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A community-based cross-sectional survey of orthostatic hypotension among elderly from south India

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ABSTRACT

Background: Orthostatic hypotension (OH) increases the risk of falls and associated morbidity and mortality in elderly. Hence, determining the prevalence of OH and its associated factors is important, especially in understudied LMIC settings.**Methods:** A community-based cross-sectional study was conducted among randomly selected 240 community-dwelling elderly from Thiruvananthapuram, Kerala. The OH symptoms were assessed by standard clinical measurements and frailty was assessed by modified Fried frailty phenotype. Logistic regression analysis was conducted to assess the factors associated with OH.**Results:** The prevalence of OH and frailty among participants was 9.6 and 29.2 percent respectively. In the first minute, OH was associated with increased odds of falls (OR = 1.97 [95%CI = 1.05, 3.72]). Increase in number of co-morbidities (OR_{adj} = 1.82 [95%CI = 1.36, 2.48]), number of medicines used (OR_{adj} = 1.73 [95%CI = 1.28, 2.34]), and orthostatic intolerance (OR_{adj} = 3.67 [95%CI = 1.13, 11.94]) increased the odds of having OH. Elderly with diabetes (OR_{adj} = 4.81 [95%CI = 1.57, 14.77]), hypertension (OR_{adj} = 4.97 [95%CI = 1.01, 24.46]) and cognitive impairment (OR_{adj} = 5.01 [95%CI = 1.40, 18.51]) were at a higher odds of having OH.**Conclusions:** OH and frailty are prevalent in community dwelling elderly in Thiruvananthapuram district. Frailty may be a risk factor for OH in the first minute. The number of co-morbidities may be an independent risk factor for OH. Hence, elderly people with comorbidities and cognitive impairment may be actively assessed for OH to prevent falls and associated injuries.© 2022 Cardiological Society of India. Published by Elsevier, a division of RELX India, Pvt. Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

Ageing, is an inevitable biological process that causes demographic transition. When coupled with the epidemiological transition in a country like India, it has varied implications specially for the elderly, like injuries and falls that may lead to further disabilities or death.^{1,2} Maintaining hemodynamic homeostasis during postural changes with age becomes less effective, and predisposes the elderly to significant changes in blood pressure upon standing and orthostatic hypotension.³ Orthostatic hypotension (OH) or

postural hypotension (PH) is a neuro-cardiovascular instability marked by a sustained fall in Blood Pressure (BP) upon standing upright from a seated or supine position.^{4,5} OH has often been implicated in the etiology of falls in older people^{6,7} affecting 17% of community cohorts⁸ and nearly 22% of the community-dwelling elderly.⁹ OH, has been associated with increased mortality,^{10–12} cognitive impairment,¹³ and hospitalization,¹⁴ as well as being a predictor of syncope,¹⁵ stroke,^{12,16} CVDs, in the elderly.^{11,12,14}

The prevalence of OH increases with advancing age^{3,5} and varies according to the population.^{3,8} Prevalence varies according to sex,^{10,17} the method of BP measurement, and the care setting under investigation.⁸ The etiology of OH is multifactorial; the normal age-related impairment of baroreflex sensitivity, the higher prevalence of comorbidities, and the use of different medications are the prime reasons for the higher prevalence of OH among the elderly.^{18,19} Frailty is a geriatric assessment criterion, and like OH, is associated with a greater risk of falling, increased morbidity, disability,

Abbreviations: LMIC, Low- or Middle-Income Countries.

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long-term care, and even death.^{20–22} Although there are studies on OH and frailty in developed countries, there is a paucity of studies on the prevalence of OH or its association with frailty and falls from low- and middle-income countries (LMICs), specially, among community-dwelling elderly people.

The elderly population in India is increasing steadily, and some Indian states like Kerala, are already at an advanced stage of epidemiological transition characterized by low mortality and high morbidity.²³ With age, vulnerability to age-related diseases and their morbidity increases. OH, and frailty significantly increases the risk of falling, disability, long-term care, and death. Hence, there is a need to document information related to such morbid conditions and geriatric issues; consequently, the present study was envisaged to determine the prevalence of orthostatic hypotension and its association with frailty, sociodemographic and clinical factors.

