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Review

The prevalence of frailty and pre-frailty among geriatric hospital inpatients and its association with economic prosperity and healthcare expenditure: A systematic review and meta-analysis of 467,779 geriatric hospital inpatients

Paul Doody [a,b,c,*], Evans A. Asamane [a,d], Justin A. Aunger [a,e], Bridgitte Swales [a,f], Janet M. Lord [g,h], Carolyn A. Greig [a,g,h], Anna C. Whittaker [a,f]

[a] School of Sport, Exercise, and Rehabilitation Sciences, University of Birmingham, United Kingdom
[b] The Irish Longitudinal Study on Ageing, School of Medicine, Trinity College Dublin, Dublin 2, Ireland
[c] Mercer's Institute for Successful Ageing, St. James Hospital, Dublin 8, Ireland
[d] Institute of Applied Health Research, University of Birmingham, United Kingdom
[e] School of Health Sciences, University of Surrey, United Kingdom
[f] Faculty of Health Sciences and Sport, University of Stirling, United Kingdom
[g] MRC-Versus Arthritis Centre for Musculoskeletal Ageing Research, Institute of Inflammation and Ageing, University of Birmingham, United Kingdom
[h] NIHR Birmingham Biomedical Research Centre, University Hospitals Birmingham NHS Foundation Trust and the University of Birmingham, United Kingdom

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ABSTRACT

Background: Frailty is a common and clinically significant condition among geriatric populations. Although well-evidenced pooled estimates of the prevalence of frailty exist within various settings and populations, presently there are none assessing the overall prevalence of frailty among geriatric hospital inpatients. The purpose of this review was to systematically search and analyse the prevalence of frailty among geriatric hospital inpatients within the literature and examine its associations with national economic indicators.

Methods: Systematic searches were conducted on Ovid, Web of Science, Scopus, CINAHL Plus, and the Cochrane Library, encompassing all literature published prior to 22 November 2018, supplemented with manual reference searches. Included studies utilised a validated operational definition of frailty, reported the prevalence of frailty, had a minimum age $\geq$ 65 years, attempted to assess the whole ward/clinical population, and occurred among hospital inpatients. Two reviewers independently extracted data and assessed study quality.

Results: Ninety-six studies with a pooled sample of 467,779 geriatric hospital inpatients were included. The median critical appraisal score was 8/9 (range 7–9). The pooled prevalence of frailty, and pre-frailty, among geriatric hospital inpatients was 47.4% (95% CI 43.7–51.1%), and 25.8% (95% CI 22.0–29.6%), respectively. Significant differences were observed in the prevalence of frailty stratified by age, prevalent morbidity, ward type, clinical population, and operational definition. No significant differences were observed in stratified analyses by sex or continent, or significant associations between the prevalence of frailty and economic indicators.

Conclusions: Frailty is highly prevalent among geriatric hospital inpatients. High heterogeneity exists within this setting based on various clinical and demographic characteristics. Pooled estimates reported in this review place the prevalence of frailty among geriatric hospital inpatients between that reported for community-dwelling older adults and older adults in nursing homes, outlining an increase in the relative prevalence of frailty with progression through the healthcare system.

1. Introduction

Frailty is a multi-dimensional and dynamic condition, theoretically defined as a state of increased vulnerability, resulting from age-associated declines in reserve and function across multiple physiologic systems such that the ability to cope with every day or acute stressors is

* Correspondence to: The Irish Longitudinal Study on Ageing (TILDA), School of Medicine, Trinity College Dublin, Dublin 2, Ireland.
E-mail address: doodyp@tcd.ie (P. Doody).

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compromised (Xue, 2011). Although declines in physiological reserve are associated with senescence in the normal ageing process, frailty is an extreme consequence of this process, where this decline is accelerated and homeostatic responses begin to fail (Ferrucci et al., 2002; Taffett, 2003). Frailty is a common and clinically significant condition amongst geriatric populations, predominantly due to its association with adverse health outcomes, such as hospitalisation, disability, and mortality (Clegg et al., 2013; Fried et al., 2001; Gill et al., 2006; Rodriguez-Mañas, Fried, 2015; Shamliyan et al., 2012; Sourial et al., 2013; Sternberg et al., 2011).

Although there are systematic reviews and meta-analyses assessing the prevalence of frailty amongst community-dwelling older adults (Collard et al., 2012; He et al., 2019; Kojima et al., 2017; Melo et al., 2020; Siriwardhana et al., 2018; Verlaan et al., 2017), nursing home residents (Kojima, 2015), older individuals with cardiovascular disease (Marinus et al., 2021), cancer (Handforth et al., 2015), diabetes (Hanlon et al., 2020), and general surgery patients (Hewitt et al., 2015), presently there are no well-evidenced pooled estimates of the overall prevalence of frailty among geriatric hospital inpatients. There are, however, several studies which have primarily aimed to produce estimates of the prevalence of frailty within this population (Andela et al., 2010; Ekerstad et al., 2011; Hewitt et al., 2015; Joosten et al., 2014; Khandelwal et al., 2012; Le Maguet et al., 2014; Oliveira et al., 2013; Purser et al., 2006). Through preliminary analysis of these existing studies, depending on the criteria utilised, the prevalence of frailty among geriatric hospital inpatients appears to range widely from 27–94%. In the five of the eight studies which utilise the Fried frailty phenotype as the operational definition of frailty (Fried et al., 2001), there is a narrower range (27–48.5%); with a mean prevalence of frailty across the five studies of 37.5 ± 6.8% (Doody, Lord et al., 2019; Joosten et al., 2014; Khandelwal et al., 2012; Le Maguet et al., 2014; Oliveira et al., 2013; Purser et al., 2006).

Recently, a scoping review reported a median frailty prevalence of 49% (range 34–69%) in acute care hospital settings (Theou et al., 2018). However, this review had a number of methodological limitations, including the inclusion of the entire sample of any study with a single participant ≥ 65 years, where up to 50% of the sample were not hospital inpatients, and studies that did not report on the method of frailty assessment. Similarly, a recently published systematic review and meta-analysis which examined the prevalence of pre-frailty and frailty together among hospitalised older adults, in studies which also assessed undernutrition risk, found a mean prevalence of 84%, but with limited data from only 11 studies (n = 2,725 patients) eligible for meta-analysis (Ligthart-Melis et al., 2020).

Consequently, there is an evident need for more robust and comprehensive research to thoroughly assess the prevalence of frailty within the overall population of geriatric hospital inpatients. This constitutes an important gap in the literature, which needs to be addressed, with an enhanced understanding regarding the prevalence of a condition within a specific setting, providing a number of potential consequential utilities. These include the enhanced ability to contribute to improvements in the planning and orientation of organisational structures and resources, to meet the needs of populations. This is particularly true regarding the ability to tailor services within settings to the needs of service users. For example, specifically with regard to frailty among geriatric hospital inpatients, the potential implementation of exercise rehabilitation treatments within this setting for this cohort; with physical activity and exercise being proposed as potentially offering the best form of treatment for frail older adults (Theou et al., 2011). Moreover, exercise has been shown to be capable of reducing, and even reversing frailty within older adults, and reversing functional decline associated with hospitalisation among acute geriatric inpatients (Fiatarone et al., 1994; Martínez-Velilla et al., 2018; Tarazona-Santabalbina et al., 2016).

As such, the purpose of this review was to systematically search and analyse the prevalence of frailty among geriatric populations (aged ≥ 65 years) within inpatient hospital settings within the literature. If a meta-analysis proved possible, the aim of this review was also to synthesise pooled estimates of the prevalence of frailty and pre-frailty, as well as the prevalence of frailty stratified by age, sex, operational frailty definition, prevalent morbidities, ward type, clinical population, and geographic location, among geriatric hospital inpatients. Additionally, this review examined the association between the prevalence of frailty among geriatric hospital inpatients, and gross domestic product (GDP) per capita purchasing power parity (PPP) and health care expenditure per capita PPP. Preliminary research into these areas have shown frailty in the community to be correlated with economic indicators (Theou et al., 2013), but note that more research is needed in this regard to better understand this relationship.

2. Methods

This systematic review and meta-analysis was designed and conducted in accordance with PRISMA standards (Moher et al., 2009; Page et al., 2021). A comprehensive review protocol was developed and adhered to for all steps of this review, and has been published as a protocol paper elsewhere (Doody, Aunger et al., 2019).

2.1. Data sources and searches

Searches were conducted on the platforms of Ovid (incorporating the databases of Journals @Ovid full text, EMBASE, CAB abstracts, Ovid MEDLINE® In process and other non-indexed citations, Ovid MEDLINE®, and PsycINFO), and Web of Science (incorporating the databases of Science Citation Index Expanded (SCI-Expanded), Conference Proceedings Citation Index – Science (CRI-S), and Emerging Sources Citation Index (ESCI)), and the databases of CINAHL Plus, Scopus, and the Cochrane Library databases (the Cochrane Database of Systematic Reviews (CDSR), the Cochrane Central Register of Controlled Trials (CENTRAL), the Cochrane Methodology Register (CMR), the Database of Abstracts of Reviews of Effect (DARE), Health Technology Assessment database (HTA) and the NHS Economic Evaluation Database (EED)), encompassing all available literature published prior to 22/11/2018 (Appendix 1), and supplemented with manual reference searches of all included articles.

2.2. Study selection

Inclusion criteria required studies to have: a minimum age of ≥ 65 years; utilised a clearly defined and validated operational definition for the classification of frailty (i.e., one which takes into consideration the multi-dimensional nature of the condition, and has been specifically validated for the assessment of frailty; either through comparison with existing validated frailty tools, or its predictive value regarding negative health outcomes associated with frailty); either assessed (or attempted to assess) the whole ward, department, unit, hospital, or specific clinical population, or employed some form of randomised selection of participants; occurred within a hospital setting, in, or including, hospital inpatients (operationally defined as any patient admitted to hospital who remains overnight, or were initially expected to remain overnight), and; report the prevalence of frailty or provide sufficient data to allow its calculation. If a study examined a mixed cohort, only data pertaining to hospital inpatients were included in this review. Exclusion criteria were all studies whose full text was not available in the English language, and studies where the sample were not hospital inpatients (i.e., outpatients, day patients, or community-dwelling individuals).

Prior to the commencement of title and abstract screening by three independent reviewers (PD, EA, and JA), duplicates were removed using EndNote (VX 8.2). The succeeding reduced list of studies was further manually screened for the removal of any remaining duplicates. All reviewers were provided with an instructional screening form, and a .ris file containing all studies captured within the platform and database searches. This screening form outlined the eligibility criteria and

instructions on setting up the file for screening within a reference manager (Appendix 2).

The title and abstract of all studies were independently screened by the three reviewers, with each reviewer placing potentially eligible studies into a separate folder. On completion, potentially eligible studies from all three reviewers were placed into a 'master folder' and the results collated. Duplicates were removed, leaving the final combined list of studies for the full text screening phase. All reviewers independently screened the full text of remaining studies utilising the screening form and maintained separate files for included and excluded studies (including reasons), as well as for studies for which they believed there was need to contact the authors for clarification or additional information.

On completion, a full text screening master file was formulated by the lead reviewer displaying each reviewer's full text screening decision for each study (Appendix 3). All three reviewers subsequently met to discuss the decisions of each study and endeavoured to come to an agreement on studies for which there was not initial unanimous consensus. During this process, a full list of included (Appendix 3) and excluded studies (with reasons) (Appendix 4), and studies for which reviewers agreed to contact authors for additional information or clarification (Appendix 5) was formed by the lead reviewer. Subsequently, the lead reviewer contacted the relevant study authors and, on receipt of clarification or additional information, forwarded this information to the two other reviewers for independent assessment. All reviewers subsequently met to further discuss and come to resolution on the eligibility of all such studies (Appendix 5).

Manual screening was also employed by reviewers and included the reference lists of all included studies, as well as excluded but potentially relevant studies or systematic reviews captured within the screening. As part of the grey literature search of this review, in process publications were also searched and conference abstracts followed up with authors to ascertain if full text's relating to these data were available. Studies of the same cohort were included only once, specifically, the study which provided the most information about the cohort relevant to this review. In the event two or more studies reported an identical quantity of data relevant to the review, the study which was published first was given precedence for inclusion.

2.3. Data extraction and quality assessment

Data extraction of eligible studies was performed by two reviewers (PD and BS) independently. In the event of any discrepancies between the two reviewers, an attempt was made to reach a consensus by discussion. A contingency plan was in place, regarding obtainment of the opinion of a third reviewer, in the event that a full consensus could not be reached between the two reviewers after an exhaustive discussion, with the majority consensus taken. However, ultimately, this contingency plan was not utilised, as both reviewers came to agreement after discussion in all cases.

The following data, where available, were extracted from all eligible studies. If any data were not immediately available, the authors of these studies were contacted in an attempt to retrieve all applicable data:

Study details: authors, year of publication, study title, journal of publication, and aim. Study methods: setting, ward/department/unit/hospital type, clinical population, study design, recruitment duration, subject characteristics (age of participants (mean and standard deviation, range)), sex (proportion of male/female participants), country/continent, sample size, diagnosis/prevalent morbidity (if applicable), any other relevant characteristics, criteria utilised for the operational definition of frailty. Results: Number of frail participants, number of pre-frail participants, number of robust/non-frail participants, prevalence of frailty, prevalence of pre-frailty, prevalence of robustness/non-frailty, number of male participants, number of frail male participants, number of pre-frail male participants, number of non-frail/robust male participants, prevalence of frailty in male participants, prevalence of pre-frailty in male participants, prevalence of non-frailty/robustness in male participants, number of female participants, number of frail female participants, number of pre-frail female participants, number of non-frail/robust female participants, prevalence of frailty in female participants, prevalence of pre-frailty in female participants, prevalence of non-frailty/robustness in female participants, and finally authors' and reviewers' comments (Appendix 6).

