.47)	0.955**
Over-weight/ Obesity	21	21.4	77	78.6	2.02 (1.05-3.86)	0.033
Multimorbidity						
Yes	39	23.2	129	76.8	5.33 (2.40-11.83)	< 0.001
No	8	5.4	141	94.6		
Polypharmacy						
Yes	26	32.9	53	67.1	5.07 (2.65-9.70)	< 0.001
No	21	8.8	217	91.2		
IADL disability						
Yes	15	34.1	29	65.9	3.90 (1.85-8.19)	< 0.001
No	32	11.7	241	88.3		
ADL disability						
Yes	14	41.2	20	58.8	5.30 (2.38-11.82)	< 0.001
No	33	11.7	250	88.3		

Variables	Frail				OR (95% CI)	p-value*
	Yes		No			
	n	%	n	%		
Falls in the previous 1 year						
Yes	5	18.5	22	81.5	1.34 (0.48-3.75)	0.573**
No	42	14.5	249	85.5		

**: Chi-squared test; **: Fisher's exact test*

Older adults aged ≥ 80 years had a significantly higher likelihood of frailty compared with those aged 60-69 years (OR = 3.94, 95%CI: 1.66-9.35). Overweight or obese individuals also demonstrated greater odds of frailty compared with those of normal weight (OR = 2.02, 95% CI: 1.05-3.86). Individuals having two or more chronic conditions showed a more than five-fold increase in risk (OR = 5.33, 95% CI: 2.40-11.83). Similarly, older adults taking five or more medications have markedly elevated odds of frailty (OR = 5.07, 95% CI: 2.65-9.70). IADL disability increased the odds of frailty three-fold (OR = 3.90, 95% CI: 1.85-8.19), and ADL disability increased it by more than five times (OR = 5.30, 95% CI: 2.38-11.82). In contrast, gender, ethnicity, and previous-year falls showed no statistically significant association with frailty (p > 0.05).

Table 4. Adjusted odds ratios (aOR) for factors associated with frailty

Variable	aOR (95% CI)	p-value*
Kinh ethnicity	1.44 (0.67-3.12)	0.353
Age ≥ 80 years	2.19 (0.83-5.79)	0.114
Multimorbidity	3.13 (1.32-7.69)	0.010
Polypharmacy	2.94 (1.39-6.25)	0.005
Overweight/obesity	1.73 (0.81-3.70)	0.157
ADL disability	2.22 (0.82-6.25)	0.117
IADL disability	2.70 (1.09-6.67)	0.033

**: Variables with p < 0.20 in univariate analysis were included in the multivariate model.*

In the multivariate logistic regression model, multimorbidity (aOR = 3.13), polypharmacy (aOR = 2.94), and IADL disability (aOR = 2.70) were independently associated with higher frailty risk. Female sex and age ≥ 80 years showed positive but non-significant trends, while BMI, ethnicity, marital status, and falls were not associated with frailty in the adjusted model.

4. DISCUSSION

4.1. Demographic characteristics

In this study of 317 community-dwelling older adults in an urban district of Ho Chi Minh City, the mean age was 71.3 years, and nearly half of the participants were aged 60-69 years, with only 12.3% aged ≥ 80 years. The age structure in our sample is therefore somewhat younger than that reported in rural Taiwanese cohort, where mean ages around 78 years and a larger proportion of very old adults have been described[10]. As in a Japanese community study, women accounted for approximately two-thirds of the sample, reflecting both longer female life expectancy and patterns of participation in community-based surveys[11]. Most participants were married and living with a partner, and a substantial proportion had completed at least primary or secondary education. In contrast, earlier Taiwanese and Japanese work has often reported higher proportions of older adults with low educational attainment, particularly in rural areas. These differences in age distribution and socioeconomic profile may partly explain why the burden of frailty in our setting appears moderate compared with some older, more disadvantaged cohorts in the region.

4.2. Frailty among community-dwelling older adults

Using the CFS-VN, we found a frailty prevalence of 14.8% among community-dwelling older adults. Our prevalence is slightly lower than that reported in rural communities in Taiwan (17.6% frail using a frailty phenotype-based approach) and close to that observed in a recent Taiwanese study using the Kihon Checklist, where 16.9% of participants were classified as frail [12]. Compared with Japan, our estimate is higher than the national frailty prevalence of 8.7% reported in a large, nationally representative Japanese survey of community-dwelling older adults, which used a Fried-type physical frailty definition[11]. However, other Japanese cohorts and meta-analyses have also shown substantial variation, with frailty generally increasing sharply after the late 70s[13]. The somewhat higher prevalence in our Vietnamese sample likely reflects a combination of measurement differences (CFS and Kihon Checklist or Fried criteria), the inclusion of participants with multiple chronic conditions, and contextual factors such as health service access in urban areas. In Vietnam, the prevalence of frailty has been reported to be higher in clinical settings with 21.7% in an outpatient population and 39.2%-64.8% among inpatients of a geriatric ward in a tertiary hospital[3–5]. Importantly, our study adds to the emerging evidence that the CFS and specifically its newly adapted Vietnamese version, is feasible for use in community settings [5]. This supports the use of CFS-based screening for early case-finding in primary care and community health programs in Vietnam. The frailty prevalence found in our study was lower than that reported in several studies from developing Asian settings[14]. This difference may relate to the cut-off used for the CFS. We applied a threshold of CFS ≥ 5, whereas some studies, particularly from Thailand and Korea, have suggested that a lower cut-off of ≥ 4 may be more sensitive for identifying early frailty in community populations[14,15]. Using a stricter threshold in our study likely contributed to the

comparatively lower prevalence observed.