2. Materials and methods

2.1. Study design

Data for this community-based cross-sectional survey was collected between December 2019 and March 2020 from the coastal district of Thiruvananthapuram, Kerala, India.

2.2. Ethics approval

The study was approved by the Institutional Ethics Committee of Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum (SCT/IEC/1446/NOVEMBER-2019). Informed written consent was obtained from all participants. At the time of the interview, privacy was ensured, and confidentiality of all the information collected was maintained.

2.3. Study population and sample size

The community-dwelling elderly over 60 years of age who could stand without any help, respond independently, and have been living in the study area (residential wards) for at least five years were included in the study. The elderly who were bedridden, wheelchair-bound, or with debilitating illnesses like cancer were excluded from the study.

The sample size was calculated using Open Epi Version 3.01 software.²⁴ For the highest prevalence of OH (34%), reported from community-based studies of high-income countries with an alpha error of 5%, absolute precision of 8.5%, and design effect of 2 a sample size of 240 was derived. Using multistage cluster sampling, a total of 20 wards were randomly selected, 10 each from the City Corporation and rural areas of Thiruvananthapuram district (Appendix I). Every third household was chosen in the direction shown by the Pen rotation method. The Kish Grid was used to select and screen the households, and the ones that did not respond were replaced by the next eligible household/participant.

2.4. Data collection tools and procedures

A structured interview schedule, which was translated into Malayalam (the language spoken and read by people in the study area), was used for data collection from participants. Standard techniques for data collection were followed according to the WHO STEPS manual.²⁵ All the instruments used for clinical measurements were calibrated before using them in the field. The Orthostatic Hypotension Questionnaire²⁶ was used to assess the symptoms of OH, and a validated fall risk self-assessment checklist developed by the centers for disease control and prevention was used to evaluate the risk of falling.²⁷ Cognitive impairment was

assessed using the brief version of the community screening interview for dementia.^{28,29} Poor endurance and energy were assessed using the Center for Epidemiologic Studies Depression Scale. Self-reported weight loss was assessed using a single item question from the Geriatric Mental State Examination.²⁸ Participants taking more than 15 s to complete a 10 m gait speed test were considered slow and Participants who scored above 600 MET as per the WHO Global Physical Activity Questionnaire (GPAQ) version 2³⁰ and the GPAQ analysis guide for Physical activity³¹ were considered for assessing physical activity.

2.5. Clinical measurements

The Bed Side Orthostatic Test, Supine to Stand Method, was used for measuring OH. Blood pressure readings were taken after at least 5 min of rest while lying down, with appropriately sized cuffs positioned at heart levels and both arms supported using a semi-automatic validated digital sphygmomanometer (OMRON HEM 907). To establish baseline BP in the supine (lying down), the first BP measurement was taken on the non-dominant arm. Three measurements alternating between arms (i.e. left-right-left or vice versa) were taken 5 min apart. For analysis, the average of three readings in the supine position was taken. This was followed by three continuous BP measurements positioned at heart level on the left hand, 1 min apart at a standing position. Isometric handgrip strength was measured using a handgrip dynamometer (Camry EH101) after optimally adjusting for each participant. Participants below the 25th percentile were considered weak.

