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Original article



Impact of hospitalizations on physical function among older adults: A 13-year longitudinal study

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ABSTRACT

Objectives: To examine the impact of hospitalizations on objectively assessed physical function among older adults and to determine whether age, sex, and social environment moderate this association.
Study design: A longitudinal observational study using data from 13 waves (2011−2023) of the U.S. National Health and Aging Trends Study. The analytic sample included 72,705 observations from 18,439 adults aged 65 years or more. Fixed-effects regression models were used to estimate within-person changes in physical function associated with hospitalizations, adjusting for time-varying sociodemographic and health-related covariates.
Main outcome measures: Physical function was measured using the Short Physical Performance Battery, an objective assessment of balance, gait speed, and lower-body strength. Hospitalizations were self-reported annually.
Results: Each additional hospitalization was associated with a 0.26-point decrease in Short Physical Performance Battery score (95% CI –0.29 to −0.23) in the fully adjusted model. Age significantly moderated this relationship, with greater declines in score observed among the oldest participants. In contrast, sex did not significantly modify the effect of hospitalization on physical function.
Conclusions: Hospitalizations exert a cumulative and detrimental effect on the physical function of older adults. These findings highlight the need for preventive strategies to reduce hospital admissions and for comprehensive post-hospital rehabilitation programs aimed at maintaining or restoring functional independence, particularly among the oldest age groups, who are the most vulnerable to declines following hospitalization.

1. Introduction

As the population ages, the incidence of both hospitalization and functional decline increases significantly [1]. Older adults are particularly vulnerable due to a higher prevalence of chronic conditions, frailty, and acute health events that frequently necessitate hospital admission. The likelihood of experiencing hospital-related events grows with aging, underscoring the importance of maintaining a high level of physical function throughout the aging process. Hospitalization represents a pivotal event, often precipitating rapid functional deterioration and the consequent loss of independence [2]. Previous studies have reported that approximately 30% to 60% of hospitalized older adults experience a decline in their ability to perform basic activities of daily living during their hospital stay [3,4].

The pathophysiological and environmental mechanisms underlying functional decline during hospitalization are complex and multifaceted.

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Factors such as immobility, inactivity, acute confusional syndrome, and polypharmacy significantly contribute to this decline [5]. The onset of delirium, or acute confusional syndrome, further contributes to both immediate and long-term cognitive and functional impairments. Moreover, medical management factors, including polypharmacy, the overuse of sedatives, prolonged bed rest, and the application of physical restraints, may exacerbate functional losses and hinder recovery trajectories [6,7].

Physical function is widely recognized as a crucial aspect of health and well-being in older adults, encompassing key components such as mobility, strength, and coordination, all of which are integral to maintaining autonomy and quality of life [8–10]. The interaction between an individual's intrinsic capacity such as cognition, sensory function, and muscle strength and their external environment plays a significant role in determining functional outcomes [11]. This dynamic relationship is influenced by various factors, including psychological well-being, metabolic efficiency, and social and environmental conditions [12]. Maintaining physical function over time is critical for successful aging, as it directly impacts the ability to live independently and reduces the risk of adverse health outcomes, including frailty, disability, and hospitalization [4].

Despite significant advances in understanding hospitalization-related functional decline, several knowledge gaps persist. Much of the existing literature has focused on short-term functional outcomes, with limited investigation into longer-term trajectories of recovery or sustained decline following hospitalization [13]. Furthermore, individual variability in response to hospitalization remains poorly characterized; specifically, the ways in which age, sex, and social environment may moderate the relationship between hospitalization and physical function are not well understood [14]. Large-scale, longitudinal studies with repeated measurements over time are necessary to elucidate these patterns and identify vulnerable subgroups.

