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# The impact of falls on the need for hospital care in older people: results from the Pro.V.A. study

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**Background and aims**. Falls have been associated with adverse health-related outcomes in older people, but their effects on the need for hospital admissions is unclear. We investigated the association between falls and all-cause hospitalizations in older people.
**Methods**. A sample of 2,123 community-dwelling adults aged ≥ 65 underwent multidimensional assessment at baseline and after 4.4 years. Self-reported falls in the year before baseline and in the year before the 4.4-year assessment were categorized as none, one, or ≥ 2 (recurrent falls). The hospitalizations number over 7 years after baseline was obtained from medical records. The association between falls and hospitalizations number was investigated using multivariable generalized mixed models with a Poisson distribution. Possible modifying effects of sociodemographic and medical factors on the studied association was investigated through interaction analysis.
**Results**. Compared with no falls, the annual hospitalizations number for people who reported recurrent falls increased by 1.38 (95% CI: 1.05-1.81) in the short-term (over one year) and by 1.20 (95% CI: 1.03-1.39) in the long term (over 3.5 years). That increase was more marked in the first two years after the fall, then tended to lessen over time. No significant modifying effects on the association between falls and hospitalizations number were found.
**Conclusions**. Recurrent falls may result in a greater need for hospital-based care, both in the short term, and, although to a lesser extent, in the long term. Since older people account for more than one in three inpatients, identifying modifiable factors for hospitalization, e.g. falls, is essential from clinical and public health perspectives.

**Key words**: accidental falls, hospitalization, secondary prevention, health resources, aged

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## INTRODUCTION

Hospitalizations in older people have been associated with a worsening of functional abilities [1-3] cognitive status [4-6], and physical performance [7,8], especially in physically frail [9,10] or cognitively impaired individuals [10-14] irrespective of the reason for admission. Given that older people account for more than one in three inpatients, and therefore incur high healthcare costs and resources, [15] identifying potentially modifiable factors for hospitalization in this group is highly important from clinical and public health perspectives.

The impact of falls on the multifaceted aspects of older adults' health is well-known. Previous studies have shown that such events may negatively affect cognitive and functional status, physical performance, and psychological well-being [1,16-18]. These effects could be exacerbated by a reduction in mobility, and also by the development of concerns about falling and depressive mood, which may arise irrespective of the presence of fall-related injuries, with a subsequent reduction in social interactions [16,19-22]. So far, little attention has been paid to the possible impact of falls on the individuals' clinical vulnerability, which is determined by the control of existing comorbidities and the onset of new morbid conditions, and may be reflected in a greater likelihood of accessing hospital-based care [23-26]. Note that the increased need for hospitalization triggered by a fall may not necessarily be due to the occurrence of fall-related injuries. Indeed, falls may also alter the labile balance of health of older people leading to an increased need for hospitalization, including in the longer term [25,27].

Since falls are potentially avoidable events, if found to affect the individual's clinical vulnerability, this will unequivocally show the need for fall prevention interventions and also for closer monitoring of the clinical status of older individuals who have already experienced a fall. Moreover, if in this regard falls are found to have a more detrimental impact on some categories of older adults and may occur in specific time windows, this would provide the basis for optimizing the design of these targeted interventions.

This study aimed to investigate the possible short- and long-term effects of falls on the need for all-cause hospitalizations in community-dwelling older adults. Our hypothesis is that falls, especially recurrent falls, may affect the individuals' labile balance in health in both the short and longer term, increasing their need for hospital care.

## METHODS

### Study design

This study uses data from the *Progetto Veneto Anziani (Pro.V.A.)*, an observational cohort study on Italian individuals aged 65 years or older. The cohort was assembled between 1995 and 1997 through a multistage age- and sex-stratified sampling strategy that randomly selected a sample of 3,099 older men and women, representative of the general population age ≥ 65 years in the study sites. Details on the sampling procedures and the main characteristics of the general older population and the selected cohort are shown in the published study protocol [28]. For the present study, we used data collected between 1995 and 2004, including the baseline assessment and the follow-ups performed after a mean of 4.4 and 7 years. Trained nurses and physicians conducted comprehensive assessments at city hospitals or, for those participants who were unable to attend a clinic, at home. In this study, in particular, we considered information on the number of falls reported in the year before the baseline assessment and in the year before the 4.4-year assessment (exposure), in relation to the frequency of hospitalizations during the subsequent years (baseline to the 4.4-year assessment, and the 4.4-year to the 7-year assessment, respectively).