External to the studies, data were additionally extracted with regard to the 5-year average GDP per capita PPP (current international $) of the country in which each study was conducted, incorporating the 5 years directly preceding the commencement of recruitment to the study (International Monetary Fund, 2019). External data were also extracted with regard to the 5-year average healthcare expenditure per capita PPP (current international $) of the country in which each study takes place, incorporating the 5-years directly preceding the commencement of recruitment to the study (World Health Organisation, 2019). Each calendar year of the study was also included provided recruitment continued through to $>$ 6 months in the preceding year (Appendix 6).

The quality of eligible studies was independently assessed by two reviewers (PD and EA) using the Joanna Briggs Institute critical appraisal tool for studies reporting prevalence data (Munn et al., 2015) (Appendix 7). In the event of any discrepancies between the two reviewers, an attempt was made to reach a consensus by discussion. Similar to the process for data extraction, a contingency plan was in place to obtain the opinion of a third reviewer, in the event a consensus could not be reached, with the proceeding majority consensus taken as final. However, ultimately this contingency plan was not utilised, as the two reviewers came to successful resolution in all cases.

2.4. Data synthesis and analysis

2.4.1. Quantitative synthesis (meta-analysis)

Where a sufficient quantity of identified studies were comparable, meta-analysis, pooling the aggregated data from each study, was performed using Review Manager (RevMan) version 5.3 (The Nordic Cochrane Centre - The Cochrane Collaboration, 2014). Clinical heterogeneity was assessed by two reviewers based on their judgement of the available data, and any disagreements discussed thoroughly with the aim of reaching unanimous consensus, which occurred in all cases. Statistical heterogeneity was assessed through the utilisation of a Cochran Q test and considered present at $p < 0.05$ (Higgins and Thompson, 2002). An I^2 test was performed to assess the magnitude of this heterogeneity, with I^2 values of 25%, 50%, and 75% being considered low, moderate, and high, respectively (Higgins et al., 2003). Where the Cochran Q statistic test detected statistically significant heterogeneity, combined with the researcher's assessments concluding that variation in effect size between studies could not be fully explained by the sampling error within each study, i.e., that the true effect-size was not identical for all studies, a randomised-effects model was utilised (Borenstein et al., 2010).

Stratified analysis was also conducted according to age (65–74 years, 75–84 years, and 85 + years), sex, operational frailty definition, ward type, prevalent morbidity, clinical population, and geographic location (country and continent) where possible. These variables were specifically chosen for stratified analysis due to an enhanced knowledge of these areas being of practical utility to researchers and clinicians; stemming from empirical evidence persistently showing variation in these factors to impact on the prevalence of frailty (Andela et al., 2010; Purser et al., 2006; Santos-Eggimann et al., 2009). As such, stratified analysis facilitated provision of a more in-depth and thorough insight into the prevalence of frailty among geriatric patients within this setting.

Clinical heterogeneity for stratified analysis was assessed by two reviewers based on their judgement of the available data. Any initial disagreements were discussed thoroughly, with a unanimous consensus reached in all cases. Statistical heterogeneity for stratified analysis was assessed as above through the utilisation of Cochran Q tests, with I^2 tests

performed to assess the magnitude of this heterogeneity (Higgins and Thompson, 2002; Higgins et al., 2003). All pooled estimates of the prevalence of frailty were reported with 95% confidence intervals.

Correlation analysis was also employed to examine the relationship between the prevalence of frailty among geriatric hospital inpatients and economic prosperity (GDP per capita PPP) (current international $), and healthcare expenditure (per capita PPP) (current international $). In addition, multi-linear regression analysis was employed to examine the predictive value between economic prosperity and healthcare expenditure and the prevalence of frailty among geriatric inpatients, using IBM Statistical Package for Social Sciences (SPSS) version 27 (IBM Corp, 2020).

2.4.2. Qualitative synthesis

A brief systematic narrative analysis of all outcomes was also performed, with findings presented in both textual and tabular formats.

2.5. Role of the funding source

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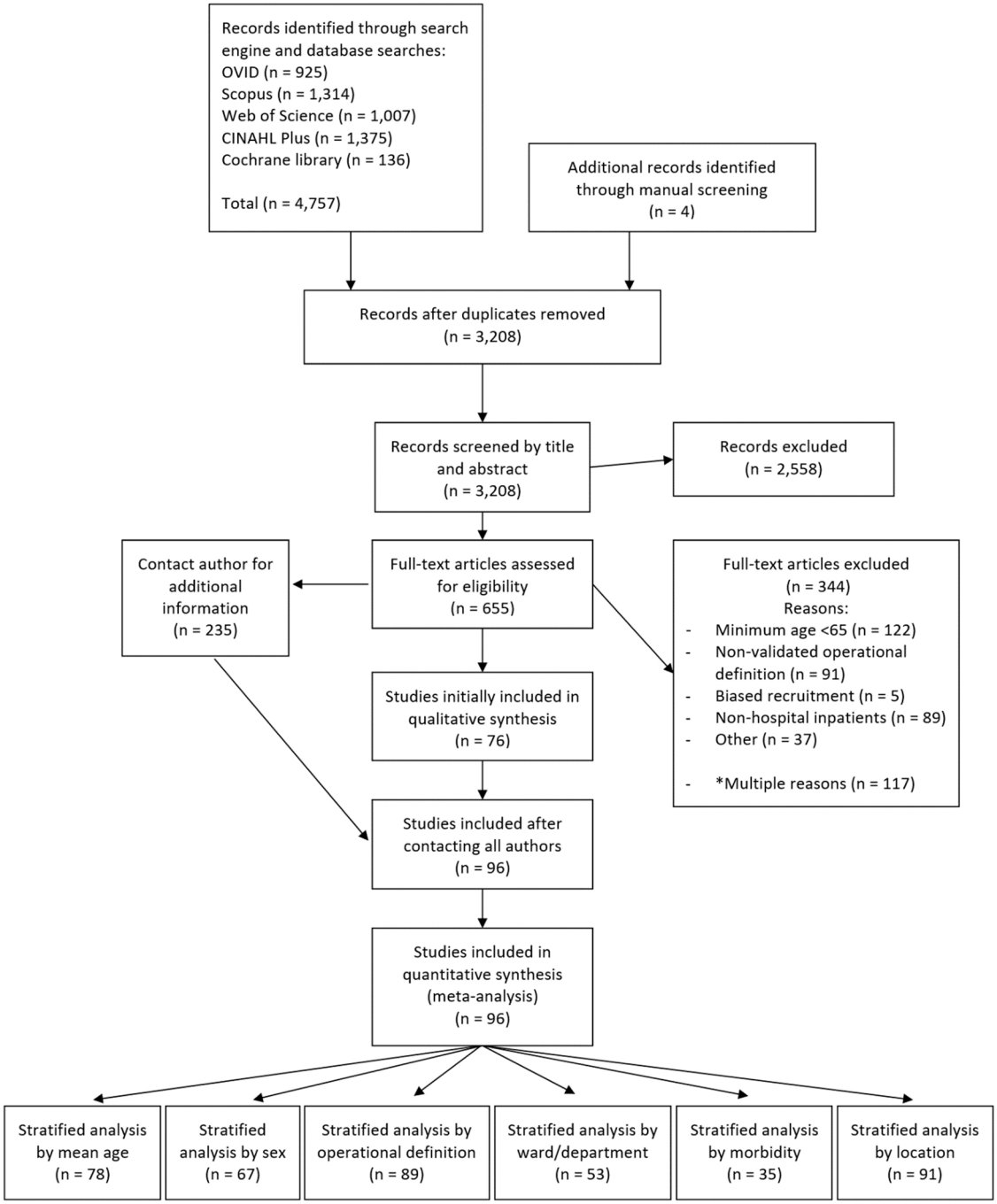

Fig. 1. PRISMA flow diagram of systematic review and meta-analysis process.

3. Results

Systematic searches yielded a combined total of 4,757 results, of which 1,549 were removed as duplicates. Four additional articles were identified within the reference list of included studies during manual screening. The remaining 3,208 articles were screened by title and abstract by the three independent reviewers and the results collated, leaving 655 studies for full text screening. 344 of these articles were initially excluded due to ineligibility: minimum age < 65 years (n = 122); utilisation of a non-validated operational definition for the classification of frailty (n = 91); sample were not hospital inpatients at the time of frailty assessment (n = 89); did not assess (or attempt to assess) the entire ward/clinical population or employ some form of randomised selection of participants (n = 5); other reasons (predominantly duplicate cohorts) (n = 37); multiple (combination of the above reasons) (n = 117).

A further 235 studies screened by full text were deemed to not be initially possible to definitively include or exclude based on available data. As such it was agreed by the three reviewers to contact the study authors for additional information or clarification regarding eligibility. The corresponding author of all 235 studies was contacted via email by the lead reviewer to obtain the relevant additional data, or clarification, to facilitate inclusion / exclusion. A response was received from 99 of the 235 corresponding authors. Of the 136 studies without an initial response from the corresponding author, a second author (typically first or senior author) of all 136 studies were contacted by the lead reviewer, a minimum of 14-days after the initial inquiry to corresponding authors. A response was received for 37 of these 136 studies, giving a combined response rate of 57.9% (n = 136) for the 235 studies. Ultimately this process resulted in an additional 20 studies being deemed eligible for inclusion in the review, resulting in 96 eligible studies in total (Fig. 1). However, this process did add considerably to the timeline for this review beyond the initial search period. (All inquiries to study authors, and responses received are detailed in Appendix 5).

Of these 96 eligible studies, only four initially reported the full range of data sought for stratified analysis. The corresponding author of the remaining 92 studies were contacted in an attempt to obtain these data. If a response was not received within 14-days, a second author was contacted. This process resulted in successful obtainment of additional data for 58 of the 92 studies with initially incomplete data for all elements of stratified analysis (All inquiries to study authors, and responses received are detailed in Appendix 5).

A detailed list of all 96 included studies, reporting selected relevant study characteristics is displayed in Table 1:

3.1. Methodological quality assessment

The median score of the Joanna Briggs Institute critical appraisal tool for studies reporting prevalence data for the 96 included studies was 8 out of 9 (range 7–9) (Appendix 7).

3.2. Pooled prevalence of frailty and pre-frailty

Ninety-six studies, comprising of data from of n = 467,779 geriatric hospital inpatients, were eligible for inclusion in the overall pooled prevalence analysis of frailty (Alonso Salinas et al., 2018; Amblàs-Novellas et al., 2018; Andela et al., 2010; Andrew et al., 2017; Attisano et al., 2017; Baldwin et al., 2014; Blanco et al., 2017; Bo et al., 2015; Bo et al., 2016; Cheung et al., 2017; Chew et al., 2017; Chia et al., 2016; Chong et al., 2017; Coleman et al., 2012; Courtney-Brooks et al., 2012; Crozier-Shaw, Joyce, 2018; Dal Moro et al., 2017; Dent et al., 2014; Dorner et al., 2014; Drudi et al., 2018; Dutzi et al., 2017; Eamer et al., 2018;; Eeles et, al., 2012; Ekerstad et al., 2011; Engelhardt et al., 2018; Ferrero et al., 2017; Ga et al., 2018; Gleason et al., 2017; Goldfarb et al., 2018; Guidet et al., 2018; Gullón et al., 2018; Hartley et al., 2017; Heppenstall et al., 2011; Hewitt et al., 2015, 2016; Hii et al., 2014; Hilmer et al., 2011; Ibrahim et al., 2019; Induruwa et al., 2017; Jacobs et al., 2017; Jokar et al., 2016; Joosten et al., 2014; Joseph et al., 2014, 2016; Juma et al., 2016; Kang et al., 2015; Karlekar et al., 2017; Keevil et al., 2018; Kenig et al., 2015; Khan et al., 2019; Kobe et al., 2016; Koyama et al., 2018; Kusunose et al., 2018; Le Maguet et al., 2014; Lee et al., 2018; Lin et al., 2017; Llaó et al., 2018; Ma et al., 2013; Madni et al., 2018; Martín et al., 2018; Mason et al., 2018; Maxwell et al., 2018; McGuckin et al., 2018; McIsaac et al., 2019; Morton et al., 2018; Muessig et al., 2018; Müller et al., 2017; Myint et al., 2018; Nguyen et al., 2016; Nolan et al., 2016; Oliveira et al., 2013; Öztürk et al., 2017; Papageorgiou et al., 2018; Papakonstantinou et al., 2018; Parmar et al., 2019; Pasqualetti et al., 2018; Patel et al., 2018; Peel et al., 2017; Pelavski et al., 2017; Perera et al., 2009; Pollack et al., 2017; Poudel et al., 2016; Purser et al., 2006; Ritt et al., 2015; Rose et al., 2014; Sánchez et al., 2011; Sanchis et al., 2015;; Sikder et al., 2019; Sündermann et al., 2014; Thai et al., 2015; Ticinesi et al., 2016; Timmons et al., 2015; Valentini et al., 2018; Vidán et al., 2014; Wallis et al., 2015; Wou et al., 2013); 62 studies, comprising of data from n = 35,348 geriatric hospital inpatients in the overall pooled prevalence analysis of pre-frailty (Alonso Salinas et al., 2018; Amblàs-Novellas et al., 2018; Andrew et al., 2017; Baldwin et al., 2014; Blanco et al., 2017; Cheung et al., 2017; Chong et al., 2017; Coleman et al., 2012; Courtney-Brooks et al., 2012; Dal Moro et al., 2017; Dent et al., 2014; Dorner et al., 2014; Dutzi et al., 2017; Eamer et al., 2018; Ekerstad et al., 2011; Ga et al., 2018; Gleason et al., 2017; Guidet et al., 2018; Hartley et al., 2017; Heppenstall et al., 2011; Hewitt et al., 2015; Hewitt et al., 2016; Hii et al., 2014; Ibrahim et al., 2019; Induruwa et al., 2017; Joosten et al., 2014; Joseph et al., 2016; Juma et al., 2016; Kang et al., 2015; Karlekar et al., 2017; Keevil et al., 2018; Koyama et al., 2018; Kusunose et al., 2018; Le Maguet et al., 2014; Lin et al., 2017; Ma et al., 2013; Madni et al., 2018; Martín et al., 2018; Mason et al., 2018; Maxwell et al., 2018; McGuckin et al., 2018; Muessig et al., 2018; Müller et al., 2017; Myint et al., 2018; Nolan et al., 2016; Oliveira, Öztürk et al., 2013, 2017; Papageorgiou et al., 2018; Papakonstantinou et al., 2018; Parmar et al., 2019; Pasqualetti et al., 2018; Peel et al., 2017; Pelavski et al., 2017; Pollack et al., 2017; Ritt et al., 2015; Rose et al., 2014; Sanchis et al., 2015; Sikder et al., 2019; Ticinesi et al., 2016; Timmons et al., 2015; Valentini et al., 2018; Wallis et al., 2015). The overall pooled prevalence of frailty and pre-frailty among geriatric hospital inpatients was 47.4% (95% CI 43.7–51.1%), and 25.8% (95% CI 22.0–29.6%) respectively (Fig. 2, Supplementary Figure A).

