Prevalence of frailty in 62 countries across the world: a systematic review and meta-analysis of population-level studies

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Abstract

Introduction: The prevalence of frailty at population-level is unclear. We examined this in population-based studies, investigating sources of heterogeneity.

Methods: PubMed, Embase, CINAHL and Cochrane Library databases were searched for observational population-level studies published between January 1st 1998 and April 1st 2020, including individuals aged ≥50 years, identified using any frailty measure. Prevalence estimates were extracted independently, assessed for bias and analysed using a random-effects model.

Results: In total, 240 studies reporting 265 prevalence proportions from 62 countries and territories, representing 1,755,497 participants, were included. Pooled prevalence in studies using physical frailty measures was 12% (95% CI=11-13%; n=178), compared with 24% (95% CI=22%-26%; n=71) for the deficit accumulation model (those using a frailty index, FI). For pre-frailty, this was 46% (95% CI=45-48%; n=147) and 49% (95% CI=46-52%; n=29), respectively. For physical frailty, prevalence was higher among females, 15% (95% CI=14-17%; n=142), than males, 11% (95% CI=10-12%; n=144). For studies using a FI, prevalence was also higher in females, 29% (95% CI=24%-35%; n=34) versus 20% (95% CI=16%-24%; n=34), for males. These values were similar for pre-frailty. Prevalence increased with minimum age at study-inclusion. Analysing only data from nationally-representative studies gave a frailty prevalence of 7% (95% CI=5%-9%; n=46) for physical frailty and 24% (95% CI=22%-26%; n=44) for FIs.

Conclusions: Population-level frailty prevalence varied by classification and sex. Data were heterogenous and limited, particularly from nationally-representative studies making the interpretation of differences by geographic region challenging. Common methodological approaches to gathering data are required to improve the accuracy of population-level prevalence estimates.

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Running head: Prevalence of frailty in 62 countries worldwide.

Introduction

Frailty is characterised by loss of biological reserves, failure of physiological mechanisms and vulnerability to a range of adverse outcomes [1]. Closely related to ageing [2], the incidence of frailty varies between studies [3] and could be expected to increase in response to projected demographic trends [4]. Although distinct from multi-morbidity, frailty overlaps with disability and chronic disease, potentially contributing to rising late-life dependency in many countries [5-8]. As such, frailty is recognised as an emerging public health priority [9,10]. Despite the importance of frailty in the context of global ageing, the worldwide population-level prevalence remains unclear. The first published systematic review of frailty prevalence, suggesting a global prevalence of 10.7%, was reported in 2012 by *Collard et al* [11]. This included only 21 studies from western, high-income countries [11]. More recently, regional prevalence data have been published for a limited number of countries in Europe [12], Latin America including the Caribbean [13] and for some low and middle income countries (LMIC) [14], albeit comparisons between countries and regions are limited.

Frailty has dynamic properties and interventions targeted to the level of frailty may slow progression [15-17]. Pre-frailty, a recognised prodromal state before the onset of clinically identifiable frailty, is therefore a useful construct to potentially delay its onset [15,16,18] and reduce associated adverse outcomes including mortality [19]. The development of frailty in community-dwellers is associated with multiple factors including age, sex, economic indicators [20], and disease burden [21,22]. Despite this, few studies have investigated whether study characteristics influence prevalence estimates at population-level.

Better understanding of the country and region-level prevalence of frailty and the impact of study characteristics on prevalence will enable policy-makers and healthcare planners to configure appropriate services including preventative approaches for older adults. Hence, we conducted a systematic review and meta-analysis of population-based studies reporting the prevalence of frailty and pre-frailty published since the development of established frailty models, examining sources of heterogeneity.

Methods

The study was carried out in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [23] (appendix). The review protocol was registered on Prospero (CRD42018105431).

Searches

The pre-specified search strategy is provided in the appendix. In brief, CINAHL, Embase, PubMed (MEDLINE), and the Cochrane Library databases were searched for studies published between January 1st 1998 and April 1st 2020 using the following search strategy: (Prevalence OR Incidence OR Epidemiology) AND (Elderly OR Aged OR "Older adult$" OR "Older person$" OR Geriatric$) AND (Frailty OR Frail) AND (Population-based OR "Population based") NOT ("Frailty model" OR "Frailty survival model"). Citation tracking of published systematic reviews and included studies, and hand-searching on Google Scholar (first 200 results) using the search string: COUNTRY "frailty prevalence" OR frail OR frailty -"frailty

model", were conducted. Pairs of reviewers independently assessed studies. Disagreements were resolved through consensus.