### Study population and data collection

From the initial sample of 3,099 participants, for the purpose of this study, we excluded 118 individuals living in nursing homes, 2 with missing data on reported falls at baseline, 23 with missing data on hospitalizations in the first time window (baseline to the 4.4-year follow-up), 166 who were absent at follow-up, and 667 who died before follow-up. The final sample comprised 2,123 community-dwelling older adults; compared with these individuals, those who were excluded because of missing data or absence at follow-up (n = 191) had a worse cognitive status (baseline Mini-Mental State Examination [MMSE]: 23.4 ± 5.8 *vs* 24.4 ± 4.7, $p = 0.02$), but there were no significant differences in age, sex, educational level, body mass index (BMI), number of chronic diseases or number of hospitalizations in the year before the first assessment.

Of the 2,123 individuals who were assessed at baseline and at the 4.4-year follow-up, 868 were absent at the 7-year follow-up, 138 of whom because they had deceased. Of the remaining participants, we had complete data on hospitalizations up to the 7-year assessment for 647 individuals. As shown in Supplementary Table I, analysis of participants by number of falls assessed at baseline and at the 4.4-year follow-up indicated that those who experienced recurrent falls were more likely to die in the subsequent years, but there were no substantial differences in the drop-out rates.

The study protocol was approved by the ethical committees of the University of Padua and the Veneto Region's Local Health Units (USSL) nos. 15 and 18. Participants (or their next of kin in case of severe cognitive disorders) gave their written informed consent.

#### Anthropometric, sociodemographic, and medical data

Baseline data were collected by trained physicians and nurses in face-to-face interviews with the study participants. In addition to age and sex, the research team collected data on formal education (< 5 or ≥ 5 years), monthly income (≤ or > 500 euro), habitation status (living alone or co-habiting), smoking habits (former, current or never) and alcohol consumption (categorized as none or occasional; light, < 7 units of alcohol [UA]/week for women and < 14 UA/week for men; and heavy, ≥ 7 UA/week for women and ≥ 14 UA/week for men). Participants' BMI (kg/m$^2$) was computed as the ratio between measured body weight (kg) and the square of height (m). Their cognitive and physical performances, functional status and depressive mood were assessed using validated scales. Cognitive function was assessed with the 30-item MMSE, a well-known instrument for evaluating cognitive performance in older adults [29]. Functional status was evaluated through the Activities of Daily Living (ADL) and the Instrumental ADL (IADL) scales. In particular, of the IADL items, we considered self-sufficiency in the following activities: shopping, using transportation, using the telephone, managing own money, and taking medicines [30,31]. Physical performance was assessed through the Short Physical Performance Battery (SPPB), which combines the results of gait speed, chair stand and static balance tests to obtain a total score ranging from 0 to 12, the higher the score the better the physical performance [32]. Depressive mood was evaluated through the 30-item Geriatric Depression Scale (GDS), which yields a score ranging from 0 to 30 in order of increasing depressive symptoms [33].

Medical conditions were assessed by expert geriatric physicians through standardized clinical algorithms and questionnaires, physical examination, medical and hospital records, blood tests, self-reported symptoms, and the list of drugs regularly taken. In this study, we considered the presence of the following chronic diseases: diabetes [34] arterial hypertension, orthostatic hypotension, ischemic heart diseases (including angina requiring a stent, angioplasty or hospitalization, and myocardial infarction), heart failure, atrial fibrillation, peripheral vascular diseases, stroke, chronic anemia, dyslipidemia, chronic kidney disease, chronic obstructive pulmonary disease (COPD), asthma, osteoporosis (with and without fractures), upper or lower limb osteoarthritis [35], degenerative disc disease, Parkinson's disease or Parkinsonism, congenital intellectual disability, vision deficits, hearing deficits, urinary incontinence, fecal incontinence, and cancer. The total number of chronic diseases for each participant was taken as an indicator of multimorbidity, categorized as no diseases, one disease, and ≥ 2 diseases.