3.3. Stratified analysis

3.3.1. Sex

Sixty-seven studies, comprising data from n = 246,241 female, and n = 210,471 male geriatric hospital inpatients, were eligible for inclusion in the pooled prevalence analysis of frailty stratified by sex (Alonso Salinas et al., 2018; Amblàs-Novellas et al., 2018; Andrew et al., 2017; Attisano et al., 2017; Baldwin et al., 2014; Blanco et al., 2017; Cheung et al., 2017; Chew et al., 2017; Chong et al., 2017; Coleman et al., 2012; Courtney-Brooks et al., 2012; Dal Moro et al., 2017; Dorner et al., 2014; Dutzi et al., 2017; Eamer et al., 2018; Ekerstad et al., 2011; Engelhardt et al., 2018; Ferrero et al., 2017; Ga et al., 2018; Gleason et al., 2017; Guidet et al., 2018; Hartley et al., 2017; Heppenstall et al., 2011; Hii et al., 2014; Hilmer et al., 2011; Induruwa et al., 2017; Jokar et al., 2016; Joosten et al., 2014; Joseph et al., 2014; Joseph et al., 2016; Juma et al., 2016; Kang et al., 2015; Karlekar et al., 2017; Keevil et al., 2018; Khan et al., 2019; Kobe et al., 2016; Kusunose et al., 2018; Le Maguet et al., 2014; Lin et al., 2017; Martín et al., 2018; Mason et al., 2018; Maxwell et al., 2018; McGuckin et al., 2018; McIsaac et al., 2019; Morton et al., 2018; Muessig et al., 2018; Nguyen et al., 2016; Nolan et al., 2016; Oliveira, Öztürk et al., 2013, 2017; Papakonstantinou et al., 2018; Parmar et al., 2019; Pasqualetti et al., 2018; Patel et al., 2018; Peel et al., 2017; Pelavski et al., 2017; Pollack et al., 2017; Poudel et al., 2016; Purser et al., 2006; Ritt et al., 2015; Sanchis et al., 2015; Sikder

Table 1
Selected characteristics of the 96 included studies.

Author/Year	Study design	Setting	Ward / Clinical population type	Diagnosis / Prevalent morbidity	Age of participants (mean (SD))	Age of participants (range)	Country	Sample size	Criteria utilised for operational definition of frailty	Prevalence of frailty (%)	Prevalence of pre-frailty (%)	Prevalence of robust/non-frail (%)	Prevalence of frailty (males) (%)	Prevalence of pre-frailty (males) (%)	Prevalence of robust/non-frail (males) (%)	Prevalence of frailty (females) (%)	Prevalence of pre-frailty (females) (%)	Prevalence of robust/non-frail (females) (%)
Alonso Salinas et al., 2018	Prospective, observational study	Three tertiary-level hospitals	Patients with acute coronary syndrome (type 1 myocardial infarction)	Acute coronary syndrome (type 1 myocardial infarction)	82.5 ± 5.0*	78-88	Spain	285	SHARE-FI	38.2%	29.8%	31.9%	29.8%	26.9%*	43.3%*	50.9%	34.2%*	14.9%*
Amblàs-Novellas et al., 2018	Prospective, observational, longitudinal study	University hospital of Vic (Barcelona, Spain)	Acute geriatric unit	N/A	86.4 ± 5.6	85+	Spain	590	Frail-VIG index	83.9%	14.6%*	1.5%	82.1%*	16.7%*	2.0%*	85.3%*	13.6%*	1.2%*
Andela et al., 2010	Observational study	Multiple: A large teaching hospital, and a university hospital	Multiple – Five wards of different specialisms	N/A	-	75+	Netherlands	276	Groningen Frailty Indicator (GFI)	73.2%	N/A	26.8%	-	N/A	-	-	N/A	-
As above	*As above*	*A large teaching hospital*	*Geriatric centre*	*N/A*	*83.8 ± 4.7*	*75+*	*As above*	*32*	*As above*	*90.6%*	*N/A*	*9.4%*	-	N/A	-	-	N/A	-
As above	*As above*	*A large teaching hospital*	*Traumatology*	*N/A*	*83.3 ± 5.3*	*75+*	*As above*	*69*	*As above*	*69.6%*	*N/A*	*30.4%*	-	N/A	-	-	N/A	-
As above	*As above*	*A large teaching hospital*	*Pulmonary / Rheumatology*	*N/A*	*79.8 ± 3.2*	*75+*	*As above*	*71*	*As above*	*70.4%*	*N/A*	*29.6%*	-	N/A	-	-	N/A	-
As above	*As above*	*A University hospital*	*Internal medicine*	*N/A*	*81.2 ± 5.1*	*75+*	*As above*	*76*	*As above*	*80.3%*	*N/A*	*19.7%*	-	N/A	-	-	N/A	-
As above	*As above*	*A University hospital*	*Surgical medicine*	*N/A*	*81.1 ± 4.9*	*75+*	*As above*	*28*	*As above*	*50.0%*	*N/A*	*50.0%*	-	N/A	-	-	N/A	-
Andrew et al., 2017	Prospective, multi-centre, test negative case control	38 academic and community sentinel hospitals	Medical and coronary intensive care units (ICUs) and medical wards. Patients with influenza related hospitalisation	Influenza related hospitalisation	-	65+	Canada	505	Frailty Index (39 item)	36.4%	45.3%	18.2%	32.7%	47.6%	19.7%	39.1%	43.8%	17.2%
Attisano et al., 2017	Retrospective observational study	Several transcatheter aortic valve implantation (TAVI) centres	Cardiac surgery patients (trans-catheter aortic valve implantation (TAVI))	Cardiac surgery patients (trans-catheter aortic valve implantation (TAVI))	83 ± 7	80+*	Italy	331	Frailty Index*	54.4%	-	-	N/A	N/A	N/A	54.4%	-	-
Baldwin et al., 2014	Single-centre prospective cohort study	Columbia University medical centre	Medical Intensive Care Unit	Survivors of respiratory failure	77.0 ± 8.9	65-95	United States of America	22	Fried frailty phenotype criteria	81.8%	18.2%	0.0%	86.7%	13.3%	0.0%	71.4%	28.6%	0.0%
Blanco et al., 2017	Prospective observational study	Tertiary care centre at a University Hospital	Patients with Acute Coronary Syndrome (ACS) - Type 1 myocardial infarction	Acute Coronary Syndrome (ACS) - Type 1 myocardial infarction	85.9 ± 3.9	85+	France	236	Adjusted Edmonton Frailty Scale (EFS)	20.8%	28.8%	50.4%	18.9%	27.9%	53.3%	22.8%	29.8%	47.4%
Bo et al., 2015	Prospective observational study	Two large metropolitan university teaching hospitals	Atrial fibrillation patients	Atrial fibrillation	81.7 ± 6.8	65+	Italy	513	Groningen Frailty Indicator (GFI)	83.0%	N/A	17.0%	-	N/A	-	-	N/A	-
Bo et al., 2016	Prospective observational study	Two large metropolitan university teaching hospitals	Eight acute geriatric and medical wards	N/A	81.0 ± 7.3	65+	Italy	1,568	Fried Frailty phenotype criteria	41.4%	-	-	-	-	-	-	-	-
Cheung et al., 2017	Prospective cohort study	Tertiary referral centre	Orthopaedic, cardiothoracic, vascular, or colorectal surgical services	Surgical inpatients	78.0 ± 7.0	65+	Australia	100	Reported Edmonton Frailty Scale (REFS)	33.0%	27.0%*	40.0%*	23.8%	23.8%*	52.4%*	39.7%	29.3%*	31.0%*
Chew et al., 2017	Prospective observational	Tan Tock Seng Hospital, Singapore	Department of Geriatric Medicine, Geriatric Monitoring	Delirium	84.1 ± 7.4	65+	Singapore	234	Frailty Index (FI)	67.9%	-	-	66.7%	-	-	68.9%	-	-

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Table 1 (*continued*)

	cohort study		Unit															
Chia et al., 2016	Prospective study	Khoo Teck Puat Hospital acute hospital, Singapore	Department of general surgery (colorectal surgery patients)	Colorectal surgery	80.4 ± 5.5*	65-97	Singapore	117	Fried Frailty Phenotype	25.6%	-	-	-	-	-	-	-	-
Chong et al., 2017	Prospective cohort study	Tan Tock Seng Hospital, Singapore	Department of geriatric medicine	N/A	89.0 ± 4.6	65+	Singapore	210	Multiple	74.5%	25.2%*	As below	72.7%	25.0%*	As below	75.3%	25.3%*	As below
As above	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*210*	*Frailty Index*	*87.1%*	*-*	*12.9%*	*82.8%*	*-*	*17.2%*	*89.0%*	*-*	*11.0%*
As above	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*210*	*FRAIL scale*	*50.0%*	*41.4%**	*8.6%**	*56.3%*	*34.4%**	*43.8%**	*47.3%*	*44.5%**	*6.8%**
As above	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*210*	*Tilburg Frailty Index*	*80.0%*	*N/A*	*20.0%*	*79.7%*	*N/A*	*20.3%*	*80.1%*	*N/A*	*19.9%*
As above	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*210*	*Clinical Frailty Scale*	*81.0%*	*9.0%**	*10.0%**	*71.9%*	*15.6%**	*28.1%**	*84.9%*	*6.2%**	*2.1%**
Coleman et al., 2012	Prospective observational study	A large urban hospital	Three rehabilitation wards	N/A	82.9 ± 6.4	65+	Ireland	32	Clinical Frailty Scale (CFS)	100.0%*	0%*	0%*	100.0%*	0%*	0%*	100.0%*	0%*	0%*
Courtney-Brooks et al., 2012	Prospective cohort study	Tertiary level hospital	Gynaecologic oncology patients	Gynaecologic cancer	73	65-95	United States of America	37	Fried frailty phenotype	16.2%	27.0%	56.8%	N/A	N/A	N/A	16.2%	27.0%	56.8%
Crozier-Shaw, Joyce, 2018	Prospective cohort study (Retrospective review)	Tertiary referral private institution	Colorectal surgery patients	Benign and malignant colorectal diseases	-	65+	Ireland	206	National Surgical Quality Improvement Program frailty index	20.9%	N/A	79.1%	-	N/A	-	-	-	-
Dal Moro et al., 2017	Prospective observational study	Tertiary level hospital	Urological surgery patients (both endoscopy and open surgery)	Urological surgery (both endoscopy and open surgery)	78.5 ± 3.9	70-94	Italy	78	Edmonton Frailty Scale (EFS)	21.8%	16.7%*	61.5%*	36.4%*	27.3%*	36.4%*	19.4%*	14.9%*	65.7%*
Dent et al., 2014	Prospective, observational study	Queen Elizabeth Hospital, South Australia	Geriatric Evaluation Medical Unit	N/A	-	70+	Australia	172	Study of Osteoporotic Fractures (SOF) index	69.8%	26.2%	4.1%	-	-	-	-	-	-
Dorner et al., 2014	Cross-sectional study	Two hospitals in Vienna; one a University hospital, and one an acute care hospital	Endocrinology and metabolism, and gastroenterology wards	N/A	76.4 ± 8.2*	65-97	Germany	133	SHARE-FI	54.1%	21.8%	24.1%	50.0%	38.3%	11.7%	57.5%	8.2%	34.2%
Drudi et al., 2018	Prospective cohort study	14 medical centres in three countries (United States of America, Canada, and France)	Transcatheter Aortic Valve Replacement (TAVR) and Surgical Aortic Valve Replacement (SAVR) inpatients*	Transcatheter Aortic Valve Replacement (TAVR) and Surgical Aortic Valve Replacement (SAVR) patients	81.4 ± 6.1	70+	Multiple (United States of America, Canada, France)	1,035	Fried Frailty Phenotype criteria	39.8%	-	-	-	-	-	-	-	-
Dutzi et al., 2017	Observational cohort study	Centre for geriatric medicine, University Hospital	Post-acute geriatric rehabilitation centre (two geriatric rehabilitation wards) / patients with mild-moderate dementia	Mild-moderate dementia	83.7 ± 5.9	65+	Germany	154	Clinical Frailty Scale (CFS)	82.5%*	13.0%*	4.5%*	93.1%*	3.4%*	3.4%*	80.0%*	15.2%*	4.8%*
Eamer et al., 2018	Prospective, observational study	Two tertiary referral teaching hospitals	Emergency abdominal surgery patients	Emergency abdominal surgery	75.5 ± 7.6	65-96.5	Canada	150	Clinical Frailty Scale	15.3%	17.3%	60.7%	14.8%*	13.6%*	71.6%*	15.9%*	21.7%*	47.8%*
Eeles et al., 2012	Prospective cohort study	District general hospital	Patients admitted acutely to a general medical service	N/A	82.3 ± 7.5	75+	Australia	273	Frailty Index	40.7%	N/A	59.3%	-	-	-	-	-	-
Ekerstad et al., 2011	Clinical, prospective, observational study	A University Hospital, and two County Hospitals	Patients with non-ST segment elevation myocardial infarction (NSTEMI)	Non-ST-segment elevation myocardial infarction (NSTEMI)	-	75+	Sweden	307	Canadian Study of Health and Ageing (CSHA) Clinical Frailty Scale (7-point)	48.5%	25.4%	26.1%	43.3%	-	-	54.0%	-	-