2.6. Study variables

The OH was defined as a decrease in systolic blood pressure (SBP) of at least 20 mmHg or a decrease in diastolic blood pressure (DBP) of at least 10 mmHg within 3 min of changing from supine to standing position, as measured ideally with a continuous BP device.⁴ The Revised consensus OH (ROH) was defined using the updated consensus statement, which revised the SBP cut-off in patients with supine hypertension to 30 mm.⁵ Fedorowski OH (FOH) was defined as a drop in SBP of at least 30 mmHg if the baseline supine SBP is 160 mmHg or 15 mmHg if the baseline SBP is 120 mmHg within 3 min of standing, with the DBP criterion being the same as the original consensus OH definition.¹⁴ Orthostatic intolerance was reported as feeling dizziness, light-headedness, or feeling faint. Frailty was defined as meeting three out of five modified Fried frailty phenotypic criteria indicating compromised energetics: exhaustion, weakness, slowness, weight loss, and low physical activity.^{28,32} Detailed operational definitions of variables are available in Appendix II. We used ration cards issued through public distribution system as an indicator of socioeconomic status among study participants. Antyodaya anna yojana ration card holders were categorized as extremely poor.

2.7. Data analysis

The data analysis was done in SPSS version 25. Continuous variables were presented as means and standard deviations. Categorical variables were presented as frequency and percentage. Multivariate logistic regression was performed to identify factors associated independently with OH adjusting for potential confounders (Appendix III). For sensitivity analysis, ROH and FOH were also used to identify the relation of postural changes with associated variables.

3. Results

3.1. Sociodemographic and behavioral profile

The demographic and socioeconomic profiles of the sample are presented in Table 1. The 240 participants were evenly distributed across urban and rural areas of the Thiruvananthapuram district, with a higher proportion of women (59.2%). Around one in ten (8.5%) women lived in extreme poverty, and six out of ten women were widowed. More than one third (35.8%) of the participants reported at least one hospital admission in the past year. Majority of the study participants (80%) were non-users of both smokeless and smoked tobacco products, however, alcohol consumption was present in nearly half (45%) of the men (current or former users). Almost one-fifth of the participants were unable to perform activities of daily living with similar proportions needing care.

3.2. Clinical characteristics

The anthropometric variables measured from the participants are presented in Table A1. Participant's handgrip strength varied between the sexes, with men having more handgrip strength than women. In the supine position, women had a higher mean DBP compared to men. One in every three participant fell at least once in the past year, among which women had a higher proportion of falls (47.2%). Also, women reported a higher fear of falling (76.1%) and had a higher risk of falling (66.9%) than men. Among comorbidities, self-reported diabetes was higher among males (46.9%) but hypertension prevalence was higher among females (66.9%). Frailty was found to affect 29.2 percent [95% CI = 23.37, 34.96] of the participants. The prevalence of frailty was higher among females (34.5%) than males (21.4%), $\chi^2 = 4.8$ $p = 0.028$ (Table 2 and Table A.2).

3.3. Prevalence of orthostatic hypotension

Table 2 shows the prevalence of different types of OH, frailty, fall and co-morbidities. The prevalence of OH was 20.4 percent [95% CI = 15.28, 25.55] in the first minute and 15.8 percent [95%

CI = 11.18, 20.49] in the second minute. One-tenth of the study participants (9.6 percent [95% CI = 5.83, 13.33]) had OH at the third minute which showed a clear difference between OH and non-OH participants (Fig. 1). The Fedorowski OH index revealed a prevalence of 7.5 percent [95% CI = 4.14, 10.86] compared to the revised consensus of 8.3 percent [95% CI = 4.81, 11.86] at the third minute.

3.4. Orthostatic hypotension and associated factors

Our bivariate analysis revealed that the OH was associated with increasing number of comorbidities, having cognitive impairment, being diabetic, and orthostatic intolerance in addition to other clinical factors listed in Table A3. The OH showed no association with frailty and previous history of falling. However, OH at the first minute was associated with frailty and previous history of falling (Table A.4).