Eligibility criteria

Only population-based studies, classified as those that included a representative sample whose results could be extrapolated to a larger population defined in terms of a geographical area (region or country), were eligible [24]. Studies were included if they reported prevalence data for community-dwellers aged ≥50 years (minimal entry criterion) and described frailty and/or pre-frailty using any externally validated measure and an established cut-off score. No language restriction was applied; non-English language papers were translated using Google Translate or by colleagues fluent in the specified language. Editorials, correspondence, abstract-only publications, conference proceedings and review papers were excluded. Studies with an upper age cut-off ≤85 years, those providing disease or condition-specific data or from defined settings (hospitals, nursing homes or public health centres), unless included as part of a population-based survey with the intention of obtaining a representative community sample, were excluded.

Data selection, extraction, and critical appraisal

Data were extracted in their original format as published articles. Where complete data were unavailable or inconsistencies were noted, corresponding authors were contacted. We also requested disaggregated data on age and sex on frailty and pre-frailty where these were not available. If more than one paper provided data for a given cohort, the paper providing the most comprehensive (largest sample size) and representative data was included. Where papers presented data for multiple countries, data for individual regions and nations were extracted and analysed separately. The *Loney* critical appraisal tool for studies assessing prevalence was used to assess reporting quality (see appendix) [25]. A cut-off of ≤3/8 was applied and lower quality studies below this threshold were excluded (n=34) [14]. All studies were appraised for quality by a pair of independent reviewers (D.S. and MO.D.) with disagreement resolved by consensus; intraclass correlation coefficient estimates were used to measure agreement (appendix).

Analysis

Data were analysed using STATA (version 14.2). Prevalence meta-analysis was performed using the Freeman-Tukey double arcsine method, utilising the 'metaprop one ftt' command [26,27]. Heterogeneity between studies was investigated with meta-regression and Higgins' I^2 statistic was used to determine the extent of variation between studies. Statistical significance was determined using the $\chi 2$ test ($p<0.05$). The primary analysis was performed according to the diagnostic classification of frailty/pre-frailty using either (1) physical frailty including the Fried Phenotype model (the presence or absence of weight loss, exhaustion, weakness e.g. reduced grip strength, low walking speed and decreased physical activity) [29], a recognised modification of this and other scales measuring physical frailty [30], or (2) a frailty index (FI), applying the deficit accumulation model based on the proportion of deficits present from a set list [31]. Subgroup analyses were conducted considering study features including age-specific

entry criteria (minimum and mean), sex, geographical location/area, sampling approach (probability and non-probability) and sampling frame: (a) registers including census data, (b) health-related data such as insurance, municipal and primary care databases and (c) other including convenience sampling. Studies with nationally-representative sampling (longitudinal studies or census data) were also analysed separately. Studies with a minimum age of inclusion between 50-59, 60-69, 70-79, 80-89 and ≥90 years were examined with a focus on studies taking an inclusion cut-off between 60-69 years, reflecting the United Nations' (UN) definition of older populations (i.e. ≥60)[32]. Regions were defined using the UN's continent areas [33]. Cohort effects were examined comparing data pre-2012 (inclusive) and post the publication by *Collard et al*. in 2012 [11].