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Table 1 (*continued*)

Engelhardt et al., 2018	Prospective time series study	An urban academic hospital (Level 1 trauma centre)	Trauma and emergency general surgery patients	N/A	76.1 ± 8.0*	65+	United States of America	239	Trauma Specific and Emergency General Surgery Specific Frailty Indices	29.3%	N/A	70.7%	25.0%*	N/A	75.0%*	32.4%*	N/A	67.6%*
Ferrero et al., 2017	Retrospective multi-centre study	Mauriziano Hospital of Turin the University of Pisa.	Patients with ovarian cancer	Ovarian cancer	-	70-89	Italy	78	modified Frailty Index	29.5%	N/A	70.5%	N/A	N/A	N/A	29.5%	N/A	70.5%
Ga et al., 2018	Retrospective review	Chronic care hospital	Long-term care	Functional impairment and multi-morbidity	81.5 ± 7.2	65+	South Korea	100	Multiple	94.5%*	2.5%*	3.0%*	91.5%*	4.7%*	3.8%*	97.9%*	0.0%*	2.1%*
As above	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*100*	*FRAIL-NH scale*	*89.0%*	*5.0%*	*6.0%*	*83.0%**	*9.4%**	*7.5%**	*95.7%**	*0.0%**	*4.3%**
As above	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*100*	*Frailty index*	*100.0%**	*0.0%**	*0.0%**	*100.0%**	*0.0%**	*0.0%**	*100.0%**	*0.0%**	*0.0%**
Gleason et al., 2017	Retrospective cohort study	Level 1 trauma centre	Geriatric fracture co-management service (orthopaedic, trauma, geriatric services)	Fracture related surgical patients	82.3 ± 7.4	70+	United States of America	175	FRAIL Scale	41.7%	41.7%	16.6%	43.2%	43.2%	13.6%	41.2%	41.2%	17.6%
Goldfarb et al., 2018	A prospective, single-arm, multinational, multicentre observational study	14 medical centres in three countries (Canada, United States of America, and France)	Cardiac surgery (transcatheter aortic valve implementation)	Cardiac surgery (transcatheter aortic valve implementation)	81.8 ± 6.2	80+	Multiple (Canada, United States of America, France)	1,158	Fried frailty phenotype criteria	37.4%	-	-	-	-	-	-	-	-
Guidet et al., 2018	Prospective observational study	39 intensive Care Units in 21 European countries	Intensive Care Unit	N/A	84.3 ± 3.6*	80-102	Multiple (Ireland, Great Britain, Portugal, Spain, France, Belgium, Denmark, Norway, Switzerland, Netherlands, Sweden, Russia, Germany, Austria, Poland, Czech Republic, Italy, Ukraine, Romania, Greece, Cyprus)	5,021	Clinical Frailty Scale	42.9%*	19.4%*	37.7%*	38.5%*	19.5%*	42.0%*	47.8%*	19.2%*	33.0%*
Gullón et al., 2018	An observational, prospective, multicentre study	64 hospitals from all the Spanish regions	Internal Medicine departments	Non-valvular atrial fibrillation	85 ± 5.1	75-101	Spain	755	FRAIL Scale	50.3%	-	-	-	-	-	-	-	-
Hartley et al., 2017	Retrospective observational study	A large tertiary University National Health Service (NHS) acute hospital	Department of Medicine for the Elderly wards	N/A	86 ± 5.8*	70+	United Kingdom	549	Clinical Frailty Scale	77.6%	10.0%*	12.4%*	74.2%	10.5%*	15.3%*	79.4%	9.7%*	10.9%*
Heppenstall et al., 2011	Prospective cohort study	Sub-acute geriatric unit	General wards	Delayed transfer of care	80.9 ± 7.2	66+	New Zealand	158	Edmonton Frailty Scale (EFS)	67.1%*	21.5%*	11.4%*	67.2%*	22.4%*	10.3%*	67.0%*	21.0%*	12.0%*
Hewitt et al., 2015	Multi-centre observational study	Acute general surgical admission units (1 site in each of Wales, England, and Scotland)	Acute general surgical units	Acute general surgery	77.3 ± 8.2	65+	United Kingdom	317	Canadian Study of Health and Ageing (CSHA) scale	27.8%	18.6%	53.6%	-	-	-	-	-	-

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Hewitt et al., 2016	Cross-sectional observational study	A UK-based multicentre hospital study	Emergency general surgery units (Emergency general surgery patients)	Emergency general surgery	-	65-98	United Kingdom	408	Canadian Study of Health and Ageing (CSHA scale)	27.7%	19.9%	52.5%	-	-	-	-	-	-
Hii et al., 2014	Prospective study	Christchurch hospital, New Zealand	Cardiology patients	Percutaneous coronary intervention / cardiac surgery	78 ± 6.1*	72-90	New Zealand	47	Reported Edmonton Frailty Scale (REFS)	19.1%	23.4%*	57.4%*	19.2%	26.9%*	53.8%*	19.0%	19.0%*	61.9%*
Hilmer et al., 2011	Prospective observational study	Three teaching hospitals	Urology inpatients (administered single dose of prophylactic intravenous gentamicin)	Urology inpatients (administered single dose of prophylactic intravenous gentamicin)	77.1 ± 7.1	65+	Australia	31	Reported Edmonton Frailty Scale (REFS)	45.2%	-	-	46.2%	-	-	40.0%	-	-
Ibrahim et al., 2019	Cross-sectional prospective study	A tertiary level hospital	Acute wards	N/A	-	70+	United Kingdom	224	Multiple	40.6%	46.2%	13.2%	-	-	-	-	-	-
As above	*As above*	*As above*	*As above*	*N/A*	-	*As above*	*As above*	*230*	*FRAIL Scale*	*33.5%*	*46.1%*	*20.4%*	-	-	-	-	-	-
As above	*As above*	*As above*	*As above*	*As above*	-	*As above*	*As above*	*218*	*Fried frailty phenotype criteria*	*48.2%*	*46.3%*	*5.5%*	-	-	-	-	-	-
Induruwa et al., 2017	Retrospective observational study	A tertiary teaching hospital	General medicine patients	Atrial fibrillation	85.2 ± 5.6*	75+	United Kingdom	419	Clinical Frailty Scale (CFS)	67.3%	14.3%	18.4%	53.4%*	16.9%*	22.8%*	78.7%*	12.2%*	14.8%*
Jacobs et al., 2017	Explorative cross-sectional study	Inpatient hospital	Psychiatric ward	N/A	72.6 ± 7.6	65+	Netherlands	55	Frailty Index (44 items)	61.8%	-	-	-	-	-	-	-	-
Jokar et al., 2016	Prospective cohort study	Acute care surgery - Level 1 trauma centre	Surgical inpatients	Emergency general surgery patients	74.8 ± 7.8	65+	United States of America	130	Multiple	44.6%	N/A	55.4%	45.3%	N/A	54.7%	43.9%	N/A	56.1%
As above	*As above*	*As above*	*As above*	*As above*	*74.8 ± 7.8*	*As above*	*As above*	*200*	*Frailty Index*	*49.0%*	*N/A*	*51.0%*	*50.0%*	*N/A*	*50.0%*	*47.9%*	*N/A*	*52.1%*
As above	*As above*	*As above*	*As above*	*As above*	*75.4 ± 7.8*	*As above*	*As above*	*60*	*Emergency General Surgery-Specific Frailty Index*	*30.0%*	*N/A*	*70.0%*	*30.3%*	*N/A*	*69.7%*	*29.6%*	*N/A*	*70.4%*
Joosten et al., 2014	Prospective study	Tertiary care hospital	Acute geriatric ward	N/A	-	70+	Belgium	212	Multiple	36.3%	55.4%	8.3%	39.0%	-	-	34.7%	-	-
As above	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*220*	*Fried Frailty Phenotype*	*40.0%*	*58.6%*	*1.4%*	*45.7%*	-	-	*35.7%*	-	-
As above	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*204*	*Study of Osteoporotic Fracture (SOF) Frailty Index*	*32.4%*	*52.0%*	*15.7%*	*32.2%*	*48.3%*	*19.5%*	*32.5%*	*54.7%*	*12.8%*
Joseph et al., 2014	Prospective cohort study	Level 1 trauma centre	Trauma centre	Trauma patients	79 ± 8.1	65+	United States of America	250	Frailty Index	44.0%	N/A	56.0%	43.4%	N/A	56.6%	45.5%	N/A	54.5%
Joseph et al., 2016	Prospective cohort study	Level 1 trauma centre	Trauma centre	Trauma patients	74.8 ± 10.8	65+	United States of America	368	Trauma Specific and Emergency General Surgery Specific Frailty Indices	37.0%	37.8%	25.3%	34.2%	40.0%	25.8%	41.3%	34.3%	24.5%
Juma et al., 2016)	Prospective observational	Acute care university hospital	General internal medicine clinical teaching units	N/A	81.4 ± 8.8	65+	Canada	75	Clinical Frailty Scale	72.0%	6.7%	21.3%	48.1%	7.4%*	37.0%*	85.4%	6.3%*	12.5%*