Multivariate analysis revealed that the OH was influenced by socio-economic status ($OR_{adj} = 2.63$ [95%CI = 1.01, 6.81]), increase in number of co-morbidities ($OR_{adj} = 1.82$ [95%CI = 1.36, 2.48]), increase in number of medicine use ($OR_{adj} = 1.73$ [95%CI = 1.28, 2.34]), risk of falling ($OR_{adj} = 4.32$ [95%CI = 1.08, 17.39]) and orthostatic intolerance ($OR_{adj} = 3.67$ [95%CI = 1.13, 11.94]). Among co-morbidities, diabetes ($OR_{adj} = 4.81$ [95%CI = 1.57, 14.77]), hypertension ($OR_{adj} = 4.97$ [95%CI = 1.01, 24.46]), cognitive impairment ($OR_{adj} = 5.01$ [95%CI = 1.40, 18.51]) and visual difficulties ($OR_{adj} = 3.57$ [95%CI = 1.34, 9.51]) influenced orthostatic hypotension (Table 3).

3.5. Sensitivity analysis

We used consensus OH and FOH definitions as well to test the relation of postural changes with associated variables. We found FOH showed an association with a previous fall ($\chi^2 = 4.45$, $p = 0.035$) and further bivariate analysis showed that using FOH, the odds of having fallen in the last year increased by three times ($OR = 2.8$ [95%CI = 1.04, 7.48]). Further, the FOH definition shows higher odds in comparison to the consensus definition while defining the association of OI with OH (Table A.4).

Table 1
Study characteristics of the participants.

Variables	Categories	Female (n = 142)	Male (n = 98)	N = 240 (%)
Place of residence	Rural	69	51	120 (50)
	Urban	73	47	120 (50)
Age group	60–69	81	55	136 (56.7)
	70–79	47	34	81 (33.7)
	>80	14	9	23 (9.6)
Mean = 68.85 SD ^a = 7.09				
Level of education	No formal education	31	12	43 (17.9)
	Some, but did not complete primary	25	12	37 (15.4)
	Completed primary education	48	36	84 (35)
	Completed secondary (metric)	36	24	60 (25)
Socio economic status	Completed tertiary (college)	2	14	16 (6.7)
	Very poor	12	2	14 (5.8)
	Below poverty line	63	38	101 (42.1)
	Above poverty line	67	58	125 (52.1)
Number of Hospitalization made in the past year	No hospitalizations	88	66	154 (64.1)
	1-2 hospitalizations	32	19	51 (21.3)
	2 hospitalizations	22	13	35 (14.6)
Living status	Living alone	3	0	3 (1.3)
	Not living alone	139	98	237 (98.7)
Activities of daily living (ADL)	Can complete all ADL	115	81	196 (81.7)
	Cannot complete all ADL	27	17	44 (18.3)
People needing care	Always	7	7	14 (5.8)
	Sometimes	20	10	30 (12.5)
	Never	115	81	196 (81.7)

^a SD: Standard Deviation.

Table 2
Prevalence of Orthostatic hypotension, frailty, fall and co-morbidities (n = 240).

VARIABLES	Female n = 142(%)	Male n = 98(%)	N = 240 (%)	95% Confidence Interval
OH ^a at 1 min (OH ₁)	36 (25.4)	13 (13.3)	49 (20.4)	15.28–25.55
OH at 2 min (OH ₂)	26 (18.3)	12 (12.2)	38 (15.8)	11.18–20.49
OH at 3 min (OH/OH ₃)	13 (9.2)	10 (10.2)	23 (9.6)	05.83–13.33
Revised COH ^b	13 (9.2)	7 (7.1)	20 (8.3)	04.81–11.86
Fedorowski OH (FOH)	11 (7.7)	7 (7.1)	18 (7.5)	04.14–10.86
Orthostatic Intolerance	32 (22.5)	15 (15.3)	47 (19.6)	14.53–24.64
Frailty	49 (34.5)	21 (21.4)	70 (29.2)	23.37–34.96
Fall in last year (Self-reported)	67 (47.2)	24 (24.5)	91 (37.9)	31.73–44.09
Fear of falling	108 (76.1)	24 (24.5)	132 (55)	48.66–61.34
Risk of falling	95 (66.9)	45 (45.9)	140 (58.3)	52.05–64.62
Hypertension (Self-reported)	94 (66.2)	52 (53.1)	146 (60.8)	54.61–67.05
Diabetes mellitus (Self-reported)	53 (37.3)	46 (46.9)	99 (41.3)	34.98–47.52
Cognitive impairment	38 (19.7)	29 (29.6)	57 (23.8)	18.33–29.17

^a OH: Orthostatic Hypotension.