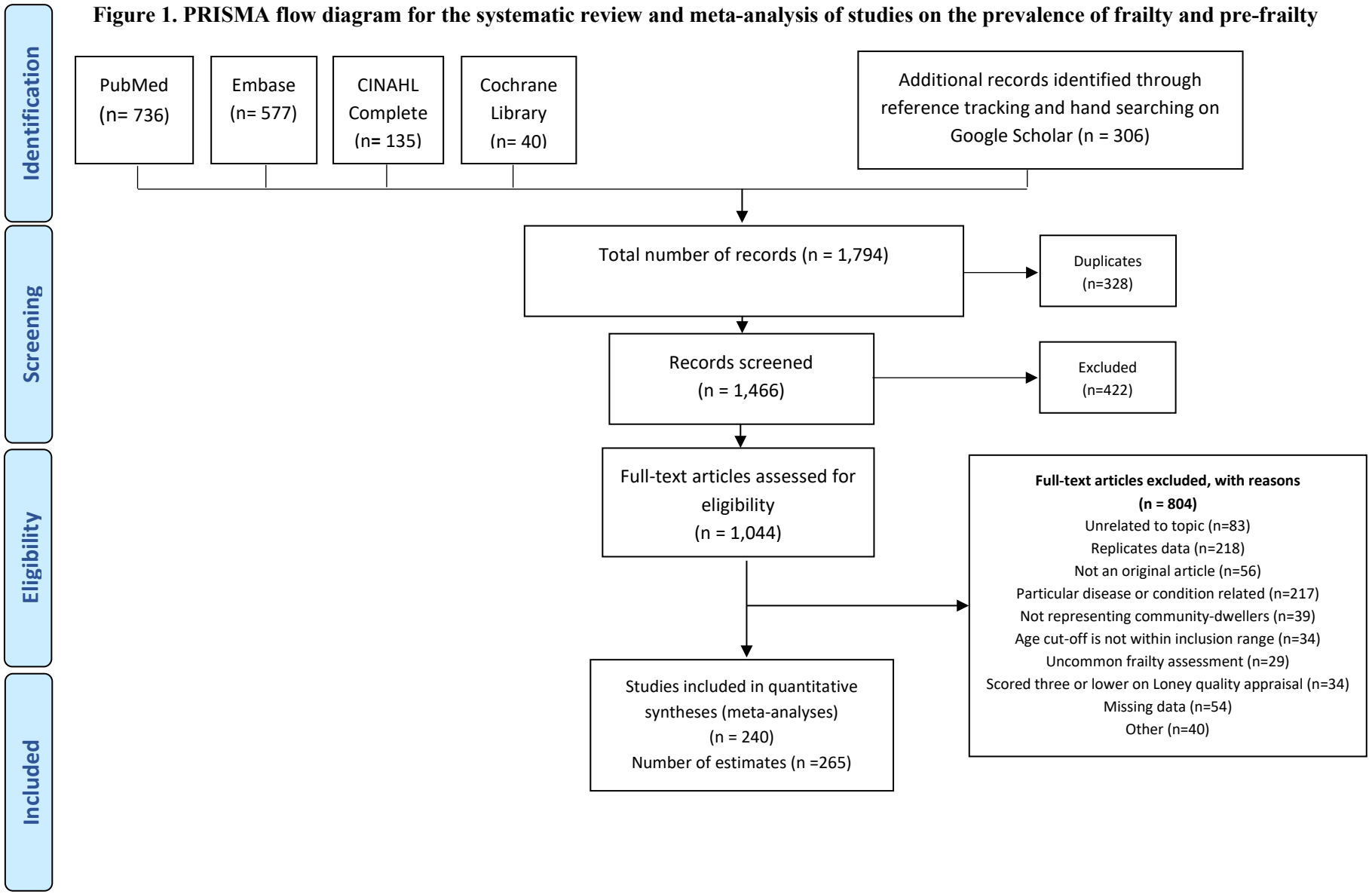
Results

In total, 240 studies providing 265 prevalence proportions, representing data from 1,755,497 participants, were included. The characteristics of each are presented in the appendix. From these, 204 provided 253 unique proportions by country. The remaining 36 studies provided additional data including age cut-offs and sex-specific results. From the 240 studies included, 40 provided data for more than one frailty tool, 87 for more than one age cut-off and 191 provided sex-specific results. The selection of papers is presented in a PRISMA flow diagram (figure 1). Most studies were published after 2012 (200/240, 83%). The majority included adults aged ≥65 years (n=136/240, 57%). Most only reported data from community-dwellers (n=218/240, 91%), though a small number (n=22/240, 9%), applying robust sampling approaches sufficient to meet inclusion criteria, sampled individuals in residential care to provide more representative population-based proportions.