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	study																	
Kang et al., 2015	Prospective cohort study	Peking Union Medical College Hospital	Cardiology and geriatric departments (inpatients with acute coronary syndrome)*	Acute Coronary Syndrome	74 ± 5.7*	65+	China	352	Canadian Study on Health and Ageing (CSHA) scale	43.2%	18.8%*	38.1%*	60.6%	-	-	19.5%	-	-
Karlekar et al., 2017	Quality improvement project	Vanderbilt University Medical Centre	Trauma intensive care unit	N/A	75.8 ± 8.3*	65+	United States of America	64	FRAIL Scale	37.5%	32.8%	29.7%	31.6%*	31.6%*	36.8%*	46.2%*	34.6%*	19.2%*
Keevil et al., 2018	Retrospective observational study	A National Health Service (NHS) University hospital	University hospital	Emergency admissions	-	75+	United Kingdom	10,662	Clinical Frailty Scale (CFS)	54.0%	17.3%*	28.7%*	48.2%*	18.7%*	33.2%*	58.2%*	16.3%*	25.5%*
Kenig et al., 2015	Prospective study	Tertiary referral hospital	Surgical unit (Emergency abdominal surgery patients)	Emergency abdominal surgery	76.9 ± 5.8	65-100	Poland	184	Multiple	52.2%	-	-	-	-	-		-	-
As above	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*184*	*Groningen Frailty Indicator (GFI)*	*54.3%*	-	-	-	-	-	-	-	-
As above	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*184*	*Rockwood frailty assessment*	*50.0%*	-	-	-	-	-	-	-	-
Khan et al., 2019	Prospective study	Banner University Medical, Centre, Tucson	Trauma centre (Emergency surgery patients)	Emergency general surgery patients	73.9 ± 8	65+	United States of America	326	Emergency General Surgery-Specific Frailty Index	39.0%	-	-	37.4%	-	-	41.0%	-	-
Kobe et al., 2016	Prospective cohort study	Two heart centres in Switzerland and Germany	Heart centres (Transcatheter Aortic Valve Replacement (TAVR) patients)	Transcatheter Aortic Valve Replacement (TAVR) patients	83.3 ± 4.3	75+	Multiple (Switzerland, Germany)	130	Frailty predicts death one yeaR after Cardiac Surgery Test (FORECAST)	54.6%	N/A	45.4%	52.3%	N/A	47.7%	56.9%	N/A	43.1%
As above	*As above*	*As above*	*As above*	*As above*	-	*75+*	*Switzerland*	-	*As above*	-	-	-	-	-	-	-	-	-
As above	*As above*	*As above*	*As above*	*As above*	-	*75+*	*Germany*	-	*As above*	-	-	-	-	-	-	-	-	-
Koyama et al., 2018	Prospective study	St. Marianna University School of Medicine Hospital, Kawasaki	Internal medicine patients	Internal medicine problems	77.2 ± 6.9	65+	Japan	151	Kihon checklist	22.5%	37.7%	39.7%	-	-	-	-	-	-
Kusunose et al., 2018	Prospective study	Tokushima University Hospital	Echocardiography inpatients*	Echocardiography inpatients*	75 ± 7	65+	Japan	191	Fried frailty phenotype criteria	19.9%	61.3%	18.8%	22.7%	60.0%	17.3%	16.0%	63.0%	21.0%
Lee et al., 2018	Cross sectional study	University hospital	Trauma, critical care, and emergency surgery service (Falls patients)	Patients admitted due to ground level falls	78.9 ± 9.1	66+	United States of America	100	Trauma specific frailty index	49%	N/A	51%	-	-	-	-	-	-
Le Maguet et al., 2014	Prospective observational study	Four university-affiliated hospitals	Intensive Care Unit (ICU)	N/A	75 ± 6	65+	France	196	Clinical Frailty Scale (CFS)	23.5%	31.6%	44.9%	21.9%	32.8%*	45.3%*	26.5%	29.4%*	44.1%*
Lin et al., 2017	Prospective cohort study	A tertiary hospital	Surgical patients	Surgical inpatients	79.0 ± 6.5	70+	Australia	246	Frailty Index - Comprehensive Geriatric Assessment (FI-CGA) (57 item)	19.1%	36.6%	44.3%	16.9%	29.7%	53.4%	21.1%	43.0%	35.9%
Llaó et al., 2018	Prospective observational study	44 Spanish hospitals	Non-ST-segment elevation acute coronary syndromes	Cardiac (non-ST-segment elevation acute coronary syndromes patients	84.3 ± 4.0	80+	Spain	531	FRAIL scale	27.3%	-	-	-	-	-	-	-	-
Ma et al., 2013	Prospective observational study	Prince of Wales teaching Hospital, Hong Kong	Pneumonia patients	Pneumonia patients	-	65+	China	428	Canadian Study of Health and Ageing (CSHA) Clinical Frailty Scale	38.8%	13.8%	47.4%	-	-	-	-	-	-

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Madni et al., 2018	Retrospective review study	Level 1 burn centre	Level 1 burn centre	Burn patients	75.5 ± 7.7	65+	United States of America	126	Canadian Study of Health and Ageing (CSHA) Clinical Frailty Scale	27.0%	34.1%	39.7%	-	-	-	-	-	-
Martin et al., 2018	Prospective observational study	Hospital de Mataró, Barcelona	Patients with Propharyngeal dysphagia in the Acute Geriatric Unit	Patients with oropharyngeal dysphagia	84.9 ± 6.0	70+	Spain	62	Fried frailty phenotype	80.6%	19.4%	0.0%	72.7%*	27.3%*	0.0%	89.7%*	10.3%*	0.0%
Mason et al., 2018	Prospective observational study	Musgrove Park Hospital	Emergency surgery patients	Emergency surgery patients	81*	70+	United Kingdom	435	Canadian Study on Health and Ageing (CSHA) Clinical Frailty Scale	41.1%	17.5%*	41.4%*	40.5%*	16.9%*	42.6%*	41.7%*	17.9%*	40.4%*
Maxwell et al., 2018	Prospective observational study	Inpatient hospital	Trauma patients (trauma, geriatrics, orthopaedic services)	Trauma patients	77.5 ± 8.9*	69-88	United States of America	188	FRAIL Scale	33.5%	37.8%	28.7%	25.6%*	42.7%*	31.7%*	39.6%*	34.0%*	26.4%*
McGuckin et al., 2018	Prospective observational study	University College Hospital London	Unscheduled non-cardiac surgery	Unscheduled non-cardiac surgery	77.1 ± 8.3	65+	United Kingdom	164	Canadian Study on Health and Ageing (CSHA) Clinical Frailty Scale	36.6%	14.0%	49.4%	38.3%*	13.3%*	48.3%*	35.6%*	14.4%*	50.0%*
McIsaac et al., 2019	Retrospective cohort study	Linked health administrative data in Ontario, Canada	Elective non-cardiac surgery	Elective non-cardiac surgery patients	-	66+	Canada	415,704	preoperative Frailty index (pFI)	28.8%	-	71.2%	31.9%	-	68.1%	26.2%	-	73.8%
Morton et al., 2018	Prospective cohort study	Inpatient hospital	Patient with acute kidney injury	Patients with acute kidney injury	81.4 ± 8.1	65+	United Kingdom	164	Clinical Frailty Scale	73.2%	-	-	70.1%	-	-	75.9%	-	-
Muessig et al., 2018	Prospectively realised observational multicentre European VIP-1 study	20 intensive care units	Intensive Care Units (ICU)	Intensive Care Unit (ICU) patients	84.6 ± 3.8*	80+	Germany	308	Clinical Frailty Scale	53.6%	22.7%	23.7%	48.7%	20.1%*	31.2%*	58.4%	25.3%*	16.2%*
Müller et al., 2017	Cross-sectional study	University Hospital Zurich, Switzerland	Geriatric Centre	Trauma patients	-	70+	Switzerland	156	Fried Frailty Phenotype	21.8%	59.6%	18.6%	-	-	-	-	-	-
Myint et al., 2018	Prospective cohort study	Five hospitals in the United Kingdom	Acute geriatric surgical unit	Acute surgical patients	-	65+	United Kingdom	644	Canadian Study of Health and Ageing (CSHA) Clinical Frailty Scale	17.5%	12.6%	69.9%	-	-	-	-	-	-
Nolan et al., 2016	Prospective cohort study	Post-acute rehabilitation unit	Post-acute rehabilitation unit	N/A	80.3 ± 7.1	65+	Ireland	41	Clinical Frailty Scale	97.6%	2.4%	0.0%	94.4%*	5.6%*	0.0%	100.0%*	0.0%*	0.0%
Nguyen et al., 2016	Prospective cohort study	A tertiary referral teaching hospital	Atrial fibrillation	Atrial fibrillation	84.7 ± 7.1	65-100	Australia	302	Reported Edmonton Frailty Scale (REFS)	53.3%	-	-	49.7%	-	-	57.0%	-	-
Oliveira et al., 2013	Cross sectional study	São Vicente de Paulo Hospital	Tertiary level hospital	N/A	74.5 ± 6.8	65+	Brazil	99	Fried frailty phenotype	46.5%	49.5%	4.0%	46.9%	49.0%	4.1%	46.0%	50.0%	4.0%

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Öztürk et al., 2017	Cross-study sectional study	Faculty of Medicine of Gaziantep University	Internal medicine clinics	N/A	71.9 ± 6.3	65-98	Turkey	420	Fried frailty phenotype	65.5%	26.2%	8.3%	54.7%	33.0%	12.3%	76.4%	19.2%	4.3%
Papageorgiou et al., 2018	Prospective, observational study	General Hospital	Intensive Care Unit (ICU)	N/A	75.6	65+	Greece	36	Clinical Frailty Scale	27.8%	22.2%	50.0%	-	-	-	-	-	-
Papakonstantinou et al., 2018	Single-centre, observational perspective study	University Hospital	Department of Internal Medicine	Atrial fibrillation	84.9 ± 5.0*	75-97*	Greece	104	Clinical Frailty Scale	58.7%*	30.8%*	10.6%*	43.1%*	43.1%*	13.7%*	73.6%*	18.9%*	7.5%*
Parmar et al., 2019	Multi-centred prospective cohort study	Multiple (49 hospital sites across the United Kingdom)	Emergency laparotomy patients	Emergency laparotomy patients	76.0 ± 6.8	65-99	United Kingdom	937	Canadian Study of Health and Ageing (CSHA) Clinical Frailty Scale	20.3%	21.2%	58.8%	18.9%	21.9%	59.2%	21.3%	20.7%	58.5%
Pasqualetti et al., 2018	Prospective observational study	University hospital	Geriatric wards (Emergency department admissions with acute disease)	Emergency department admissions with acute disease	83.8 +/- 7.4	66+	Italy	643	Multi Prognostic Index	43.2%	25.3%	31.4%	39.3%*	26%*	35.7%*	46.9%*	24.5%*	27.7%*
Patel et al., 2018	Multi-centred (registry based), prospective, observational study	41 hospitals (CONCORDANCE registry, a prospective Australian registry of myocardial infarction patients)	Myocardial infarction (ST-segment-elevation Myocardial Infarction (STEMI) and non-STEMI (NSTEMI)) patients	Myocardial infarction (ST-segment-elevation Myocardial Infarction (STEMI) and non-STEMI (NSTEMI))	-	65+	Australia	3,944	Frailty index	27.7%	-	-	29.1%	-	-	25.1%	-	-
As above	*As above*	*As above*	*ST-segment elevation myocardial infarction (STEMI)*	*ST-segment elevation myocardial infarction (STEMI)*	-	*As above*	*As above*	*1,275*	*As above*	*15.1%*	-	-	*13.4%*	-	-	*14.4%*	-	-
As above	*As above*	*As above*	*Non-ST-segment elevation myocardial infarction (NSTEMI)*	*Non-ST-segment elevation myocardial infarction (NSTEMI)*	-	*As above*	*As above*	*2,669*	*As above*	*33.8%*	-	-	*35.9%*	-	-	*29.9%*	-	-
Peel et al., 2017	Retrospective observational study	Tertiary level hospital	Geriatric and general medicine patients with three or more transfers	N/A	85.0 ± 6.2*	65+	Australia	89	Clinical Frailty Scale (CFS)	91.0%	5.6%	3.4%	84.8%*	9.1%*	6.1%*	94.6%*	3.6%*	1.8%*
As above	*As above*	*As above*	*Geriatric medicine*	*N/A*	*84.7 ± 6.4**	*As above*	*As above*	*67*	*As above*	*98.5%*	*1.5%*	*0.0%*	*95.8%**	*4.2%**	*0.0%*	*100.0%**	*0.0%**	*0.0%*
As above	*As above*	*As above*	*General medicine*	*N/A*	*86.0 ± 5.9**	*As above*	*As above*	*22*	*As above*	*68.2%*	*18.2%*	*13.6%*	*55.6%**	*22.2%**	*22.2%*	*76.9%**	*15.4%**	*7.7%*
Pelavski et al., 2017	Prospective observational study	Tertiary care hospital	Elective surgery patients	N/A	87.5 ± 2.3*	85-96	Spain	127	Fried frailty phenotype	22.8%	51.2%	17.3%	21.1%*	47.4%*	31.6%*	24.3%*	54.3%*	5.7%*
Perera et al., 2009	Prospective observational study	Teaching hospital	Atrial fibrillation patients	Atrial fibrillation	82.7 ± 6.3	65+	Australia	220	Reported Edmonton Frailty Scale (REFS)	63.6%	-	-	-	-	-	-	-	-
Pollack et al., 2017	Prospective cohort study	An urban tertiary-care hospital and community hospital	Intensive Care Unit	Survivors of critical illness	74.0 ± 8.1*	65+	United States of America	125	Fried frailty phenotype criteria	85.6%	12.8%*	1.6%*	80.3%*	16.4%*	3.3%*	90.6%*	9.4%*	0.0%*
Poudel et al., 2016	Prospective study	11 acute care hospitals in Queensland and Victoria, Australia	Tertiary level hospitals	N/A	81.0 ± 6.8	70+	Australia	1,418	Frailty Index (52 items)	64.5%*	-	-	58.5%*	-	-	69.5%*	-	-
Purser et al., 2006	Prospective observational study	Duke University Medical Centre	Cardiology ward (severe (minimum two-vessel) coronary artery disease)	Severe (minimum two-vessel) coronary artery disease	77 ± 5	70+	United States of America	309	Multiple	45.0%	-	-	40.3%	-	-	55.9%	-	-