#### Exposure variable: falls

At both the baseline and the 4.4-year follow-up assessments, the number of self-reported falls in the previous year was ascertained through face-to-face interviews with the participants or with their caregivers. We adopted the World Health Organization's definition of a fall as any "unexpected event where a person falls to the ground from an upper level or the same level" [36]. To investigate the impact of recurrent falls on outcome, the number of falls in the previous year was categorized as none, one, or two or more (recurrent falls).

#### Outcome variable: hospitalizations

The total number of all-cause hospitalizations in the period from baseline to the 4.4-year follow-up, and from the 4.4-year to the 7-year follow-up was obtained by physicians through comprehensive analysis of medical and hospital records.

#### Statistical analysis

The characteristics of the sample at baseline were expressed as means ± standard deviations for the quantitative variables, and as absolute numbers and percentages for the categoric variables. Comparison of these characteristics by reported falls at baseline was performed by ANOVA or Chi-squared test, as appropriate. The associations between falls assessed at baseline and the number of hospitalizations in the period from baseline to 4.4 years, and between falls assessed at the 4.4-year assessment and the number of hospitalizations in the period from the 4.4- to the 7-year assessments were investigated using a generalized mixed model with Poisson distribution for the study outcome. The reference group was those individuals who reported no falls. We used 2 models for these analyses: Model 1 was adjusted only for age, sex, and time to follow-up or death; Model 2 was further adjusted for factors known to be associated with falls and hospitalizations, which included educational level, smoking and drinking habits, habitation status, number of hospitalizations in the year before assessment, number of chronic diseases, MMSE, and hip fractures (as time-varying variable).

The possible modifying effects of age, sex, habitation status, and number of chronic diseases on the association between falls and hospitalizations was investigated through interaction analysis by adding each multiplicative interaction term to the model. All statistical tests were two-tailed and the alpha for statistical significance was set at 0.05. Analyses were performed in R [37].

## RESULTS

Our sample consisted of 2,123 older adults (786 M, 1,337 F) with a mean age of 74.4 ± 6.9 years. In the year before the baseline assessment 15.6% of the sample had experienced one fall, and 12.3% declared two or more falls. As shown in Table I, compared with the other categories, participants reporting recurrent falls were more likely to be older, women, and to have lower educational and socioeconomic levels. They also had a lower prevalence of smoking and alcohol consumption, while the multidimensional evaluation showed them to have worse cognitive, functional and physical performances, and depressive symptoms. More than 90% of the sample had ≥ 2 chronic diseases; these and the number of hospitalizations in the previous year did not vary according to the number of previous falls. Considering health status, individuals who experienced a higher number of falls were more likely to have had previous hip fractures and stroke, and to suffer from osteoporosis and osteoarthritis, while no significant differences were observed on the prevalence of cardiovascular diseases, diabetes and COPD (data not shown). There were 2,934 hospitalizations between baseline and the 4.4-year assessment (median 1 [IQR: 0-2] per each individual), and 407 between the 4.4- and 7-year assessments (median 0 [IQR: 0-1]). Between baseline and the 4.4-year follow-up 54.4% of individuals were hospitalized at least once, and between the 4.4- and 7-year follow-ups 32.6% were hospitalized at least once. In the first year after the baseline assessment, 18% of individuals were hospitalized at least once, and in the first year after the 4.4-year visit, 17.6%.

The results of the Poisson mixed models for the association between falls and the number of subsequent hospitalizations are shown in Table II. After adjusting for