Results of individual studies

Prevalence for frailty and pre-frailty were reported for 62 and 54 countries/territories, respectively, with unique data points available across all UN regions. The reported prevalence of frailty ranged from 75% among those aged ≥65 years in Romania using the Groningen Frailty Indicator (GFI)[34] and 91% among centenarians in Italy using a FI [35] to <1% in Denmark for individuals aged ≥50 using a (modified) phenotype model [36]. Similarly, pre-frailty prevalence proportions varied by country. The most common frailty scales were measures of physical frailty, (n=142/240, 59%), followed by any FI (n=52/240, 22%) [31] and the Tilburg Frailty Indicator (n=13/240, 5%) [37].

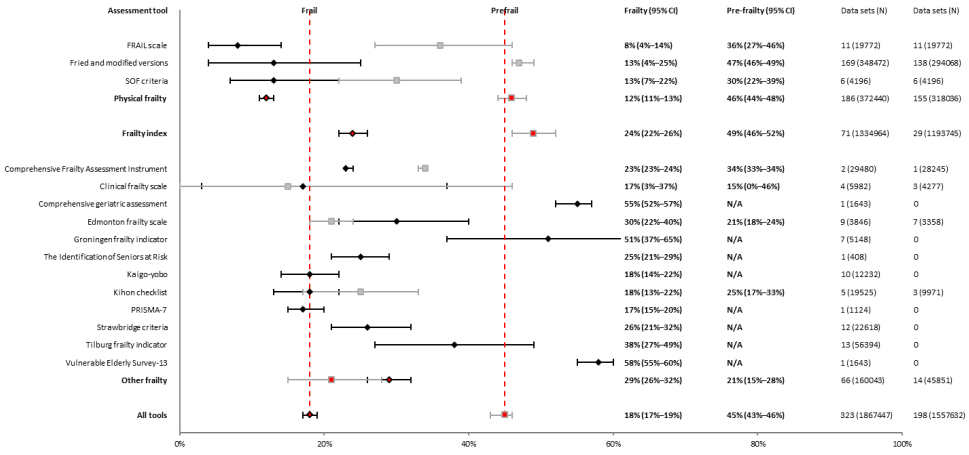
Figure 1. PRISMA flow diagram for the systematic review and meta-analysis of studies on the prevalence of frailty and pre-frailty



Overall prevalence by frailty measure

From the 253 unique data points available, 1,731,107 individuals aged ≥50 using any definition of frailty were included in the initial meta-analysis; 175 data points for 1,512,048 individuals were available for pre-frailty. Only 16 studies reported prevalence using both physical frailty and deficit accumulation models. For studies measuring physical frailty, 178 prevalence proportions representing 360,438 individuals were found compared with 71 representing 1,334,964 individuals for the deficit accumulation model. These provided an overall estimated frailty prevalence of 12% (95% CI=11-13%; n=178, I^2=99%; p<0.005) for physical frailty and 24% (95% CI=22-26%; n=71, I^2=100%; p<0.005) for FIs. The overall estimate for pre-frailty using instruments measuring physical frailty was 46% (95% CI=45-48%; n=147, I^2=99%; p<0.005) versus 49% (95% CI=46-52%; n=29, I^2=100%; p<0.005) for the FI. When data for all frailty measures including other scales were pooled, the overall estimated frailty prevalence was 17% (95% CI=16-18%; n=265, I^2=100%; p<0.005); the prevalence of pre-frailty was 45% (95% CI=44-46%; n=175, I^2=100%; p<0.005). Prevalence estimates were unchanged with the exclusion of one large outlier including 931,541 patients [38], irrespective of frailty measure. Prevalence proportions by assessment scale are presented as a forest plot in figure 2.

Figure 2. Frailty and pre-frailty prevalence estimates and number of participants (N) by classification (scale) from studies including those aged ≥50 years*.



*Note: the total number of data points/participants in this figure is more than the total reported elsewhere since datasets were included more than once for different scales.