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As above	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*309*	*Fried frailty phenotype*	*27.2%*	-	-	*22.7%*	-	-	*37.6%*	-	-
As above	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*309*	*Rockwood frailty assessment*	*62.8%*	-	-	*57.9%*	-	-	*74.2%*	-	-
Ritt et al., 2015	Prospective cohort study	Hospital of the Congregation of St. Francis, Sisters of Vierzehnheiligen, Erlangen	Geriatric wards	N/A	-	65+	Germany	307	Clinical Frailty Scale	72.0%	21.8%	6.2%	79.8%	17.2%	3.0%	68.3%	24.0%	7.7%
Rose et al., 2014	Prospective cohort study	Private hospital	General medical unit	N/A	86.5 ± 6.1	70+	Australia	133	Reported Edmonton Frailty Scale (REFS)	50.4%	17.3%	32.3%	-	-	-	-	-	-
Sánchez et al., 2011	Observational prospective study	University hospital	Clinical cardiology unit	Acute cardiac diseases (direct urgent admissions)	81.6 ± 5.0	75-95	Spain	211	Fried frailty phenotype criteria	40.8%	-	-	-	-	-	-	-	-
Sanchis et al., 2015	Prospective, single centre cohort study	University Clinic Hospital	Cardiology Department (patients with acute coronary syndromes)	Patients with acute coronary syndrome	77.5 ± 7.1*	75+	Spain	342	Fried frailty phenotype criteria	33.9%	58.8%*	7.3%*	24.0%	65.8%*	10.2%*	47.3%	49.3%*	3.4%*
Sikder et al., 2019	Prospective study	Two University hospitals	Elective abdominal surgery patients	Elective abdominal surgery	77.8 ± 5.0	70+	Canada	144	Fried frailty phenotype criteria	17.4%	60.4%	22.2%	19.0%	59.5%	21.5%	15.4%	61.5%	23.1%
Sündermann et al., 2014	Prospective cohort study	Heart centre	Heart centre (Elective cardiac surgery inpatients)*	Elective cardiac surgery	79 +/- 4	74+	Germany	450	Multiple	55.7%*	N/A	44.3%*	50.7%*	N/A	49.3%*	60.8%*	N/A	39.2%*
As above	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*450*	*Comprehensive Assessment of Frailty (CAF)*	*48.9%*	*N/A*	*51.1%*	*44.1%**	*N/A*	*55.9%**	*53.8%**	*N/A*	*46.2%**
As above	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*As above*	*450*	*Frailty predicts death one yeaR after Cardiac Surgery Test (FORECAST)*	*62.4%**	*N/A*	*37.6%**	*57.3%**	*N/A*	*42.7%**	*67.7%**	*N/A*	*32.3%**
Thai et al., 2015	Cross-sectional study	A large teaching hospital	Patients prescribed a statin	Patients prescribed statins	-	65+	Australia	180	Reported Edmonton Frailty Scale (REFS)	35.0%	-	-	28.4%	-	-	42.4%	-	-
Ticinesi et al., 2016	Prospective cohort study	Teaching hospital	Acute care geriatric ward	Multimorbid patients with acute respiratory complaints urgently admitted from the emergency department	83 ± 10*	65+	Italy	270	Clinical Frailty Scale	59.6%*	24.1%*	16.3%*	61.3%*	23.4%*	15.3%*	58.2%*	24.7%*	17.1%*
Timmons et al., 2015	Prospective study	Six hospitals (five public (two rural, three urban) and one private) in County Cork, South-West Ireland	All hospital inpatients	N/A	80.0 ± 6.5*	70+	Ireland	248	SHARE-FI	45.2%	20.6%	30.2%	30.4%*	27.7%*	42.0%*	57.4%*	22.1%*	20.6%*
Valentini et al., 2018	Observational study	The "Tor Vergata" Polyclinic in Rome	Orthopaedic Department (hip fracture)	Hip fracture patients	79.9 ± 7.7	65+	Italy	62	SHARE -FI	59.7%	21.0%	19.4%	-	-	-	-	-	-
Vidán et al., 2014	Prospective cohort observational study	Department of cardiology at a large University hospital	Heart failure patients in the cardiology, internal medicine and geriatrics departments	Heart failure	80 ± 6	70+	Spain	450	Fried frailty phenotype criteria	70.2%	-	-	-	-	-	-	-	-
As above	*As above*	*As above*	*Cardiology department*	*As above*	*78.6 ± 5.2*	*As above*	*As above*	*311*	*As above*	*67.5%*	-	-	-	-	-	-	-	-

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As above	*As above*	*As above*	*Internal medicine department*	*As above*	*80.2 ± 5.4*	*As above*	*As above*	*78*	*As above*	*73.1%*	-	-	-	-	-	-	-	-	-
As above	*As above*	*As above*	*Geriatrics department*	*As above*	*87.3 ± 5.7*	*As above*	*As above*	*61*	Clinical Frailty Scale (CFS)	*80.3%*	-	-	-	-	-	-	-	-	-
Wallis et al., 2015	Retrospective observational study	A large tertiary university National Health Service acute hospital in the UK	University hospital	Emergency admissions	84.6 ± 5.9	75+	United Kingdom	5,764		56.7%	17.8%	25.6%	49.6%	19.8%	30.7%	62.2%	16.2%	21.6%	
Woo et al., 2013	Observational cohort study	Queen's Medical Centre, Nottingham, and the Leicester Royal Infirmary, Leicester	Acute Medical Units	N/A	-	70+	United Kingdom	559	Frailty Index	30.9%	-	-	-	-	-	-	-	-	-

* =Data not initially reported, or possible to derive from available data. Obtained, or derived, from correspondence with study authors.

et al., 2019; Sündermann et al., 2014; Thai et al., 2015; Ticinesi et al., 2016; Timmons et al., 2015; Wallis et al., 2015). Overall, the pooled prevalence of frailty was 51.9% (95% CI 46.1–57.8%) among female, and 47.0% (95% CI 43.3–50.8%) among male geriatric hospital inpatients. Differences in the prevalence of frailty between sexes were not statistically significant ($p = 0.17$) (Supplementary Figure B).

3.3.2. Age

Seventy-eight studies were included in the pooled analysis of the prevalence of frailty, stratified by the mean age of the study sample. Six of the included studies had a mean age between 65–74 years (Courtney-Brooks et al., 2012; Jacobs et al., 2017; Kang et al., 2015; Khan, Öztürk et al., 2019, 2017; Pollack et al., 2017); 58 between 75–84 years (Alonso Salinas et al., 2018; Attisano et al., 2017; Baldwin et al., 2014; Bo et al., 2015; Bo et al., 2016; Cheung et al., 2017; Chew et al., 2017; Chia et al., 2016; Coleman et al., 2012; Dal Moro et al., 2017; Dorner et al., 2014; Drudi et al., 2018; Dutzi et al., 2017; Eamer et al., 2018; Eeles et al., 2012; Engelhardt et al., 2018; Ga et al., 2018; Gleason et al., 2017; Goldfarb et al., 2018; Guidet et al., 2018; Heppenstall et al., 2011; Hewitt et al., 2015; Hii et al., 2014; Hilmer et al., 2011; Jokar et al., 2016; Joseph et al., 2014; Joseph et al., 2016; Juma et al., 2016; Karlekar et al., 2017; Kenig et al., 2015; Kobe et al., 2016; Koyama et al., 2018; Kusunose et al., 2018; Lee et al., 2018; Le Maguet et al., 2014; Lin et al., 2017; Llaó et al., 2018; Madni et al., 2018; Mason et al., 2018; Maxwell et al., 2018; McGuckin et al., 2018; Morton et al., 2018; Nolan et al., 2016; Oliveira et al., 2013; Papageorgiou et al., 2018; Parmar et al., 2019; Pasqualetti et al., 2018; Perera et al., 2009; Poudel et al., 2016; Purser et al., 2006; Sánchez et al., 2011; Sanchis et al., 2015; Sikder et al., 2019; Sündermann et al., 2014; Ticinesi et al., 2016; Timmons et al., 2015; Valentini et al., 2018; Vidán et al., 2014); and 14 $\geq$ 85 years (Amblàs-Novellas et al., 2018; Blanco et al., 2017; Chong et al., 2017; Gullón et al., 2018; Hartley et al., 2017; Induruwa et al., 2017; Martín et al., 2018; Muessig et al., 2018; Nguyen et al., 2016; Papakonstantinou et al., 2018; Peel et al., 2017; Pelavski et al., 2017; Rose et al., 2014; Wallis et al., 2015). The pooled prevalence of frailty was 52.1% (95% CI 35.1–69%) among studies with a mean age between 65–74 years; 46.1% (95% CI 41.0–51.0%) with a mean age between 75–84 years; and 60.2% (95% CI 51.1–69.2%) with a mean age $\geq$ 85 years. Differences in the pooled prevalence estimates of frailty were statistically significant between these age groups, based on the mean age of study samples ($p < 0.03$) (Supplementary Figure C). Among the 35 studies with a mean age between 65–79 years, the pooled prevalence of frailty was 37.4% (95% CI, 31.8–43.1), while among the 43 studies with a mean age $\geq$ 80 years, the pooled prevalence of frailty was 58.3% (95% CI, 53–63.7%). Differences in the pooled prevalence estimates of frailty were also statistically significant between these alternative age group classifications based on the mean age of study samples ($p < 0.001$) (Supplementary Figure D).

3.3.3. Ward / Department / Unit / Hospital type

Fifty-three studies were included in pooled analysis of the prevalence of frailty stratified by ward type (Amblàs-Novellas et al., 2018; Andela et al., 2010; Baldwin et al., 2014; Bo et al., 2016; Cheung et al., 2017; Chew et al., 2017; Chia et al., 2016; Chong et al., 2017; Coleman et al., 2012; Dent et al., 2014; Dutzi et al., 2017; Eeles et al., 2012; Guidet et al., 2018; Gullón et al., 2018; Hartley et al., 2017; Heppenstall et al., 2011; Hewitt et al., 2015; Hewitt et al., 2016; Hii et al., 2014; Ibrahim et al., 2019; Induruwa et al., 2017; Jokar et al., 2016; Joosten et al., 2014; Joseph et al., 2014; Joseph et al., 2016; Juma et al., 2016; Karlekar et al., 2017; Khan et al., 2019; Kobe et al., 2016; Koyama et al., 2018; Lee et al., 2018; Le Maguet et al., 2014; Martín et al., 2018; Muessig et al., 2018; Müller et al., 2017; Myint et al., 2018; Nolan, Öztürk et al., 2016, 2017; Papageorgiou et al., 2018; Papakonstantinou et al., 2018; Pasqualetti et al., 2018; Peel et al., 2017; Pollack et al., 2017; Poudel et al., 2016; Purser et al., 2006; Ritt et al., 2015; Rose et al., 2014; Sánchez et al., 2011; Sanchis et al., 2015; Sündermann et al.,

2014; Ticinesi et al., 2016; Vidán et al., 2014; Wou et al., 2013). Fifteen of the included studies were specifically conducted on geriatric wards (Amblàs-Novellas et al., 2018; Andela et al., 2010; Bo et al., 2016; Chew et al., 2017; Chong et al., 2017; Dent et al., 2014; Hartley et al., 2017; Joosten et al., 2014; Martín et al., 2018; Müller et al., 2017; Pasqualetti et al., 2018; Peel et al., 2017; Ritt et al., 2015; Ticinesi et al., 2016; Vidán et al., 2014); twelve on general internal medicine wards (Andela et al., 2010; Eeles et al., 2012; Gullón et al., 2018; Heppenstall et al., 2011; Induruwa et al., 2017; Juma et al., 2016; Koyama, Öztürk et al., 2018, 2017; Papakonstantinou et al., 2018; Peel et al., 2017; Rose et al., 2014; Vidán et al., 2014); seven acute wards (Amblàs-Novellas et al., 2018; Bo et al., 2016; Ibrahim et al., 2019; Joosten et al., 2014; Poudel et al., 2016; Ticinesi et al., 2016; Wou et al., 2013), seven cardiology wards (Hii et al., 2014; Kobe et al., 2016; Purser et al., 2006; Sánchez et al., 2011; Sanchis et al., 2015; Sündermann et al., 2014; Vidán et al., 2014); seven surgical wards (Andela et al., 2010; Cheung et al., 2017; Chia et al., 2016; Hewitt et al., 2015; Hewitt et al., 2016; Jokar et al., 2016; Myint et al., 2018); six intensive care wards (Baldwin et al., 2014; Guidet et al., 2018; Le Maguet et al., 2014; Muessig et al., 2018; Papageorgiou et al., 2018; Pollack et al., 2017); six traumatology wards (Andela et al., 2010; Joseph et al., 2014; Joseph et al., 2016; Karlekar et al., 2017; Khan et al., 2019; Lee et al., 2018); and, three on rehabilitation wards (Coleman et al., 2012; Dutzi et al., 2017; Nolan et al., 2016). The overall pooled prevalence of frailty was 93% (95% CI 81.8–100%) among geriatric hospital inpatients on rehabilitation wards; 66.5% (95% CI 54.3–78.7%) on geriatric wards; 59.3% (95% CI 50.5–68.1%) on general internal medicine wards; 52.3% (95% CI 36.2–68.4%) on intensive care wards; 51.1% (95% CI 35.9–66.2%) on acute wards; 45.6% (95% CI 35–56.2%) on cardiology wards; 45.3% (95% CI 37.7–53.0%) on traumatology wards; and, 30.6% (95% CI 23.5–37.7%) on surgical wards (Supplementary Figure E). Differences in the pooled prevalence estimates of frailty were statistically significant between ward types ($p < 0.001$). Additionally, one study was specifically conducted on each of burns (Madni et al., 2018), endocrinology (Dorner et al., 2014), orthopaedic (Valentini et al., 2018), psychiatric (Jacobs et al., 2017), and pulmonary wards (Andela et al., 2010). These studies were not included in the above pooled prevalence analysis stratified by ward type due to a lack of multiple comparable data points to facilitate stratified pooled analyses in the above regard.