**Table I.** Characteristics of the 2,123 study participants by the number of falls reported at baseline.

| | All | Number of previous falls | | | |
|---|---|---|---|---|---|
| Characteristics | | 0 | 1 | ≥ 2 | *P* value |
| n | 2123 | 1524 | 338 | 261 | |
| Age (years) | 74.4 (6.9) | 74.0 (6.8) | 74.9 (7.1) | 76.0 (7.2) | < 0.001 |
| Sex (female) | 1337 (63.0) | 899 (59.0) | 241 (71.3) | 197 (75.5) | < 0.001 |
| Educational level (< 5 y) | 979 (46.1) | 661 (43.4) | 167 (49.4) | 151 (57.9) | < 0.001 |
| Habitation status* | | | | | 0.010 |
| Living with somebody | 1727 (81.3) | 1269 (83.3) | 258 (76.3) | 200 (76.6) | |
| Living alone | 390 (18.4) | 251 (16.5) | 79 (23.4) | 60 (23.0) | |
| Monthly income* | | | | | 0.024 |
| > €500 | 833 (39.2) | 629 (41.3) | 122 (36.1) | 82 (31.4) | |
| ≤ €500 | 1289 (60.7) | 894 (58.7) | 216 (63.9) | 179 (68.6) | |
| Alcohol consumption | | | | | < 0.001 |
| None or occasional | 1467 (69.1) | 1013 (66.5) | 251 (74.3) | 203 (77.8) | |
| Light | 395 (18.6) | 298 (19.6) | 59 (17.5) | 38 (14.6) | |
| Heavy | 261 (12.3) | 213 (14.0) | 28 (8.3) | 20 (7.7) | |
| Smoking habit | | | | | < 0.001 |
| Never | 1329 (62.6) | 906 (59.4) | 226 (66.9) | 197 (75.5) | |
| Former | 602 (28.4) | 477 (31.3) | 81 (24.0) | 44 (16.9) | |
| Current | 192 (9.0) | 141 (9.3) | 31 (9.2) | 20 (7.7) | |
| ADL | 4.56 (1.04) | 4.66 (0.92) | 4.54 (0.96) | 4.05 (1.52) | < 0.001 |
| IADL | 4.17 (1.18) | 4.27 (1.09) | 4.10 (1.14) | 3.64 (1.51) | < 0.001 |
| Total SPPB | 8.51 (3.26) | 8.85 (3.11) | 8.36 (3.15) | 6.73 (3.68) | < 0.001 |
| Mini-Mental State Examination | 24.41 (4.74) | 24.71 (4.61) | 24.06 (4.81) | 23.09 (5.10) | < 0.001 |
| Geriatric depression scale | 8.68 (6.20) | 8.12 (6.00) | 9.21 (6.09) | 11.26 (6.73) | < 0.001 |
| Body mass index (kg/m$^2$) | 27.84 (4.55) | 27.84 (4.55) | 27.76 (4.34) | 27.95 (4.78) | 0.841 |
| Previous hip fracture | 72 (3.4) | 43 (2.8) | 10 (3.0) | 19 (7.3) | 0.001 |
| N. chronic diseases | | | | | 0.155 |
| 0 | 19 (0.9) | 14 (0.9) | 3 (0.9) | 2 (0.8) | |
| 1 | 142 (6.7) | 112 (7.3) | 22 (6.5) | 8 (3.1) | |
| ≥ 2 | 1962 (92.4) | 1398 (91.7) | 313 (92.6) | 251 (96.2) | |
| N. hospitalizations in the previous year | 0.29 (0.57) | 0.27 (0.56) | 0.32 (0.59) | 0.34 (0.61) | 0.111 |

Numbers are frequencies and percentages, or means ± standard deviations, as appropriate. ADL, Activities of Daily Living; IADL, Instrumental Activities of Daily Living; SPPB, Short Physical Performance Battery. *Six participants had missing data on habitation status, and one participant on monthly income.

**Table II.** Generalized mixed model for the short- and long-term associations between falls and the annual number of hospitalizations.

| | Exponentiated coefficients and 95% confidence intervals p-values | | | |
|---|---|---|---|---|
| | Short term (1 year) | | Long term (3.5 years) | |
| **Falls** | **Model 1** | **Model 2** | **Model 1** | **Model 2** |
| **0** | [ref] | [ref] | [ref] | [ref] |
| **1** | 1.19 (0.93, 1.52) *p = 0.178* | 1.19 (0.92, 1.52) *p = 0.181* | 1.08 (0.94, 1.24) *p = 0.271* | 1.08 (0.94, 1.24) *p = 0.268* |
| **≥ 2** | 1.51 (1.16, 1.97) *p = 0.002* | 1.38 (1.05, 1.81) *p = 0.021* | 1.25 (1.08, 1.46) *p = 0.004* | 1.20 (1.03, 1.39) *p = 0.021* |

Model 1 is adjusted for age and sex. Model 2 is also adjusted for educational level, habitation status, smoking habits, alcohol consumption, number of hospitalizations in the year before the assessment, baseline Mini-Mental State Examination, hip fracture (as time-varying variables), and time. A random intercept is included in the model.