Age subgroups

Studies were grouped based on minimum age at study-inclusion (table 1). Most data were available for studies with a minimum age between 60-69, which provided a prevalence of 12% (95% CI=11-14%; n=150, I^2=99%; p<0.005) for physical frailty and 23% (95% CI=20-25%; n=36, I^2=100%; p<0.005) for FIs. For pre-frailty the estimates were 47% (95% CI=45-49%; n=125, I^2=98%; p<0.005) and 50% (95% CI=46-53%; n=24, I^2=100%; p<0.005), respectively. Pooling prevalence proportions for all scales using the ≥60-69 minimum age cut-off produced an estimate of 16% (95% CI=15-17%) for frailty and 45% (95% CI=44%-47%) for pre-frailty. The correlation between mean age of participants at study-entry and prevalence was weak

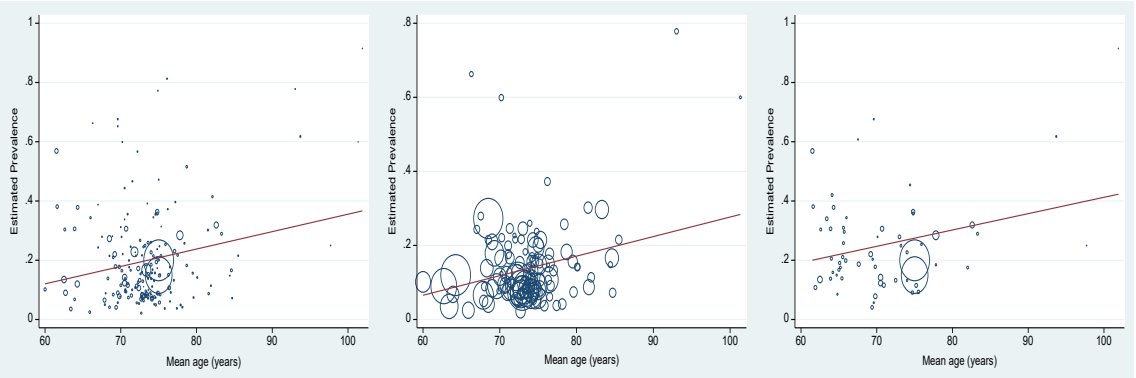
(*adjusted* r^2=3.00%, p=0.004), irrespective of frailty classification (figure 3). These correlations were similar (*adjusted* r^2=3.04%, p=0.004) with the exclusion of the largest outlier [38].

Table 1: Frailty and pre-frailty estimates with 95% confidence intervals (CI) grouped by minimum age cut-off at inclusion for all scales, physical frailty and deficit accumulation (frailty index) models.

Age	All Scales		Physical Frailty		Frailty Index	
Min cut-off (at study entry)	Number of data points (sample size)	Prevalence (95% CI)	Number of studies (sample size)	Prevalence (95% CI)	Number of data points (sample size)	Prevalence (95% CI)
Frailty						
50-59+	50 (217,631)	11% (8%-14%)	37 (136,456)	6% (4%-8%)	31 (129,260)	23% (19%-28%)
60-69+	205 (1,404,663)	16% (15%-17%)	150 (268,989)	12% (11%-14%)	36 (1,059,987)	23% (20%-25%)
70-79+	118 (166,697)	20% (18%-22%)	92 (99,865)	18% (16%-19%)	14 (25,468)	25% (19%-32%)
80-89+	95 (189,122)	31% (29%-34%)	75 (23,297)	28% (26%-30%)	10 (156,316)	32% (24%-41%)
90+	12 (1,930)	51% (38%-63%)	9 (945)	46% (33%-61%)	3 (985)	61% (29%-89%)
Pre-frailty						
50-59+	36 (151,358)	41% (38%-44%)	34 (124,730)	41% (38%-44%)	3 (30,724)	41% (27%-56%)
60-69+	151 (1,262,568)	45% (44%-47%)	125 (223,741)	47% (45%-49%)	24 (1,018,888)	50% (46%-53%)
70-79+	72 (71,339)	49% (47%-51%)	68 (68,465)	50% (48%-52%)	6 (7,385)	47% (35%-60%)
80-89+	56 (165,312)	52% (48%-56%)	52 (14,129)	53% (51%-55%)	3 (151,138)	49% (24%-75%)
90+	7 (652)	48% (41%-55%)	6 (528)	46% (42%-51%)	1 (124)	49% (46%-51%)

*Note: the total number of data points exceeds the total number of datasets included as some studies provided multiple age cut-offs.

Figure 3. Meta-regression plots for datasets from studies providing frailty proportions for mean age of participants at study entry for (a) all scales, (b) physical frailty and (c) deficit accumulation (frailty index) models.