^b COH: Consensus Orthostatic Hypotension.

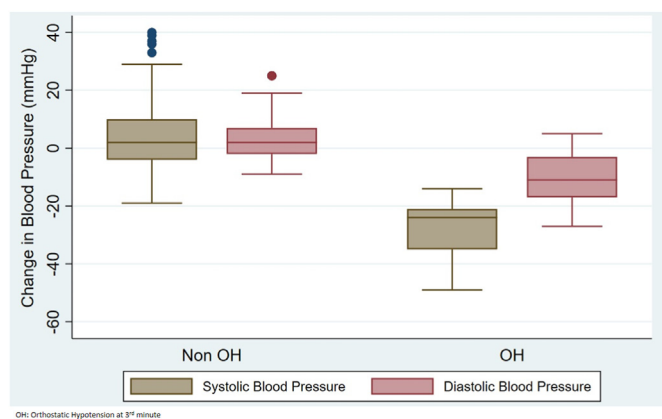


Fig. 1. Difference in systolic and diastolic blood pressure among OH and non-OH study participants.

4. Discussion

The primary aim of the study was to determine the prevalence of OH among community-dwelling elderly people over 60 years of age and its association with frailty, sociodemographic and clinical factors. In doing so, we investigated the prevalence of OH using multiple definitions and the prevalence of frailty using Fried's criteria. The prevalence of OH using the consensus definition was found to be 9.6% among the study participants. Our findings are similar to the Progetto Veneto Anziani (Pro.V.A) study, which was conducted in Italy among community-dwelling elderly over the age of 65 and discovered a 9.3 percent prevalence of OH at baseline.³³ Although our study showed a lower prevalence of OH in community dwelling elderly as compared to the pooled prevalence of OH reported by a recent systematic review and meta-analysis (SRMA) using the consensus definition of 17%,⁸ as well as a previous SRMA among community dwellers in developed countries, which reported a pooled prevalence of 22.2 percent.⁹ This difference in the prevalence may be attributed to a difference in methods used for measuring OH, the study setting (old age homes or community) or the stage of the epidemiological transition. Similarly a difference in the medications used by the study participants may have contributed to the observed differences in the prevalence of OH.

The prevalence of frailty (29.2%) found in our study is comparable to other studies done in developing countries and in India, including a study done in rural Tamil Nadu, where the prevalence of frailty in the elderly for physical definition was 28 percent.³⁴

According to our study findings, the odds of having OH increased by 58 percent for every additional co-morbidity. In line with our results, previous literature suggests that multiple co-morbidities have been linked to an increased risk of OH.¹⁷ Our study showed that certain established risk factors for impaired prognosis were independently associated with an increased odds of having OH. These risk factors include but are not limited to diabetes mellitus, arthritis, urinary incontinence, hypertension, cognitive impairment, orthostatic intolerance, difficulty with vision, and taking multiple medicines. The number of co-morbidities increases with age this in turn will lead to an increased medications. This vicious cycle of increasing age, comorbidities and medications results in increased OH among the elderly population.³⁵

Our study found that OH in the first minute was common among frail males, and they were six times more likely to experience OH. This result was comparable with a recent study done among geriatric clinic inpatients, which found that frailty was associated with OH at the first minute.³⁶ However, the study was done among geriatric clinic inpatients, and they used different assessment tools—Comprehensive Geriatric Assessment and HUT—for measuring frailty and OH.³⁶ Our study findings of a two-fold increased odds of having fallen at least once in the past year for those having OH at the first minute are in congruence with recent systematic reviews which have already shown how falling and OH are positively associated.^{6,7,9}

4.1. Strengths and limitations

We incorporated multistage sampling, with a reasonable geographical representation of the study area. This would have reduced the likelihood of selection bias. Data collection was done exclusively by the primary investigator; for limiting the inter-observer bias. Calibration of instruments was done to minimize the systematic technical bias from our study.