potential confounders, we found that individuals who experienced only one fall did not differ from those with no falls with respect to the number of hospitalizations either in the short term (over the first year) or in the long term (over a median of 3.5 [IQR: 3.4, 3.5] years from baseline or from the 4.4-year follow-up). The annual number of hospitalizations for people who reported recurrent falls increased significantly by 1.38 (1.05, 1.81) in the short term, and by 1.20 (1.03, 1.39) in the long term compared with those with no falls. This trend can be seen in Figure 1, which reports the number of hospitalizations over time for individuals who experienced none, one, or two or more falls. As can be seen, compared with the other groups, older adults with previous recurrent falls showed a more marked increase in the number of hospitalizations in the first two years after fall assessment, which was then attenuated over time. The interaction analyses revealed no significant interactions between falls and age, sex, habitation status, and number of chronic diseases modifying the association between falls and the number of hospitalizations (data not shown).

## DISCUSSION

The results of our study show that recurrent falls in community-dwelling older adults can increase the need for hospitalization in both the short and the long term. On the other hand, a history of only one fall was not associated with any significant increase in the number of ward admissions over time.

The frequency of hospitalizations in our sample is in line with the findings of previous studies on similar populations, which have estimated that around one in five community-dwelling individuals are hospitalized at least once per year [24-26,38,39]. This draws attention to the need to identify those factors that may trigger a need for hospital-based care in older individuals, who are high users of healthcare resources with concomitant high costs.

In this regard, our study found that having experienced recurrent falls was associated with a greater number of ward admissions compared with having had no falls. On the other hand, there were no differences between individuals who had fallen only once and those who had experienced no falls in terms of the need for hospitalization in subsequent years. These findings confirm previous studies that observed that recurrent falls, but not single falls, were associated with higher use of the health service [23-25], even when adjusting, as in our work, for potential confounders like major injuries, risk behaviors, and health status. Interestingly, we found that the factors that might influence the impact of falls on subsequent hospitalizations, such as advanced age, sex, living alone or number of chronic diseases, did not have any significant effect on the association. Similar results were obtained by Stel et al., who did not find any specific factor associated with use of the health service in the

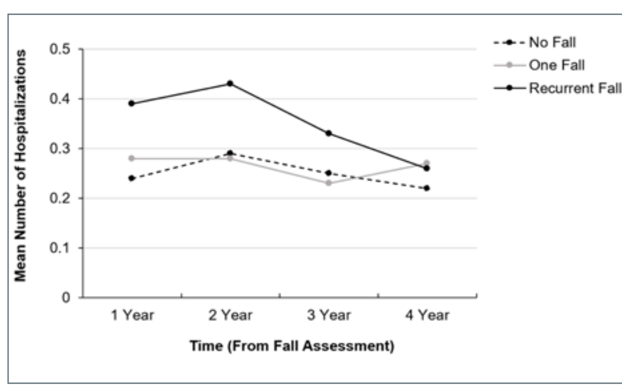


**Figure 1.** Mean number of hospitalizations after the assessments by number of reported falls.

Unadjusted mean (95% confidence interval) for the number of hospitalizations for the "No fall" group: year 1, 0.24 (0.21, 0.27); year 2, 0.29 (0.25, 0.32); year 3, 0.25 (0.22, 0.28); year 4, 0.22 (0.19, 0.25). "One fall" group: year 1, 0.28 (0.22, 0.33); year 2, 0.28 (0.22, 0.34); year 3, 0.23 (0.17, 0.29); year 4, 0.27 (0.21, 0.33). "Recurrent fall" group: year 1, 0.39 (0.30, 0.47); year 2, 0.43 (0.34, 0.53); year 3, 0.33 (0.26, 0.40); year 4, 0.26 (0.19, 0.33).

**Supplementary Table I.** Frequency of deaths and dropout rates with respect to the number of falls reported before the baseline and before the 4.4-year assessment.

| Falls before baseline | n | Deaths at 4.4-year assessment | Dropouts at 4.4-year assessment | Falls before the 4.4-year assessment | n | Deaths at 7-year assessment | Dropouts at 7-year assessment |
|---|---|---|---|---|---|---|---|
| 0 | 2056 | 409 (19.9) | 122 (5.9) | 0 | 1358 | 76 (5.6) | 493 (36.3) |
| 1 | 485 | 120 (24.7) | 28 (5.8) | 1 | 453 | 30 (6.6) | 145 (32.0) |
| ≥ 2 | 415 | 138 (33.3) | 16 (3.9) | ≥ 2 | 312 | 32 (10.3) | 92 (29.5) |