Accordingly, the present study aimed to examine the impact of hospitalization on physical function among older adults over time, utilizing data from 13 waves of the National Health and Aging Trends Study (NHATS) [15]. Furthermore, this research ought to explore how individual characteristics, including age, sex, and social environment, may modify this relationship. By identifying key factors that contribute to functional decline and recovery in the context of hospitalization, the findings of this study may enhance the understanding of at-risk populations and inform the development of targeted preventive and rehabilitative interventions aimed at preserving functional health in older adults.

2. Methods

To examine the longitudinal associations between hospitalization and physical functioning, this study used 13 waves of panel data (2011–2023) from the National Health and Aging Trends Study (NHATS) [15], a nationally representative sample of U.S. adults aged ≥65 years. This study analyzed unbalanced panel data from 18,439 NHATS participants.

2.1. Measures

Hospitalization was defined as the number of self-reported hospital stayment recorded by participants in each annual wave of NHATS. This variable was treated as a cumulative measure, representing the total number of hospitalizations experienced by an individual over the study period. Physical function was objectively-assessed using the NHATS adapted version of the Short Physical Performance Battery (SPPB). Physical function was assessed using the Short Physical Performance Battery (SPPB), which is administered once per survey wave in NHATS during the annual in-person interview. The three standardized components (balance test, 4-m gait speed, and repeated chair stands) are conducted in participants' homes by trained interviewers following a uniform protocol. Therefore, SPPB scores reflect functional status at the time of each survey wave rather than measurements linked to acute hospital admission or discharge. Details on the implementation of the SPPB in NHATS are available elsewhere [16]. The SPPB aggregates objective evaluations of respondent's balance, walking speed, and lower-body muscle function into an index ranging from 0 to 12 (higher scores indicate better physical functioning). SPPB scores of ≤10 indicate an increased risk of morbidity [17], disability [18] and all-cause mortality [19]. Using this threshold, the authors constructed a second outcome variable taking the value 1 if the SPPB was ≤10 and taking the value 0 otherwise.

The multivariable models were adjusted for an encompassing set of time-varying covariates known to influence physical functioning among older adults [20] These variables included respondent's age, sex, ethnicity, total household income, engagement in paid work in the last month, residence in the general community, waist circumference, depressive symptoms (assessed using the Patient Health Questionnaire-2 [21]), anxiety, social isolation index (NHATS Social Isolation Index, a composite measure of social connectedness collected at each wave, where higher values indicate greater social isolation), vision problems, hearing problems, presence of physician-diagnosed comorbidities, chronic pain, smoking status, and exercise habit. Missing data due to panel attrition and item nonresponse were approximately 10% (Supplementary Fig. S1, available online). Chained equations were utilized to create 25 imputed data sets to fill any missing data values, the models were fitted in each of the imputed data sets, and Rubin's rule was used to integrate the results into a pooled estimate.

2.2. Statistical analysis

To examine the associations between hospitalization and physical function, this study employed fixed-effects panel regression models. Fixed-effects models utilize repeated observations from the same individuals over time, allowing for the control of confounding by time-invariant unobserved factors (u) that may be correlated with both the exposure (hospitalization) and the outcome (physical function) [22,23]. These models estimate how within-individual deviations in hospitalization frequency are associated with corresponding deviations in physical function scores. Through this approach, both observed and unobserved between-person differences (u) are conditioned out of the model, implicitly accounting for factors such as sex or ethnicity without the need to include them as explicit covariates.

The fully specified model follows this structure:

$$(\mathrm{SPPBit} - \bar{\mathrm{SPPBi}}) = \beta 1\ (\mathrm{HospStayit} - \bar{\mathrm{HospStayi}}) + \beta 2\ (\mathrm{Xit} - \bar{\mathrm{Xi}}) + (\epsilon \mathrm{it} - \bar{\epsilon \mathrm{i}})$$

where subscripts “i” and “t” denote individuals and time periods. SPPB represents physical functioning as measured by the Short Physical Performance Battery (SPPB), while β_1 captures the effect of hospitalization (HospStay) on physical function. X is a vector of time-varying control variables, including age, waist circumference, depressive symptoms, chronic conditions, smoking status, exercise, chronic pain, hearing and vision problems, anxiety, social isolation index, income, employment, and residence, with corresponding coefficients β_2. The within-transformation eliminates time-invariant unobserved heterogeneity (u), ensuring that the model estimates are based on within-individual variations rather than between-person differences. Time-invariant characteristics, such as sex or ethnicity, are therefore implicitly controlled for by the fixed-effects specification. Hausman tests confirmed that the fixed-effects specification was preferable to a random-effects (random-intercept) model.