3.3.4. *Prevalent morbidities*

Thirty-five studies were included in pooled analysis of the prevalence of frailty stratified by prevalent morbidity (Alonso Salinas et al., 2018; Andela et al., 2010; Andrew et al., 2017; Attisano et al., 2017; Baldwin et al., 2014; Blanco et al., 2017; Bo et al., 2015; Courtney-Brooks et al., 2012; Chia et al., 2016; Chew et al., 2017; Crozier-Shaw, Joyce, 2018; Drudi et al., 2018; Dutzi et al., 2017; Ekerstad et al., 2011; Ferrero et al., 2017; Gleason et al., 2017; Goldfarb et al., 2018; Gullón et al., 2018; Hii et al., 2014; Induruwa et al., 2017; Jacobs et al., 2017; Kang et al., 2015; Kobe et al., 2016; Llaó et al., 2018; Ma et al., 2013; Nguyen et al., 2016; Papakonstantinou et al., 2018; Patel et al., 2018; Perera et al., 2009; Purser et al., 2006; Sánchez et al., 2011; Sanchis, Juan et al., 2015; Sündermann et al., 2014; Valentini et al., 2018; Vidán et al., 2014), which were grouped into the following categories: cardiovascular, neoplastic, pulmonary, orthopaedic (musculoskeletal), neurological, gastrointestinal, and psychiatric-related morbidities (Supplementary Figure F, Supplementary Table A).

3.3.4.1. Cardiovascular morbidities. Twenty-two of the included studies were conducted among patients identified as primarily possessing a cardiovascular-related morbidity (Alonso Salinas et al., 2018; Attisano et al., 2017; Blanco et al., 2017; Bo et al., 2015; Drudi et al., 2018; Ekerstad et al., 2011; Goldfarb et al., 2018; Gullón et al., 2018; Hii et al., 2014; Induruwa et al., 2017; Kang et al., 2015; Kobe et al., 2016; Llaó et al., 2018; Nguyen et al., 2016; Papakonstantinou et al., 2018; Patel et al., 2018; Perera et al., 2009; Purser et al., 2006; Sánchez et al., 2011; Sanchis et al., 2015; Sündermann et al., 2014; Vidán et al., 2014): seven specifically among acute coronary syndrome patients (Alonso Salinas et al., 2018; Blanco et al., 2017; Ekerstad et al., 2011; Kang et al., 2015; Llaó et al., 2018; Patel et al., 2018; Sanchis et al., 2015) (three among non-ST segment elevation myocardial infarction (NSTEMI) patients (Ekerstad et al., 2011; Llaó et al., 2018; Patel et al., 2018)); four among aortic valve stenosis patients (Attisano et al., 2017; Drudi et al., 2018; Goldfarb et al., 2018; Kobe et al., 2016); and six among atrial fibrillation patients (Bo et al., 2015; Gullón et al., 2018; Induruwa et al., 2017; Nguyen et al., 2016; Papakonstantinou et al., 2018; Perera et al., 2009). The overall pooled prevalence of frailty was 46.9% (95% CI 39.3–54.4%) among geriatric hospital inpatients identified as primarily possessing a cardiovascular-related morbidity: 34% (95% CI 27.9–40.2%) among acute coronary syndrome patients (36.3% (95% CI 27.3–45.2%) specifically among patients with a non-ST segment elevation myocardial infarction); 45.9% (95% CI 38.3–53.5%) among aortic stenosis patients; and 62.8% (95% CI 50.4–72.5%) among atrial fibrillation patients. Additionally, one study each was specifically conducted among ST segment elevation myocardial infarction patients (Patel et al., 2018); coronary artery disease patients (Purser et al., 2006); and heart failure patients (Vidán et al., 2014). These studies were not included in their own specific stratified analysis due to a lack of multiple comparable data points to facilitate stratified pooled analyses in the above regard.

3.3.4.2. Neoplastic morbidities. Three of the included studies were conducted among patients identified as primarily possessing a neoplastic-related morbidity (Courtney-Brooks et al., 2012; Crozier-Shaw, Joyce, 2018; Ferrero et al., 2017): two specifically among female cancer patients (gynaecologic, and ovarian) (Courtney-Brooks et al., 2012; Ferrero et al., 2017). The overall pooled prevalence of frailty was 22.2% (95% CI 15.9–28.6%) among geriatric hospital inpatients identified as primarily possessing a neoplastic-related morbidity; 23.2% (95% CI 10.2–36.3%) among female cancer inpatients.

3.3.4.3. Pulmonary morbidities. Four of the included studies were conducted among geriatric hospital inpatients identified as primarily possessing a pulmonary-related morbidity (Andela et al., 2010; Andrew et al., 2017; Baldwin et al., 2014; Ma et al., 2013); the overall pooled prevalence frailty among these inpatients was 55.0% (95% CI 39.9–70.1%).

3.3.4.4. Orthopaedic (musculoskeletal) morbidities. Two of the included studies were conducted among geriatric hospital inpatients identified as primarily possessing an orthopaedic (musculoskeletal)-related morbidity (Gleason et al., 2017; Valentini et al., 2018); the overall pooled prevalence of frailty among these inpatients was 50% (95% CI 32.4–67.6%).

3.3.4.5. Neurological morbidities. Two of the included studies were conducted among geriatric hospital inpatients identified as primarily possessing a neurological-related morbidity (Chew et al., 2017; Dutzi et al., 2017); the overall pooled prevalence of frailty among these inpatients was 75.2% (95% CI 60.9–89.5%).

3.3.4.6. Gastrointestinal morbidities. Two of the included studies were conducted among geriatric hospital inpatients identified as primarily possessing a gastrointestinal-related morbidity (Chia et al., 2016; Crozier-Shaw, Joyce, 2018); the overall pooled prevalence of frailty among these inpatients was 22.5% (95% CI 17.9–27%).

3.3.4.7. Psychiatric morbidities. Two of the included studies were conducted among geriatric hospital inpatients identified as primarily

possessing a psychiatric-related morbidity (Chew et al., 2017; Jacobs et al., 2017); the overall pooled prevalence of frailty among these inpatients was 66.8% (95% CI 61.5–72.2%).

Additionally, of the 96 included studies, one study each was conducted among patients identified as primarily possessing dermal (Madni et al., 2018); oral (Martín et al., 2018); and renal (Morton et al., 2018) related morbidities. These studies were not included in the above pooled prevalence analysis stratified by prevalent morbidity due to the lack of multiple comparable data points to facilitate stratified pooled analyses in the above regard.

3.3.5. Operational definition

Twenty-four validated operational definitions of frailty were utilised among the 96 studies included within this review. Fourteen were eligible for inclusion in stratified analysis, and 89 studies in total were included in the pooled analysis of the prevalence of frailty stratified by these operational definition, with the most commonly utilised operational definition being the Fried frailty phenotype, followed by the clinical frailty scale, and frailty index. Twenty studies utilised the Fried frailty phenotype as the operational definition for the classification of frailty among geriatric hospital inpatients (Baldwin et al., 2014; Bo et al., 2016; Chia et al., 2016; Courtney-Brooks et al., 2012; Drudi et al., 2018; Goldfarb et al., 2018; Ibrahim et al., 2019; Joosten et al., 2014; Kusunose et al., 2018; Martín et al., 2018; Müller et al., 2017; Oliveira, Öztürk et al., 2013, 2017; Pelavski et al., 2017; Pollack et al., 2017; Purser et al., 2006; Sánchez et al., 2011; Sanchis et al., 2015; Sikder et al., 2019; Vidán et al., 2014); 18 the clinical frailty scale (Chong et al., 2017; Coleman et al., 2012; Dutzi et al., 2017; Eamer et al., 2018; Guidet et al., 2018; Hartley et al., 2017; Induruwa et al., 2017; Juma et al., 2016; Keevil et al., 2018; Le Maguet et al., 2014; Morton et al., 2018; Nolan et al., 2016; Papageorgiou et al., 2018; Papakonstantinou et al., 2018; Peel et al., 2017; Ritt et al., 2015; Ticinesi et al., 2016; Wallis et al., 2015); 13 the frailty index (Andrew et al., 2017; Attisano et al., 2017; Chew et al., 2017; Chong et al., 2017; Eeles et al., 2012; Ga et al., 2018; Jacobs et al., 2017; Jokar et al., 2016; Joseph et al., 2014; Lin et al., 2017; Patel et al., 2018; Poudel et al., 2016; Wou et al., 2013); 10 the Canadian Study on Health and Ageing (CSHA) clinical frailty scale (7-point) (Ekerstad et al., 2011; Hewitt et al., 2015; Hewitt et al., 2016; Kang et al., 2015; Ma et al., 2013; Madni et al., 2018; Mason et al., 2018; McGuckin et al., 2018; Myint et al., 2018; Parmar et al., 2019); seven the reported Edmonton frailty scale (Cheung et al., 2017; Hii et al., 2014; Hilmer et al., 2011; Nguyen et al., 2016; Perera et al., 2009; Rose et al., 2014; Thai et al., 2015); seven the FRAIL scale (Chong et al., 2017; Gleason et al., 2017; Gullón et al., 2018; Ibrahim et al., 2019; Karlekar et al., 2017; Llaó et al., 2018; Maxwell et al., 2018); five the SHARE-FI (Alonso Salinas et al., 2018; Dorner et al., 2014; Muessig et al., 2018; Timmons et al., 2015; Valentini et al., 2018); three the Groningen frailty indicator (Andela et al., 2010; Bo et al., 2015; Kenig et al., 2015); three the trauma specific and emergency general surgery specific frailty indices (Engelhardt et al., 2018; Joseph et al., 2016; Lee et al., 2018); two the frailty predicts death one year after cardiac surgery test (FORECAST) (Kobe et al., 2016; Sündermann et al., 2014); two the emergency general surgery-specific frailty index (Jokar et al., 2016; Khan et al., 2019); two the Rockwood frailty assessment (Kenig et al., 2015; Purser et al., 2006); two the study of osteoporotic fractures index (Dent et al., 2014; Joosten et al., 2014); and two the Edmonton frailty scale (Dal Moro et al., 2017; Heppenstall et al., 2011).

The overall pooled prevalence of frailty among geriatric hospital inpatients was 42.9% (95% CI 35.4–50.4%) among patients assessed using the Fried frailty phenotype criteria; 64.2% (95% CI 57.3–71.0%) using the clinical frailty scale; 52.6% (95% CI 38–67.1%) using the frailty index; 32.7% (95% CI 25.8–39.7%) using the Canadian Study on Health and Ageing (CSHA) clinical frailty scale (7-point); 43.1% (95% CI 32.1–54.2%) using the reported Edmonton frailty scale; 39.2% (95% CI 30.7–47.6%) using the FRAIL scale; 49.4% (95% CI 42.0–56.8%) using the SHARE-FI; 70.5% (55.6–85.4%) using the Groningen frailty indicator; 59.4% (95% CI 51.9–66.9%) using the frailty predicts death one year after cardiac surgery test (FORECAST); 37.7% (95% CI 28.4–46.9%) using the trauma specific and emergency general surgery specific frailty indices; 36.0% (95% CI 27.8–44.3%) using the emergency general surgery-specific frailty index; 56.6% (95% CI 44.1–69.1%) using the Rockwood frailty assessment; 51.1% (95% CI 14.4–87.7%) using the study of osteoporotic fractures index; and 44.5% (95% CI 0.2–88.9%) using the Edmonton frailty scale (Supplementary Figure G).

Additionally, one study each utilised one of the ten additional validated operational definition of frailty. However, these studies were not included in the above pooled prevalence analysis stratified by operational definition due to the lack of multiple comparable data points to facilitate stratified pooled analyses in the above regard.

3.3.6. Geographic location

Ninety-one studies were included in the pooled analysis of the prevalence of frailty stratified by geographic location (country/continent) (Alonso Salinas et al., 2018; Amblàs-Novellas et al., 2018; Andela et al., 2010; Andrew et al., 2017; Attisano et al., 2017; Baldwin et al., 2014; Blanco et al., 2017; Bo et al., 2015; Bo et al., 2016; Cheung et al., 2017; Chew et al., 2017; Chia et al., 2016; Chong et al., 2017; Coleman et al., 2012; Courtney-Brooks et al., 2012; Crozier-Shaw, Joyce, 2018; Dal Moro et al., 2017; Dent et al., 2014; Dorner et al., 2014; Dutzi et al., 2017; Eamer et al., 2018; Eeles et al., 2012; Ekerstad et al., 2011; Engelhardt et al., 2018; Ferrero et al., 2017; Ga et al., 2018; Gleason et al., 2017; Gullón et al., 2018; Hartley et al., 2017; Heppenstall et al., 2011; Hewitt et al., 2015, 2016; Hii et al., 2014; Hilmer et al., 2011; Ibrahim et al., 2019; Induruwa et al., 2017; Karlekar et al., 2017; Jacobs et al., 2017; Jokar et al., 2016; Joosten et al., 2014; Joseph et al., 2014; 2016; Juma et al., 2016; Kang et al., 2015; Keevil et al., 2018; Kenig et al., 2015; Khan et al., 2019; Koyama et al., 2018; Kusunose et al., 2018; Lee et al., 2018; Le Maguet et al., 2014; Lin et al., 2017; Llaó et al., 2018; Ma et al., 2013; Madni et al., 2018; Martín et al., 2018; Mason et al., 2018; Maxwell et al., 2018; McGuckin et al., 2018; McIsaac et al., 2019; Morton et al., 2018; Muessig et al., 2018; Müller et al., 2017; Myint et al., 2018; Nguyen et al., 2016; Nolan et al., 2016; Öztürk et al., 2017; Papageorgiou et al., 2018; Papakonstantinou et al., 2018; Parmar et al., 2019; Pasqualetti et al., 2018; Patel et al., 2018; Peel et al., 2017; Pelavski et al., 2017; Perera et al., 2009; Pollack et al., 2017; Poudel et al., 2016; Purser et al., 2006; Ritt et al., 2015; Rose et al., 2014; Sánchez et al., 2011; Sanchis et al., 2015; Sikder et al., 2019; Sündermann et al., 2014; Thai et al., 2015; Ticinesi et al., 2016; Timmons et al., 2015; Valentini et al., 2018; Vidán et al., 2014; Wallis et al., 2015; Wou et al., 2013).