(a) **(b)** **(c)**

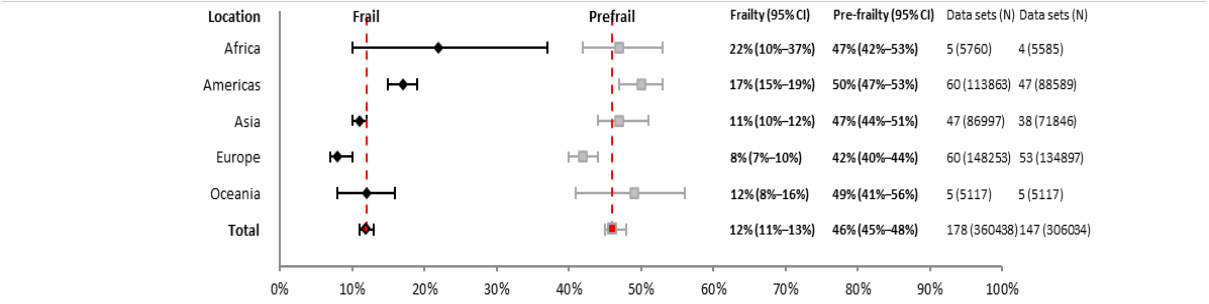
Biological Sex

Among studies providing sex-specific results, 55% of participants were female (303,805 of 552,300 individuals). For physical models, frailty and pre-frailty prevalence proportions for females were 15% (95% CI=14-17%; n=143, I^2=99%; p<0.005) and 49% (95% CI=47-50%; n=117, I^2=99%; p<0.005), respectively, compared with 11% (95% CI=10-12%; n=145, I^2=97%; p<0.005) and 45% (95% CI=44-47%; n=119, I^2=97%; p<0.005), respectively, for males. For studies using a FI there was also a higher prevalence of frailty in females than males, 29% (95% CI=24-35%; n=34, I^2=100%; p<0.005) and 20% (95% CI=16-24%; n=34, I^2=99%; p<0.005), respectively. Pre-frailty was the same for males and females for the FI (appendix).

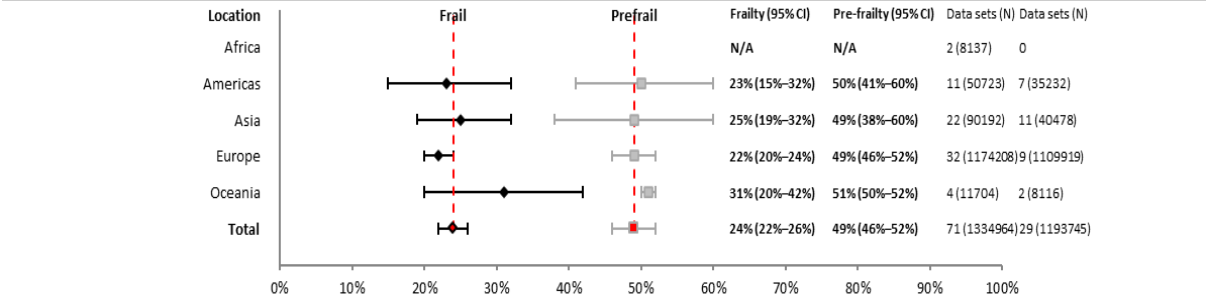
Geographical location

By region, the highest frailty prevalence for physical frailty was reported in Africa 22% (95% CI=10-37%; n=5, I^2=99%; p<0.005) and the Americas 17% (95% CI=15-19%; n=60, I^2=99%; p<0.005) and the lowest in Europe 8% (95% CI=7-10%; n=60, I^2=99%; p<0.005). For the deficit accumulation model, the highest frailty prevalence was in Oceania 31% (95% CI=20-42%; n=4, I^2=99%; p<0.001) and the Americas 25% (95% CI=16-35%; n=10, I^2=100%; p<0.001) and the lowest value was again for Europe 19% (95% CI=16-21%; n=9, I^2=100%; p<0.001). Estimates for frailty and pre-frailty according to the physical frailty and deficit accumulation models by UN region are summarised as forest plots in figure 4. Results by country are presented in supplementary table 1 (appendix).

Figure 4. Frailty and pre-frailty prevalence estimates and number of participants (N) by UN regions (Minimum age 50 years) for (a) physical frailty (b) and the deficit accumulation model (frailty index).