Despite the strengths of our study, it has some limitations, such as the possibility of participant over-reporting causing information bias, which may have led to an overestimation of the strength of association. Also, our study may be susceptible to volunteer bias and recall bias.

Our study would have underestimated the risk since we overlooked those who were not present at the time of data collection, particularly those admitted to hospitals because of falls or other ailments, and people who were out of homes due to employment or other reasons. The number of people who live alone would be an underestimate, since people living alone had a lower participation rate in the survey. We were unable to verify prescribing records or

Table 3
Multivariate regression analysis of the associated factors with OH.

VARIABLES	Univariate OR [95%CI]	p-value ^b	Multivariate ^a OR _{adj} [95%CI]	p-value
People needing care				
Never	Referent			
Sometimes	1.86 [0.57, 6.02]	0.303	1.53 [0.33, 6.98]	0.587
Always	4.83 [1.35, 17.25]	0.015	2.29 [0.37, 14.11]	0.372
Socio economic status (SES) ^d				
APL	2.27 [0.89, 5.72]	0.084	2.63 [1.01,6.81]	0.047
Co-morbidities				
Increase by 1 comorbidity	1.58 [1.25, 1.99]	<0.001	1.82 [1.36, 2.48]	<0.001
Medicine use				
Increase by 1 medicine	1.67 [1.27, 2.19]	<0.001	1.73 [1.28, 2.34]	<0.001
Diabetes ^c				
Yes	6.04 [2.16, 16.90]	<0.001	4.81 [1.57, 14.77]	0.006
Arthritis ^c				
Yes	2.83 [1.02, 7.89]	0.046	1.84 [0.55, 6.12]	0.322
Visual difficulties ^c				
Yes	4.69 [1.89, 11.61]	<0.001	3.57 [1.34, 9.51]	0.011
Cognition impairment ^c				
Yes	4.17 [1.73, 10.07]	0.001	5.01 [1.40, 18.51]	0.014
Hypertension ^c				
Yes	7.73 [1.77, 33.79]	0.007	4.97 [1.01, 24.46]	0.049
Urinary incontinence ^c				
Yes	3.62 [1.47, 8.94]	0.005	2.40 [0.84, 6.89]	0.103
Risk of falling ^c				
Yes	5.39 [1.56, 18.67]	0.008	4.32 [1.08, 17.39]	0.039
Orthostatic Intolerance ^c				
Yes	3.03 [1.22, 7.51]	0.017	3.67 [1.13, 11.94]	0.031^b

^a Multivariate models explained in Appendix III.

^b $p < 0.10$ is considered as significant in univariate analysis.

^c For variables categorized into dichotomous outcomes, the referent will be the alternate category.

^d For SES, BPL is referent, Bold values were statistically significant at 0.05 level in multivariate analysis. BPL – below poverty line, APL – above poverty line, SES - Socio economic status.

take into consideration dosage and dose compliance, especially antihypertensive drugs.

5. Conclusions

The OH prevalence observed in our study is comparable to similar research from developed countries. This points to the epidemiologic transition Kerala is undergoing leading to health issues in elderly population. Diabetes mellitus, hypertension, cognitive impairment, orthostatic intolerance, arthritis, and urinary incontinence are comorbid diseases that can be independent risk factors for OH. People with comorbidities and on multiple medications have a markedly increased likelihood of having OH. Our study findings shows that among elderly above 60 years of age, one out of ten will have OH, three will be frail, and four would have fallen in the previous year. Frailty may increase the risk of OH in the first minute. OH is an easily diagnosable and remediable conditions with important clinical implications. People with comorbidities and with cognitive impairment should be closely monitored for OH. This may lead to a lower chance of falling among the elderly and an improved quality of life.