4.3. Factors associated with frailty

In the adjusted model, multimorbidity, polypharmacy, and IADL disability emerged as the strongest independent correlates of frailty. Older adults with two or more chronic conditions had approximately a threefold higher odds of frailty compared with those without multimorbidity, and those taking five or more medications had a similar magnitude of increased risk. These findings are consistent with the growing body of literature from Vietnam, Japan, and Taiwan describing a close, bidirectional relationship between frailty, multimorbidity, and medication burden (also called the geriatric triad)[5,16,17]. In Taiwanese cohorts, a higher number of comorbidities has been repeatedly identified as a major risk factor for frailty and frailty progression, while Japanese studies likewise show that individuals with multiple chronic diseases or at risk of long-term care needs are substantially more likely to be frail[10,18].

Our observation that IADL disability is strongly linked to frailty, with roughly a 2.7-fold elevation in odds among those with IADL limitations, aligns with Taiwanese work using the Kihon Checklist and other frailty tools, where functional dependency and performance are among the most powerful predictors of frailty status. Japanese longitudinal studies have also shown that frailty and subsequent disability in IADL are tightly interconnected over time, suggesting a vicious cycle of functional decline. Our findings reinforce the importance of early identification of subtle IADL impairment in community settings as a practical marker of underlying frailty and heightened vulnerability. Given that standard ADL scales are prone to a 'ceiling effect' in relatively robust community populations, IADL deficits function as a superior and earlier indicator of underlying frailty[19].

Although age ≥ 80 years and female sex were associated with higher odds of frailty in crude analyses, these associations did not reach conventional statistical significance after adjustment ($p > 0.05$). In contrast, large-scale surveys from Japan and China consistently report higher frailty prevalence among women and the oldest age groups[11,20]. The borderline effects in our study may reflect limited statistical power given the relatively small number of very old participants. We also did not observe significant independent associations with BMI, marital status, or history of falls, whereas some Vietnamese, Japanese and Taiwanese studies have reported links between low physical activity, nutritional risk, social isolation, or depressive symptoms and frailty[4]. These differences point to the complex, context-specific nature of frailty and suggest that broader psychosocial and environmental factors may warrant greater attention in future Vietnamese research.

Overall, our results are largely concordant with recent evidence from Japan and Taiwan, particularly regarding the central role of multimorbidity, polypharmacy, and functional impairment as core determinants of frailty in community-dwelling older adults. At the same time, the use of the Vietnamese CFS and the focus on an urban fringe population provide novel, locally relevant data that can help inform targeted screening and intervention strategies in Vietnam.

4.4. Limitations

This study has several limitations. First, its cross-sectional design precludes causal inference between associated factors and frailty. The sample was drawn from a single urban district in Ho Chi Minh City, which may limit generalizability to other regions of Vietnam. Residual confounding cannot be excluded due to unmeasured factors such as nutrition, depression, and physical activity.

4.5. Funding: This research is funded by Nguyen Tat Thanh University, Ho Chi Minh City, Vietnam.

5. CONCLUSION

Frailty remains a notable public health concern among community-dwelling older adults in Ho Chi Minh City. Multimorbidity, polypharmacy, and impaired IADL function were the strongest factors associated with frailty, underscoring the need for early detection and integrated chronic disease management. Thus, the CFS-VN (version 2.0) proved practical for routine screening in community settings and may support scalable frailty prevention strategies in urban Vietnam.

REFERENCES

[1] Nguyen Trung Anh. Orientation for developing human resources specialized in geriatrics in Vietnam, 2024, Hội nghị Khoa học Lão Khoa Quốc Gia lần thứ V:17.

[2] Wu Y-C, Chen C-T, Shen S-F, Chen L-K, Peng L-N, Tung H-H. Comparative analysis of frailty identification tools in community services across the Asia-Pacific: A systematic review and meta-analysis. J Nutr Health Aging 2025;29:100496. https://doi.org/10.1016/j.jnha.2025.100496.

[3] Long NH, Hiền HT, Hòa NT, Lý PH, Thiện LP, Khánh PH. Nghiên cứu tỷ lệ suy yếu và một số yếu tố liên quan ở người bệnh cao tuổi điều trị nội trú tại Bệnh viện trường Đại học Y Dược Cần Thơ. Tạp Chí Dược Học Cần Thơ 2023:56–63. https://doi.org/10.58490/ctump.2023i67.2181.