(a)



(b)

Additional analyses

We also examined data (46 data points; 175,555 participants) from studies that were considered nationally-representative. This gave a frailty estimate of 7% (95% CI=5-9%; n=46, I^2=100%; p<0.005) and pre-frailty estimate of 43% (95% CI=40-46%; n=43, I^2=99%; p<0.005) for physical frailty. These were 24% (95% CI=22-26%; n=44, I^2=100%; p<0.005) and 47% (95% CI=44-50%; n=14, I^2=100%; p<0.005), respectively, for studies using a FI. We then investigated cohort effects. This showed that for studies using physical models, frailty prevalence increased marginally in the period after 2012 from 12% (95% CI=10-13%; n=111, I^2=99%; p<0.005) to 13% (95% CI=11-15%; n=63, I^2=99%; p<0.005). This was similar for studies using a FI, increasing from 24% (95% CI=22-26%; n=62, I^2=100%; p<0.005) to 28% (95% CI=17-41%; n=8, I^2=100%; p<0.005). Examining data for both physical frailty and FIs by sampling method and frame, showed that the prevalence of both frailty and pre-frailty were higher in studies using non-probability sampling and health-related databases or other sources (appendix).

Discussion

This paper provides prevalence proportions for adults aged ≥50 included in population-level studies from 62 countries/territories for the two most commonly used approaches to classify frailty, generating an overall estimate of 12% (11%-13%) for physical frailty and 24% (22%-26%) for the deficit accumulation model. For pre-frailty the overall estimates were 46% (45%-48%) and 49% (46%-52%) for physical frailty and deficit models, respectively. This study highlights that proportions are consistently lower in population-based studies when measuring physical frailty and that although complementary, these models measure different constructs and are not interchangeable [39]. The tendency for FIs to produce higher estimates than measures of physical frailty likely relates to conceptual differences; FIs represent risk profiles of classified conditions that accumulate over time whereas physical frailty captures signs and symptoms that more-clearly differentiate between frailty and disability [39]. While multiple studies (n=240) were available (265 unique data points), most were reported after 2012 when the last systematic review published proportions of 10.7% for frailty and 41.6% for pre-frailty for all scales among community-dwellers aged ≥65 years [11]. By comparison, examining studies with similar samples, this meta-analysis showed higher estimates of 16% and 45%, respectively. While it is probable that the difference reflects the more extensive data available rather than a true increase in frailty over time, heterogeneity between studies precludes a definitive conclusion. Although some studies have found evidence for cohort effects [40], our temporal sub-analysis found little change in frailty prevalence since 2012, apart from a slight increase among studies using FIs.

Examining prevalence by region, using measures of physical frailty, prevalence was highest in Africa (22%) and lowest in Europe (8%). For studies using the FI, frailty was highest in Oceania (31%), followed by Asia (25%), the Americas (23%) and Europe (22%). While this is the first study to present regional prevalence estimates for the two main classification approaches, these results are similar to large population-based studies. The Survey of Health, Ageing and Retirement in Europe (SHARE), which made up a large proportion of European data points, found an overall frailty prevalence of 7.7% using the frailty phenotype [36].

However, few data and heterogenous samples were available for LMIC, particularly using the FI. For example, proportions ranged from 17.3% in Tanzanian adults aged ≥60 applying the phenotype [41] to 38% in South Africa [42] and Ghana [42] using the FI in those aged ≥50. Results also varied within countries depending on the frailty classification and setting with a study conducted in rural South Africa finding a prevalence of 5.7% among those aged ≥50 using the frailty phenotype [43]. Although lower estimates would be expected in Africa, the region is now experiencing rapid urbanisation, demographic change and high proportions of frailty in middle-aged cohorts (≥40 years)[43]. Epidemiological transitions in LMICs, where frailty prevalence may be higher in younger age cohorts due in part to improved survival amongst HIV patients [44], are also to be expected.