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Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ihj.2022.11.007>.

References

1. Kannus P, Parkkari J, Koskinen S, et al. Fall-induced injuries and deaths among older adults. *JAMA*. 1999;281(20):1895–1899.
2. World Health Organization. *WHO Fact Sheet on Falls: World Health Organization*; 2021 [updated 26 April 2021]. Available from: <https://www.who.int/news-room/fact-sheets/detail/falls>.
3. Hiitola P, Enlund H, Kettunen R, Sulkava R, Hartikainen S. Postural changes in blood pressure and the prevalence of orthostatic hypotension among home-dwelling elderly aged 75 years or older. *J Hum Hypertens*. 2009;23(1):33–39.
4. The Consensus Committee of the American Autonomic S, the American Academy of N. Consensus statement on the definition of orthostatic hypotension, pure autonomic failure, and multiple system atrophy. *Neurology*. 1996;46(5):1470.
5. Freeman R, Wieling W, Axelrod FB, et al. Consensus statement on the definition of orthostatic hypotension, neurally mediated syncope and the postural tachycardia syndrome. *Clin Auton Res*. 2011;21(2):69–72.
6. Mol A, Hoang PTSB, Sharmin S, et al. Orthostatic hypotension and falls in older adults: a systematic review and meta-analysis. *J Am Med Dir Assoc*. 2019;20(5):589–597. e5.
7. Shaw BH, Borrel D, Sabbaghan K, et al. Relationships between orthostatic hypotension, frailty, falling and mortality in elderly care home residents. *BMC Geriatr*. 2019;19(1):80.