[4] Nguyen AT, Nguyen LH, Nguyen TX, Nguyen HTT, Nguyen TN, Pham HQ, et al. Frailty Prevalence and Association with Health-Related Quality of Life Impairment among Rural Community-Dwelling Older Adults in Vietnam. Int J Environ Res Public Health 2019;16:3869. https://doi.org/10.3390/ijerph16203869.

[5] Nguyen TV, Nguyen TTT, Nguyen TC, Pham THK. The Clinical Frailty Scale version 2.0: Translation and defining reliability in Vietnamese older patients. MedPharmRes 2025;9:84–94. https://doi.org/10.32895/UMP.MPR.9.1.8.

[6] Rockwood K, Stadnyk K, MacKnight C, McDowell I,

Hébert R, Hogan DB. A brief clinical instrument to classify frailty in elderly people. Lancet Lond Engl 1999;353:205–6. https://doi.org/10.1016/S0140-6736(98)04402-X.

[7] Özsürekci C, Balcı C, Kızılarslanoğlu MC, Çalışkan H, Tuna Doğrul R, Ayçiçek GŞ, et al. An important problem in an aging country: identifying the frailty via 9 Point Clinical Frailty Scale. Acta Clin Belg 2020;75:200–4. https://doi.org/10.1080/17843286.2019.1597457.

[8] Shelkey M, Wallace M. Katz Index of Independence in Activities of Daily Living (ADL). Dir Cincinnati Ohio 2000;8:72–3.

[9] Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. The Gerontologist 1969;9:179–86.

[10] Huang CY, Lee WJ, Lin HP, Chen RC, Lin CH, Peng LN, et al. Epidemiology of frailty and associated factors among older adults living in rural communities in Taiwan. Arch Gerontol Geriatr 2020;87. https://doi.org/10.1016/j.archger.2019.103986.

[11] Murayama H, Kobayashi E, Okamoto S, Fukaya T, Ishizaki T, Liang J, et al. National prevalence of frailty in the older Japanese population: Findings from a nationally representative survey. Arch Gerontol Geriatr 2020;91:104220. https://doi.org/10.1016/j.archger.2020.104220.

[12] Chen C-C, Hsu W-C, Wu Y-H, Lai F-Y, Yang P-Y, Lin I-C. Prevalence and Associated Factors with Frailty Using the Kihon Checklist among Community-Dwelling Older Adults in Taiwan. Medicina (Mex) 2024;60:1231. https://doi.org/10.3390/medicina60081231.

[13] Makizako H, Nishita Y, Jeong S, Otsuka R, Shimada H, Iijima K, et al. Trends in the Prevalence of Frailty in Japan: A Meta-Analysis from the ILSA-J. J Frailty Aging 2021;10:211–8. https://doi.org/10.14283/jfa.2020.68.

[14] Jung H-W, Jang I-Y, Back JY, Park S, Park CM, Han SJ, et al. Validity of the Clinical Frailty Scale in Korean older patients at a geriatric clinic. Korean J Intern Med 2021;36:1242–50. https://doi.org/10.3904/kjim.2020.652.

[15] Jesadaporn P, Teepaneeteerakul S, Wongsarikan N, Phirom K, Poonthananiwatkul S, Limpawattana P. Translation and validation of the Thai clinical frailty scale and classification tree in older adults. BMC Geriatr 2025;25:339. https://doi.org/10.1186/s12877-025-06013-5.

[16] Montandon SL, Aggarwal P, Patel HP. Frailty, multimorbidity and polypharmacy. Medicine (Baltimore) 2025;53:154–60. https://doi.org/10.1016/j.mpmed.2024.12.004.

[17] Nguyen T, Nguyen T, Nguyen T. Frailty and Multimorbidity Among Community-Dwelling Older People in Vietnam 2022. https://doi.org/10.33879/AMH.131.2021.02008.

[18] Yang M, Liu Y, Miura KW, Matsumoto M, Jiao D, Zhu Z, et al. Identification and prediction of frailty among community-dwelling older Japanese adults based on Bayesian network analysis: a cross-sectional and longitudinal study. BMC Public Health 2024;24:2141. https://doi.org/10.1186/s12889-024-19697-y.

[19] Vermeulen J, Neyens JCL, van Rossum E, Spreeuwenberg MD, de Witte LP. Predicting ADL disability in community-dwelling elderly people using physical frailty indicators: a systematic review. BMC Geriatr 2011;11:33. https://doi.org/10.1186/1471-2318-11-33.

[20] Wu B, Qi Z, Shen D, Sun L, Chen J, Yu Z, et al. Prevalence of frailty and associated factors in Shanghai older community-dwelling adults: a cross-sectional study. BMJ Open 2025;15:e095371. https://doi.org/10.1136/bmjopen-2024-095371.