A series of four nested models were estimated: Model 1 was an unadjusted fixed-effects model that inherently accounted for all time-invariant factors. Model 2 incorporated adjustments for time-varying demographic factors, including age, income, paid work, and living

arrangements. Model 3 extended the adjustments to include a comprehensive set of time-varying factors: age, waist circumference, depression, sex, ethnicity, social isolation index, anxiety, vision problems, hearing problems, comorbidities, chronic pain, smoking status, and exercise. Model 4 combined both time-varying demographic factors and the minimal sufficient adjustment set, providing the most comprehensive specification of the relationship between hospitalization and physical function. More details about fit model in Supplementary Table S1.

2.3. Sensitivity analysis

To assess the robustness of our findings, we conducted a sensitivity analysis using un-imputed data and sampling weights provided by NHATS. The un-imputed data analysis aimed to verify that missing data imputation did not influence the observed associations, while the use of sampling weights accounted for potential selection bias and ensured the representativeness of the estimates.

3. Results

The analytic sample encompassed 72.705 observations from 18,439 individuals, and thus, respondents were observed approximately 4.30 times on average. Descriptive statistics for all variables included in the model and some contextual variables (age and sex) pooled across the 13 time periods are presented in Table 1 considering that during wave 10 physical function data was not collected. A detailed flow diagram of study participation is provided in Supplementary Fig. S2.

As expected, there was evidence of an unadjusted, inverse, dose−response relationship between hospital number of stayments and physical functioning (Fig. 1). The average SPPB score was 6.52, indicating a relatively higher level of physical function. However, this score gradually declined with each additional hospitalization, decreasing to 4.88 after one hospitalization, 3.90 after two, and 3.39 after three. Patients with four hospitalizations or more had an average SPPB of 2.91. Additional analyses examining the impact of hospitalization on other dimensions of physical function (handgrip strength, STS, and gait speed) is presented in Supplementary Table S2 and Supplementary Fig. S3. These results further support the observed decline in physical performance with increasing hospitalizations.

Table 1
Descriptive statistics: national health and aging trend study, 2011–2023.

Variable	Mean (SD) or %
Physical functioning (SPPBa Score 0–12)	6.03 (3.50)
Physical functioning (SPPBa Score ≤ 10), yes	80.67
Age, years	79.68 (7.85)
Sex, female	59.34
Hospital number of stayment	0.36 (0.81) (excluding 0: 1.58(0.96))
Education	
Less than high school	22.20
High school	33.51
Some college	13.82
Bachelor's degree or higher	29.47
Annual income, $	
<14,000	25.64
14,000 to <22,000	14.56
22,000 to <36,000	18.22
36,000 to <49,000	10.10
≥49,000	32.47
Paid work, yes	13.61
Living in the general community, yes	87.43
Waist circumference (inches)	39.72 (5.99)
Depression symptoms (PHQ-2 ≥ 3), yes	18.26
Social Isolation Index	3.71 (1.29)
Anxiety diagnosis, yes	11.24
Vision problems, yes	10.56
Hearing problems, yes	14.55
Presence of at least 1 chronic conditions[a]	93.35
Pain, yes	55.37
Smoking status	
Never	49.49
Former	41.38
Current	9.14
Exercise, yes	66.50

Note: Sample size: 18,439 individuals and 72.705 person-year observations; Hospital number of stayment is presented as mean and standard deviation (SD). SPPB, Short Physical Performance Battery; PHQ-2, Patient Health Questionnaire 2.