As expected prevalence increased with age, albeit the correlation was weak. Prevalence based on age at study entry increased for each stratum but this gradient was less evident for studies using a FI. This may reflect the smaller number of studies available with higher age cut-offs, particularly for the FI. Further, age at entry is only an crude estimate of each cohort's true age profile. The results also reaffirm higher prevalence of frailty and pre-frailty among females, consistent with other studies [11,20,45], which may relate to survival effects that result in a greater accumulation of frailty-associated deficits over time [45]. Higher quality, nationally-representative studies, while limited in number (n=46), produced a lower prevalence for measures of physical frailty but not FIs. This may relate to selection, sampling and participation bias inherent to less rigorous and less representative sampling and an over-reporting and reduced reliability of symptoms when questionnaires rather than objective measures are used to record physical frailty. For similar reasons, there were differences in prevalence according to the sampling strategy and frame with proportions lower for studies using probability sampling and registers as the sampling frame, irrespective of frailty classification.

Overall, this study highlights that instrument selection influences prevalence proportions. This is exemplified by the single study from Romania measuring frailty with the GFI, which reported a prevalence of 75% [34]. The GFI and similar scales likely over-estimate frailty as shown by a pooled prevalence of 51% from seven studies. It is also important to appreciate that frailty and pre-frailty are inherently heterogenous, associated with multiple pathologies and impairments [46]. The results also highlight the limited data available, supporting the need for more robust epidemiological data. Although the generally high prevalence of frailty and pre-frailty suggest that screening at population-based would have a high yield, benefits can only be realized if acceptable instruments and treatments are used [47,48]. However, as few high-quality randomised studies are yet published, the risk- benefit ratio remains unclear [49].

Limitations

This study has some limitations. While we planned to conduct a review of global frailty prevalence, limited data from only 62 countries were available. Many countries had little or no data available, particularly in developing regions, making meta-analysis and international comparisons difficult. Hence, data may not be representative of each country or region. To address this, we examined those that used nationally-representative data in a sub-analysis but found high levels of heterogeneity among these studies too in terms of setting, sampling

approach, response rates and participant characteristics as reflected in the I^2 values. This was expected based on previous studies [12-14], which have shown similar heterogeneity. Without individual-level data, exploring the true underlying differences between samples is difficult, though our subgroup analysis highlighted sources including differences in age, sex and frailty classification. While minimum age cut-offs were used to define the study inclusion, there may still be substantial differences in the age distribution of the samples, and age-weighted estimates were not used. This also holds true for sex. The current lack of a consensus definition [50] and the inherent differences between physical frailty and accumulation of deficits classifications [39], suggests that both models should be applied in population studies. Few papers (n=16) report both models in the same study. In addition, frailty cut-offs, while similar, were not necessarily identical, potentially adding to the heterogeneity.

Determining whether a study is truly population-based, reflecting the burden of a health-related condition is itself inherently challenging as strict definitions of population-level and nationally-representative designs are lacking. To minimise selection bias and establish accurate prevalence proportions, studies should aim to include all individuals resident in clearly defined geographical areas with the exclusion of non-residents [51]. Some studies might not have been identified in the search. To minimise this, we performed citation and reference tracking. Inability to extract some information due to the publication of percentages without numbers occurred in some cases with stratified results and we recommend that future studies provide the number of people in each strata. Finally, the critical appraisal tool used reflects available data in the journal publications and is liable to reporting bias. This may have allowed less high-quality studies to be included.

Conclusions

This study provides the best available estimates of population-level frailty and pre-frailty prevalence according to the two most commonly used approaches to classify frailty (physical frailty and deficit accumulation models), from 62 countries around the world. The results while showing marked variations between countries and territories, reflect the heterogenous and limited data available with few derived from high-quality, nationally-representative samples. Insufficient data were available from many regions, particularly LMIC, suggesting the need for more research in these countries and a more homogenous approach to the conduct and reporting of prevalence studies. Given the expected ageing of societies around the world, the high prevalence of frailty at population-level should be considered when planning future health and social care policies and services, particularly those targeting prevention and early intervention.

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Notes

Supplement (appendix)

Supplemental references

eTable 1. PRISMA Checklist.

eTable 2. Characteristics of all population-based studies.

eTable 3. Frailty and pre-frailty prevalence estimates by location (country, United Nations economic areas and continent).

eTable 4. Frailty and pre-frailty prevalence estimates by sampling approach (probability vs non-probability) and sampling frame.

eTable 5. Frailty and pre-frailty estimates grouped by sex.

eTable 6. Results of the critical appraisal.

eTable 7. Search strategy.

eTable 8. Inter-rater reliability testing.

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