Numbers are frequencies and percentages of participants within the same fall category.

months following the fall [26]. A possible interpretation of these results is that the impact of falls may extend to the entire older population, affecting even the healthiest older individuals. This hypothesis is supported by the fact that the burden of falls, and especially recurrent falls, is multidimensional, in the sense that they do not impact only on one aspect of the individual's health but can affect functional status [9,16,21,40], the occurrence of new falls and mobility limitations [41-43], and psychological well-being [20]. The physical and psychological effects of falls are exacerbated by the development of fear of falling, which further leads older adults to avoid physical activities and to reduce physical performance, exposing them to a higher risk of new falls [44,45]. Moreover, over time, these broad-spectrum consequences of falls may facilitate the development of chronic diseases and hamper the control of existing conditions, ultimately increasing clinical vulnerability and use of health services [38,39,46].

As far as we are aware, most previous studies on this topic have examined the association between falls and the subsequent need for hospitalization over a follow-up period of 2 years or less [23-26]. Only Wolinsky et al.'s study examined two time windows, namely a 2-year and a 4-year period [25], and they found that recurrent falls were associated with a lower likelihood of contact with a physician in the following two years, but a greater likelihood of hospitalization over both the 2-year and, even more so, the 4-year follow-up period. Similarly, in our study we distinguished between the effect of falls on the need for hospital care in the short and the long term. In agreement with Wolinsky et al. [25], we found that the increased need for hospitalization in individuals who had experienced recurrent falls compared with non-fallers, persisted up to 4 years. This supports Tinetti et al.'s hypothesis of a *spiral response* to falls, according to which falls could trigger a gradual and spiraling deterioration in health status, ultimately leading to greater use of health resources. At the same time, we found that the tendency of accumulating hospitalizations increased in the first years after the fall, then gradually lessened over time. Although recurrent falls may have led to a worsening in health status up to death, such that the most resilient individuals selectively survive over the longer follow-up period, the observed trend supports the further possibility that falls can initially cause a drop in health status, which then stabilizes over time (the *drop-stabilization* response) [25,47].

Our study has some limitations that need to be mentioned. Firstly, fall occurrences were assessed only twice over the observation period, and the date of the falls was not recorded so we could not take into account other possible events occurring between the assessments. Secondly, the use of self-reported data on falls is susceptible to recall bias, and hence misclassification bias. However, this is more likely to result in underestimation of the frequency of falls and of the strength of the association between falls and hospitalizations. Thirdly, we did not take into account possible differences in the causes and durations of hospitalizations as a function of fall occurrence, which will be a matter for future studies. Finally, the Pro.V.A. study period could affect the generalizability of our results. Indeed, although falls remain a major health concern in particular for the oldest old [48-50], we did not account for changes in society and healthcare system that occurred in the latter years and may have influenced the clinical management of older adults. On the other hand, one of the strengths of our work is in having based our research on a large sample and a long follow-up period, offering us the possibility of evaluating the impact of falls on hospitalizations in two time windows. Moreover, our results are further supported by the fact that the frequency of hospitalizations was obtained from reliable sources (i.e. medical and hospital records) rather than from self-reported information, and by our analyses having taken into account the temporal relationship between falls and subsequent ward admissions.

Recurrent falls are associated with a greater need for hospital-based care, which seems to be more marked in the first years after fall occurrence, and persists in the long term, although tending to attenuate over time. These findings have important clinical implications since they highlight the need to develop new, effective interventions for fall prevention and to closely monitor the health status of older individuals reporting recent experiences of recurrent falls.

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### Conflict of interest statement

The Authors declare no conflict of interest.

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### Author contributions

CT, AKW, CC, GS, SM: contributed to the conception and design of the work; GS, SM, MN: contributed to the acquisition of data; CT, MN: performed the analyses; all authors contributed to the interpretation of data for the work; CT: drafted the manuscript; AKW, MN, SM, CC, GS: critically revised the manuscript. All gave final approval and agree to be accountable for all aspects of work ensuring integrity and accuracy.

### Ethical consideration

This study was approved by the Institutional Ethics Committee of the participating centers.

The research was conducted ethically, with all study procedures being performed in accordance with the requirements of the World Medical Association's Declaration of Helsinki. Written informed consent was obtained from each participant/patient for study participation and data publication.

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