[a] Dummy variable indicating a diagnosis of at least 1 of the following: heart attack, heart disease, high blood pressure, arthritis, osteoporosis, lung disease, stroke, dementia/Alzheimer, and cancer.

The results unveiled by the unadjusted linear fixed-effects model (Table 2) indicate an average within-individual decrease in SPPB with each 1-unit increase in the number of hospitalizations, as observed in Model 1 (−0.36; 95% CI = −0.39, −0.33). This trend persists even after adjustments for time varying demographic factors in Model 2 (−0.29; 95% CI = −0.31, −0.25), time-varying adjusted for minimal sufficient adjustment sets in Model 3 (−0.27; 95% CI = −0.30, −0.24), and time varying demographic factors and minimal sufficient adjustment sets in Model 4 (−0.26; 95% CI = −0.29, −0.23), consistently indicating a significant decrease in SPPB associated with an increasing number of hospitalizations across all evaluated scenarios. Sex differences in physical function measures were also evident, with men demonstrating higher SPPB scores than women (Supplementary Table S3). Specifically, the average SPPB score was 6.61 (SD = 3.40) for men and 5.62 (SD = 3.52) for women, reflecting a statistically significant difference ($p < 0.01$; 95% CI: 0.93 to 1.05). These findings highlight a consistent disparity in physical function.

The model coefficients on the control variables are presented and discussed in Supplementary Table S4. The interactive linear model revealed that age moderated the number of hospitalization−SPPB relationships, as inferred from a statistically significant interaction term ($p < 0.05$) (Table 3). However, the interactive linear model for sex revealed that the results suggest that both the number of hospital stayment and gender have significant effects on the SPPB outcome, but the interaction between them did not reach significance (Table 4). Further analyses examining the moderating effects of age and sex on handgrip strength, STS, and gait speed are presented in Supplementary Table S5 and Supplementary Table S6. Additionally, the moderation effect of age in the association between hospitalization and physical function is further represented in Supplementary Fig. S4.

Sensitivity analysis presented in Supplementary Table S7, remained consistent with our main analyses, demonstrating that an increase in the number of hospital stayment was associated with lower physical performance scores across all functional measures. These associations persisted even when applying sampling weights, further reinforcing the reliability of our findings.

4. Discussion

The main aim of this study was to examine the impact of hospitalization on physical function and how age, sex, and social environment may influence this relationship. Using a fixed-effects model, our findings indicate a significant inverse relationship between the number of hospitalizations and physical function measured by the SPPB. In the unadjusted model, each additional hospitalization was associated with a 0.36 point decline in SPPB scores (95% CI: −0.39, −0.33). In the fully adjusted model, each additional hospitalization was associated with a 0.26 point decline in SPPB scores (95% CI: −0.29, −0.23). Age moderated this relationship, with a more pronounced decline in SPPB observed among older adults. In contrast, sex did not exhibit a statistically significant interaction effect, suggesting that the impact of hospitalizations on physical function is comparable between men and women. These findings highlight the need for targeted interventions to prevent functional decline after hospitalization, particularly in older adults, to reduce long-term public health burden.