8. McDonagh STJ, Mejnzer N, Clark CE. Prevalence of postural hypotension in primary, community and institutional care: a systematic review and meta-analysis. *BMC Fam Pract.* 2021;22(1):1.
9. Saedon NLZ, Pin Tan M, Frith J. The prevalence of orthostatic hypotension: a systematic review and meta-analysis. *J Gerontol: Ser A.* 2018;75(1):117–122.
10. Masaki KH, Schatz IJ, Burchfiel CM, et al. Orthostatic hypotension predicts mortality in elderly men: the Honolulu Heart Program. *Circulation.* 1998;98(21):2290–2295.
11. Verwoert GC, Mattace-Raso FU, Hofman A, et al. Orthostatic hypotension and risk of cardiovascular disease in elderly people: the Rotterdam study. *J Am Geriatr Soc.* 2008;56(10):1816–1820.
12. Xin W, Mi S, Lin Z, Wang H, Wei W. Orthostatic hypotension and the risk of incidental cardiovascular diseases: a meta-analysis of prospective cohort studies. *Prev Med.* 2016;85:90–97.
13. Rose KM, Couper D, Eigenbrodt ML, Mosley TH, Sharrett AR, Gottesman RF. Orthostatic hypotension and cognitive function: the atherosclerosis risk in communities study. *Neuroepidemiology.* 2010;34(1):1–7.
14. Fedorowski A, Engström G, Hedblad B, Melander O. Orthostatic hypotension predicts incidence of heart failure: the malmö preventive project. *Am J Hypertens.* 2010;23(11):1209–1215.
15. Lipsitz LA, Pluchino FC, Wei JY, Rowe JW. Syncope in institutionalized elderly: the impact of multiple pathological conditions and situational stress. *J Chron Dis.* 1986;39(8):619–630.
16. Rose KM, Tyroler HA, Nardo CJ, et al. Orthostatic hypotension and the incidence of coronary heart disease: the Atherosclerosis Risk in Communities study. *Am J Hypertens.* 2000;13(6):571–578.
17. Kamaruzzaman S, Watt H, Carson C, Ebrahim S. The association between orthostatic hypotension and medication use in the British Women's Heart and Health Study. *Age Ageing.* 2010;39(1):51–56.
18. Feldstein C, Weder AB. Orthostatic hypotension: a common, serious and underrecognized problem in hospitalized patients. *J Am Soc Hypertens.* 2012;6(1):27–39.
19. Ricci F, Fedorowski A, Radico F, et al. Cardiovascular morbidity and mortality related to orthostatic hypotension: a meta-analysis of prospective observational studies. *Eur Heart J.* 2015;36(25):1609–1617.
20. Boyd CM, Xue Q-L, Simpson CF, Guralnik JM, Fried LP. Frailty, hospitalization, and progression of disability in a cohort of disabled older women. *Am J Med.* 2005;118(11):1225–1231.
21. Ensrud KE, Ewing SK, Cawthon PM, et al. A comparison of frailty indexes for the prediction of falls, disability, fractures, and mortality in older men. *J Am Geriatr Soc.* 2009;57(3):492–498.
22. Nowak A, Hubbard RE. Falls and frailty: lessons from complex systems. *J R Soc Med.* 2009;102(3):98–102.
23. Kumar BG. Low mortality and high morbidity in Kerala reconsidered. *Popul Dev Rev.* 1993;19(1):103.
24. Dean AG, Sullivan KM, Soe MM. *OpenEpi: Open Source Epidemiologic Statistics for Public Health.* version; 2013.
25. World Health Organization. *Noncommunicable D, Mental Health C. WHO STEPS Surveillance Manual: The WHO STEPwise Approach to Chronic Disease Risk Factor surveillance/Noncommunicable Diseases and Mental Health.* World Health Organization. World Health Organization; 2005. Report No.: 9241593830.
26. Kaufmann H, Malamut R, Norcliffe-Kaufmann L, Rosa K, Freeman R. The Orthostatic Hypotension Questionnaire (OHQ): validation of a novel symptom assessment scale. *Clin Auton Res.* 2012;22(2):79–90.
27. Rubenstein LZ, Vivrette R, Harker JO, Stevens JA, Kramer BJ. Validating an evidence-based, self-rated fall risk questionnaire (FRQ) for older adults. *J Saf Res.* 2011;42(6):493–499.
28. At J, Bryce R, Prina M, et al. Frailty and the prediction of dependence and mortality in low- and middle-income countries: a 10/66 population-based cohort study. *BMC Med.* 2015;13(1):138.
29. At J, Dias A, Philp I, Beard J, Patel V, Prince M. Identifying common impairments in frail and dependent older people: validation of the COPE assessment for non-specialised health workers in low resource primary health care settings. *BMC Geriatr.* 2015;15(1):123.
30. Herrmann SD, Heumann KJ, Der Ananian CA, Ainsworth BE. Validity and reliability of the global physical activity questionnaire (GPAQ). *Meas Phys Educ Exerc Sci.* 2013;17(3):221–235.
31. Armstrong T, Bull F. Development of the world health organization global physical activity questionnaire (GPAQ). *J Publ Health.* 2006;14(2):66–70.
32. Fried LP, Tangen CM, Walston J, et al. Frailty in older adults: evidence for a phenotype. *J Gerontol Ser A: Biol Sci Med Sci.* 2001;56(3):M146–M157.
33. Veronese N, De Rui M, Bolzetta F, et al. Orthostatic changes in blood pressure and mortality in the elderly: the Pro. VA Study. *Am J Hypertens.* 2015;28(10):1248–1256.
34. Kendhapedi KK, Devasenapathy N. Prevalence and factors associated with frailty among community-dwelling older people in rural Thanjavur district of South India: a cross-sectional study. *BMJ Open.* 2019;9(10), e032904.
35. Milazzo V, Stefano C, Servo S, Crudo V, Fulcheri C, Maule S. Drugs and orthostatic hypotension: evidence from literature. *J Hypertens.* 2012;1(104):2167, 1095.1000104.
36. Kocyigit SE, Soysal P, Bulut EA, Aydin AE, Dokuzlar O, Isik AT. What is the relationship between frailty and orthostatic hypotension in older adults? *J Geriatr Cardiol: JGC.* 2019;16(3):272.