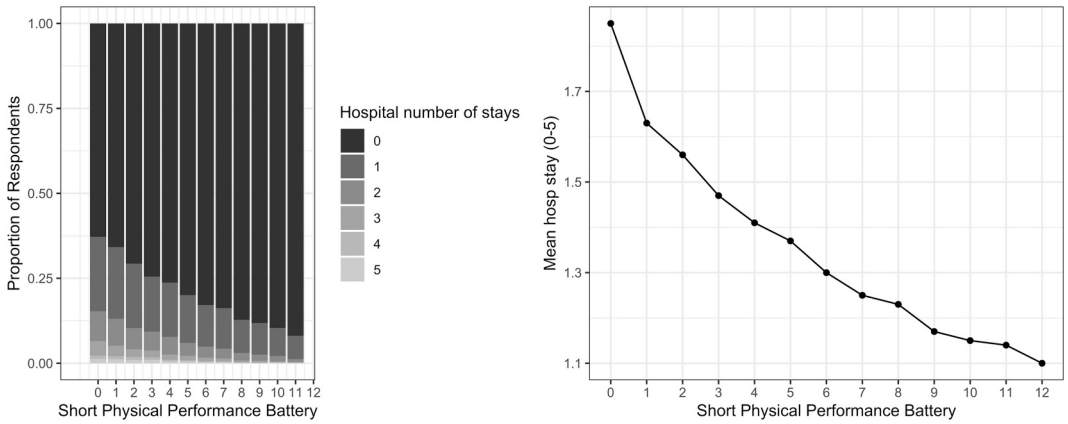


Fig. 1. Relationship between hospitalizations and physical function (SPPB).
The left panel shows the proportion of respondents by number of hospital stays across SPPB scores (0–12). The right panel presents the mean number of hospital stays by SPPB level. Both panels illustrate an inverse relationship between hospitalization frequency and physical performance, with higher numbers of hospitalizations associated with lower SPPB scores.

Table 2
Hospital number of stayment coefficient from linear fixed-effect regression models of physical functioning: National Health and Aging Trend Study, 2011–2023.

Model	SPPB (0−12) β (95% CI)[a]
Model 1	−0.36 (−0.39 to −0.33)
Model 2	−0.29 (−0.31 to −0.25)
Model 3	−0.27 (−0.30 to −0.24)
Model 4	−0.26 (−0.29 to −0.23)

Note: Model 1 is an unadjusted model. Model 2 is adjusted for time varying demographic factors (age, income, paid work, and living arrangements). Model 3 is adjusted for time-varying adjusted for minimal sufficient adjustment sets (age, waist circumference, depression, sex, ethnicity, social isolation index, anxiety, vision problems, hearing problems, comorbidities, chronic pain, smoking habit, and exercise). Model 4 is adjusted for time varying demographic factors (age, income, paid work, and living arrangements) and for minimal sufficient adjustment sets (age, waist circumference, depression, sex, ethnicity, social isolation index, anxiety, vision problems, hearing problems, comorbidities, chronic pain, smoking habit, and exercise). Sample size: 18,439 individuals and 72.705 person-year observations.
[a] CIs are calculated using cluster-robust SEs.; SPPB, Short Physical Performance Battery.

Table 3
Hospital number of stayment coefficient from a linear fixed-effect regression model on physical functioning (moderation by age): National Health and Aging Trend Study, 2011–2023.

Model[a]	SPPB (0–12) β (95% CI)[b]
Main effect: hospital number of stayment	−3.13 (−3.47 to −2.79)
Main effect: age	−0.21 (−0.22 to −0.21)
Interaction effect: age X hospital number of stayment	0.027 (0.023 to 0.031)

Note: Sample size: 18,439 individuals and 72.705 person-year observations. SPPB, Short Physical Performance Battery.
[a] Model 1 is an unadjusted model. Model 2 is adjusted for time varying demographic factors (age, income, paid work, and living arrangements). Model 3 is adjusted for time-varying adjusted for minimal sufficient adjustment sets (age, waist circumference, depression, sex, ethnicity, social isolation index, anxiety, vision problems, hearing problems, comorbidities, chronic pain, smoking habit, and exercise). Model 4 is adjusted for time varying demographic factors (age, income, paid work, and living arrangements) and for minimal sufficient adjustment sets (age, waist circumference, depression, sex, ethnicity, social isolation index, anxiety, vision problems, hearing problems, comorbidities, chronic pain, smoking habit, and exercise).
[b] CIs are calculated using cluster-robust SEs.

Table 4
Hospital number of stayments coefficient from a linear fixed-effect regression model on physical functioning (moderation by sex): National Health and Aging Trend Study, 2011–2023.

Model[a]	SPPB (0–12) β (95% CI)[b]
Main effect: hospital number of stayments	−1.05 (−1.16 to −0.93)
Main effect: sex	−0.98 (−1.04 to −0.92)
Interaction effect: sex X hospital number of stayment	−0.033 (−0.105 to 0.038)

Note: Sample size: 18,439 individuals and 72.705 person-year observations.
[a] The model is adjusted for time varying demographic factors (age, income, paid work, and living arrangements) and for minimal sufficient adjustment sets (age, waist circumference, depression, sex, ethnicity, social isolation index, anxiety, vision problems, hearing problems, comorbidities, chronic pain, smoking habit, and exercise).
[b] CIs are calculated using cluster-robust SEs; SPPB, Short Physical Performance Battery.

Functional decline associated with hospitalizations is well-documented in the literature. Previous studies have demonstrated that hospitalized older adults face an increased risk of mobility loss and reduced muscle strength due to prolonged immobilization, the physiological impact of acute illness, and the adverse effects of certain medical treatments [24,25]. Our findings are consistent with previous research indicating that each hospitalization episode contributes to a significant decline in self-reported physical function, even after adjusting for demographic and health-related factors [26,27]. Covinsky et al. [27] reported that 35% of hospitalized older adults experienced a decline in at least one activity of daily living, with only 50% recovering their pre-hospitalization functional status. Several mechanisms may underlie this association, including physical deconditioning, muscle mass loss due to prolonged bed rest [28], and the psychological impact of hospitalization, can lead to depressive symptoms and increased stress, further impeding functional recovery [29].

The interaction analysis revealed that age significantly, albeit weakly, moderates the relationship between the number of hospitalizations and physical function, indicating that the negative effects of hospitalization are more pronounced in older adults. This finding is consistent with previous studies showing that physical recovery capacity declines with age, likely due to reduced physiological reserve and the presence of multiple comorbidities [30]. In contrast, while both the number of hospitalizations and sex were significant predictors of

physical function, their interaction was not statistically significant. This suggests that the impact of hospitalizations on physical function is comparable between men and women. However, prior studies have proposed that women may be more susceptible to post-hospitalization disability, potentially due to differences in muscle composition and pre-existing levels of frailty. Our results may reflect the use of fixed-effects models, which estimate within-individual changes over time and control for stable baseline differences between individuals, including sex-related disparities in functional status. In this context, factors such as advanced age or baseline functional vulnerability may play a more prominent role in shaping post-hospital functional decline than sex alone [31,32].

4.1. Clinical and public health implications

Our findings have significant implications for the medical care of hospitalized older adults. First, they highlight the need to implement prevention and rehabilitation strategies aimed at reducing the functional impact of hospitalization. Early rehabilitation programs, such as active mobilization during hospitalization and post-discharge follow-up with physical and occupational therapies, have been shown to be effective in mitigating functional decline and improving long-term outcomes [33]. Moreover, the high prevalence of comorbidities in the study sample (93.35% with at least one chronic condition) highlights the importance of a comprehensive geriatric health/care approach that integrates chronic disease management with targeted interventions to preserve physical function. In this regard, evidence supports that regular exercise can help preserve mobility and reduce the risk of disability in older adults [34,35].

Importantly, our results indicate that age slightly moderates the relationship between hospitalizations and physical function, with older individuals showing a marginally greater decline. This suggests that although the effect is relatively small, older patients may still be somewhat more vulnerable to the functional consequences of hospitalization. As such, it is important to consider targeted preventive measures, early rehabilitation, and post-discharge monitoring for this group, which could help mitigate functional deterioration and support healthier aging outcomes.

Overall, these findings enhance the understanding of at-risk populations and may help inform future research and clinical guidelines on age-sensitive preventive and rehabilitative strategies aimed at improving health outcomes in hospitalized older adults.

4.2. Strengths, limitations and future directions

This study presents several strengths that enhance its validity and relevance. The use of a fixed-effects design allows for the control of time-invariant individual characteristics, reducing confounding bias and strengthening causal inferences regarding the impact of hospitalization on physical function. Additionally, the inclusion of a large and well-characterized sample of older adults improves the generalizability of the findings to similar populations. The study also accounts for a comprehensive set of covariates, minimizing potential biases related to demographic, clinical, and functional factors, minimizing potential biases and providing a more precise estimation of the hospitalization and physical function relationship. Furthermore, its longitudinal approach provides valuable insights into the long-term effects of hospitalization, offering a more nuanced understanding of its impact on physical function over time.

Despite these strengths, certain limitations should be acknowledged. First, the exclusion of period 10 due to the COVID-19 pandemic may have influenced the observed trends in physical function, as the health crisis significantly affected older adults, both in terms of hospitalization rates and access to rehabilitation services. Moreover, although the study controls for a wide range of covariates, unmeasured factors (hospital care quality or post-discharge social support) may still influence functional recovery. Our study relies on self-reported hospitalization data, which may introduce recall bias or misclassification. Participants may underreport, overreport, or inaccurately recall the number of hospitalizations, potentially affecting the precision of the estimated associations with physical function. Nevertheless, NHATS employs structured, in-person interviews conducted by trained staff using standardized questionnaires, which likely reduces reporting errors. However, some degree of recall bias or misclassification cannot be entirely ruled out and should be considered when interpreting the findings. Future research should explore these aspects in greater depth and assess targeted interventions to enhance functional outcomes.

Finally, the findings indicate a relationship between hospitalization and physical function, with cumulative effects becoming more pronounced in individuals experiencing multiple hospitalizations. Future studies should investigate potential critical hospitalization thresholds beyond which functional recovery becomes significantly more challenging, providing evidence to inform more effective prevention and rehabilitation strategies.

5. Conclusion

This study provides strong evidence of the cumulative negative impact of hospitalizations on the physical function of older adults, emphasizing the importance of preventive and rehabilitative strategies to mitigate this issue. The observed association suggests that reducing the frequency and duration of hospitalizations could contribute to preserving functional independence in this population. Given the aging population and the increasing burden of chronic diseases, these findings underscore the need for public health policies that prioritize disability prevention and the promotion of mobility and activity in hospitalized older adults to prevent declines in physical function and future disability.

Contributors

Javier Ramos-Munell contributed to conceptualization of the study, data analysis, writing the original draft, and reviewing and editing the draft article.

Juan Antonio Corral-Pernía contributed to methodology, writing the original draft, and reviewing and editing the draft article.

Daniel Gallardo-Gómez contributed to data analysis, methodology, and reviewing and editing the draft article.

Jesús del Pozo-Cruz contributed to conceptualization of the study, methodology, and reviewing and editing the draft article.

Borja del Pozo Cruz contributed to conceptualization of the study, methodology, and reviewing and editing the draft article.

Rosa M. Alfonso-Rosa contributed to reviewing and editing the draft article.

Manuel Reguera-Rodríguez contributed to reviewing and editing the draft article.

José Luis Ceballos-Sánchez contributed to reviewing and editing the draft article.

Fátima Chacón-Borrego contributed to investigation and reviewing and editing the draft article.

Pablo Galán-López contributed to investigation and reviewing and editing the draft article.

Miguel Ángel Pérez-Sousa contributed to investigation and reviewing and editing the draft article.

Francisco Álvarez-Barbosa contributed to conceptualization of the study, data analysis, methodology and reviewing and editing the draft article.

All authors saw and approved the final version and no other person made a substantial contribution to the paper.

Ethical approval

This study is based on publicly available, de-identified data from the National Health and Aging Trends Study (NHATS). The NHATS protocol was approved by the Johns Hopkins University Institutional Review Board, and all participants provided written informed consent. No additional ethical approval was required for this secondary data analysis.

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Data sharing and collaboration

There are no linked research data sets for this paper. Data will be made available on request.

Declaration of competing interest

The authors declare that they have no competing interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.maturitas.2026.108933.

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