3.3.6.1. Continent. Fifty-two of the included studies were conducted in Europe (Alonso Salinas et al., 2018; Amblàs-Novellas et al., 2018; Andela et al., 2010; Attisano et al., 2017; Blanco et al., 2017; Bo et al., 2015; Bo et al., 2016; Coleman et al., 2012; Crozier-Shaw, Joyce, 2018; Dal Moro et al., 2017; Dorner et al., 2014; Dutzi et al., 2017; Ekerstad et al., 2011; Ferrero et al., 2017; Gullón et al., 2018; Hartley et al., 2017; Hewitt et al., 2015; Hewitt et al., 2016; Ibrahim et al., 2019; Induruwa et al., 2017; Jacobs et al., 2017; Joosten et al., 2014; Keevil et al., 2018; Kenig et al., 2015; Le Maguet et al., 2014; Lin et al., 2017; Llaó et al., 2018; Martín et al., 2018; Mason et al., 2018; McGuckin et al., 2018; Morton et al., 2018; Muessig et al., 2018; Müller et al., 2017; Myint et al., 2018; Nolan, Öztürk et al., 2016, 2017; Papageorgiou et al., 2018; Papakonstantinou et al., 2018; Parmar et al., 2019; Pasqualetti et al., 2018; Pelavski et al., 2017; Ritt et al., 2015; Rose et al., 2014; Sánchez et al., 2011; Sanchis et al., 2015; Sündermann et al., 2014; Ticinesi et al., 2016; Timmons et al., 2015; Valentini et al., 2018; Vidán et al., 2014; Wallis et al., 2015; Wou et al., 2013); 19 in North America (Andrew et al., 2017; Baldwin et al., 2014; Courtney-Brooks et al., 2012; Eamer et al., 2018; Engelhardt et al., 2018; Gleason et al., 2017; Jokar et al.,

2016; Joseph et al., 2014; Joseph et al., 2016; Juma et al., 2016; Karlekar et al., 2017; Khan et al., 2019; Lee et al., 2018; Madni et al., 2018; Maxwell et al., 2018; McIsaac et al., 2019; Pollack et al., 2017; Purser et al., 2006; Sikder et al., 2019); 12 Australasia (Cheung et al., 2017; Dent et al., 2014; Eeles et al., 2012; Heppenstall et al., 2011; Hii et al., 2014; Hilmer et al., 2011; Nguyen et al., 2016; Patel et al., 2018; Peel et al., 2017; Perera et al., 2009; Poudel et al., 2016; Thai et al., 2015); eight Asia (Chew et al., 2017; Chia et al., 2016; Chong et al., 2017; Ga et al., 2018; Kang et al., 2015; Koyama et al., 2018; Kusunose et al., 2018; Ma et al., 2013); and one additional study, not included in overall pooled analysis stratified by continent, was conducted in South America (Oliveira et al., 2013). The overall pooled prevalence of frailty among geriatric hospital inpatients in Europe was 49.1% (95% CI 43.9–54.2%); 40.6% (95% CI 34.2–47%) in North America; 51.0% (95% CI 37.5–64.6%) in Australasia; and 48.4% (95% CI 28.5–68.3%) in Asia. There was no significant difference in pooled prevalence estimates of frailty stratified by continent ($p = 0.32$) (Supplementary Figure H).

3.3.6.2. Country. Fourteen of the included studies were conducted in the United States of America (Baldwin et al., 2014; Courtney-Brooks et al., 2012; Engelhardt et al., 2018; Gleason et al., 2017; Jokar et al., 2016; Joseph et al., 2014; Joseph et al., 2016; Karlekar et al., 2017; Khan et al., 2019; Lee et al., 2018; Madni et al., 2018; Maxwell et al., 2018; Pollack et al., 2017; Purser et al., 2006); 13 the United Kingdom (Hartley et al., 2017; Hewitt et al., 2015; Hewitt et al., 2016; Ibrahim et al., 2019; Induruwa et al., 2017; Keevil et al., 2018; Mason et al., 2018; McGuckin et al., 2018; Morton et al., 2018; Myint et al., 2018; Parmar et al., 2019; Wallis et al., 2015; Wou et al., 2013); 12 Australia (Cheung et al., 2017; Dent et al., 2014; Eeles et al., 2012; Hilmer et al., 2011; Lin et al., 2017; Nguyen et al., 2016; Patel et al., 2018; Peel et al., 2017; Perera et al., 2009; Poudel et al., 2016; Rose et al., 2014; Thai et al., 2015); nine Spain (Alonso Salinas et al., 2018; Amblàs-Novellas et al., 2018; Gullón et al., 2018; Llaó et al., 2018; Martín et al., 2018; Pelavski et al., 2017; Sánchez et al., 2011; Sanchis et al., 2015; Vidán et al., 2014); eight Italy (Attisano et al., 2017; Bo et al., 2015; Bo et al., 2016; Dal Moro et al., 2017; Ferrero et al., 2017; Pasqualetti et al., 2018; Ticinesi et al., 2016; Valentini et al., 2018); five Canada (Andrew et al., 2017; Eamer et al., 2018; Juma et al., 2016; McIsaac et al., 2019; Sikder et al., 2019); five Germany (Dorner et al., 2014; Dutzi et al., 2017; Muessig et al., 2018; Ritt et al., 2015; Sündermann et al., 2014); four Ireland (Coleman et al., 2012; Crozier-Shaw, Joyce, 2018; Nolan et al., 2016; Timmons et al., 2015); three Singapore (Chew et al., 2017; Chia et al., 2016; Chong et al., 2017) two New Zealand (Heppenstall et al., 2011; Hii et al., 2014); two China (Kang et al., 2015; Ma et al., 2013); two France (Blanco et al., 2017; Le Maguet et al., 2014); two Greece (Papageorgiou et al., 2018; Papakonstantinou et al., 2018); two Japan (Koyama et al., 2018; Kusunose et al., 2018); and, two the Netherlands (Andela et al., 2010; Jacobs et al., 2017). Additionally, one study was conducted in each of Belgium (Joosten et al., 2014); Brazil (Oliveira et al., 2013); Turkey (Öztürk et al., 2017); Poland (Kenig et al., 2015); Sweden (Ekerstad et al., 2011); and Switzerland (Müller et al., 2017). These studies were not included in the above pooled prevalence analysis stratified by country due to a lack of multiple comparable data points to facilitate stratified pooled analyses in the above regard.

The overall pooled prevalence of frailty among geriatric hospital inpatients was 43.4% (95% CI 34.6–52.2%) in the United States of America; 43.9% (95% CI 34.7–53.1%) in the United Kingdom; 49.5% (95% CI 36.2–62.7%) in Australia; 49.8% (95% CI 33.9–65.6%) in Spain; 49.2% (95% CI 35–63.5%) in Italy; 33% (95% CI 23.1–42.9%) in Canada; 63.7% (95% CI 52.5–74.8%) in Germany; 65.8% (95% CI 25.7–100%) in Ireland; 56.1% (95% CI 29.3–83%) in Singapore; 43.3% (95% CI 0–90.3%) in New Zealand; 40.8% (95% CI 36.5–45.1%) in China; 22% (95% CI 18.0–25.9%) in France; 43.8% (95% CI 13.5–74.0%) in Greece; 21.0% (95% CI 16.7–25.3%) in Japan; and, 69.1% (95% CI 58.3–79.8%) in Netherlands. Differences in the pooled prevalence estimates of frailty were statistically significant between countries ($p < 0.001$) (Supplementary Figure I).

3.3.7. Clinical population

Ninety-four studies were included in pooled analysis of the prevalence of frailty stratified by clinical population: a broad combination of ward type and morbidity (Alonso Salinas et al., 2018; Amblàs-Novellas et al., 2018; Andela et al., 2010; Andrew et al., 2017; Attisano et al., 2017; Baldwin et al., 2014; Blanco et al., 2017; Bo et al., 2015; Bo et al., 2016; Cheung et al., 2017; Chew et al., 2017; Chia et al., 2016; Chong et al., 2017; Coleman et al., 2012; Courtney-Brooks et al., 2012; Crozier-Shaw, Joyce, 2018; Dal Moro et al., 2017; Dent et al., 2014; Dorner et al., 2014; Drudi et al., 2018; Dutzi et al., 2017; Eamer et al., 2018; Eeles et al., 2012; Ekerstad et al., 2011; Engelhardt et al., 2018; Ferrero et al., 2017; Ga et al., 2018; Gleason et al., 2017; Goldfarb et al., 2018; Guidet et al., 2018; Gullón et al., 2018; Hartley et al., 2017; Heppenstall et al., 2011; Hewitt et al., 2015; Hewitt et al., 2016; Hii et al., 2014; Hilmer et al., 2011; Ibrahim et al., 2019; Induruwa et al., 2017; Jacobs et al., 2017; Jokar et al., 2016; Joosten et al., 2014; Joseph et al., 2014; Joseph et al., 2016; Juma et al., 2016; Kang et al., 2015; Karlekar et al., 2017; Keevil et al., 2018; Kenig et al., 2015; Khan et al., 2019; Kobe et al., 2016; Koyama et al., 2018; Kusunose et al., 2018; Lee et al., 2018; Le Maguet et al., 2014; Lin et al., 2017; Llaó et al., 2018; Ma et al., 2013; Madni et al., 2018; Martín et al., 2018; Mason et al., 2018; Maxwell et al., 2018; McGuckin et al., 2018; McIsaac et al., 2019; Morton et al., 2018; Muessig et al., 2018; Müller et al., 2017; Myint et al., 2018; Nguyen et al., 2016; Nolan, Öztürk et al., 2016, 2017; Papageorgiou et al., 2018; Papakonstantinou et al., 2018; Parmar et al., 2019; Pasqualetti et al., 2018; Patel et al., 2018; Peel et al., 2017; Pelavski et al., 2017; Perera et al., 2009; Pollack et al., 2017; Poudel et al., 2016; Purser et al., 2006; Ritt et al., 2015; Rose et al., 2014; Sánchez et al., 2011; Sanchis et al., 2015; Sikder et al., 2019; Sündermann et al., 2014; Thai et al., 2015; Ticinesi et al., 2016; Valentini et al., 2018; Vidán et al., 2014; Wallis et al., 2015; Wou et al., 2013). Fifty-eight of the included studies were conducted among acute patients (Alonso Salinas et al., 2018; Amblàs-Novellas et al., 2018; Andela et al., 2010; Andrew et al., 2017; Blanco et al., 2017; Bo et al., 2016; Chew et al., 2017; Chong et al., 2017; Dent et al., 2014; Dorner et al., 2014; Eamer et al., 2018; Eeles et al., 2012; Ekerstad et al., 2011; Engelhardt et al., 2018; Gleason et al., 2017; Hartley et al., 2017; Hewitt et al., 2015; Hewitt et al., 2016; Hii et al., 2014; Ibrahim et al., 2019; Induruwa et al., 2017; Jokar et al., 2016; Joosten et al., 2014; Joseph et al., 2014; Joseph et al., 2016; Juma et al., 2016; Kang et al., 2015; Karlekar et al., 2017; Keevil et al., 2018; Kenig et al., 2015; Khan et al., 2019; Lee et al., 2018; Llaó et al., 2018; Ma et al., 2013; Madni et al., 2018; Martín et al., 2018; Mason et al., 2018; Maxwell et al., 2018; McGuckin et al., 2018; Morton et al., 2018; Müller et al., 2017; Myint et al., 2018; Parmar et al., 2019; Pasqualetti et al., 2018; Patel et al., 2018; Perera et al., 2009; Poudel et al., 2016; Purser et al., 2006; Ritt et al., 2015; Rose et al., 2014; Sánchez et al., 2011; Thai et al., 2015; Ticinesi et al., 2016; Vidán et al., 2014; Wallis et al., 2015; Wou et al., 2013) (eight specifically among acute trauma patients (Andela et al., 2010; Joseph et al., 2014, 2016; Karlekar et al., 2017; Khan et al., 2019; Lee et al., 2018; Maxwell et al., 2018; Müller et al., 2017)); twenty-six were conducted among surgical inpatients (Andela et al., 2010; Attisano et al., 2017; Cheung et al., 2017; Chia et al., 2016; Crozier-Shaw, Joyce, 2018; Dal Moro et al., 2017; Eamer et al., 2018; Engelhardt et al., 2018; Gleason et al., 2017; Goldfarb et al., 2018; Hewitt et al., 2015; Hewitt et al., 2016; Hii et al., 2014; Jokar et al., 2016; Kenig et al., 2015; Khan et al., 2019; Kobe et al., 2016; Lin et al., 2017; Mason et al., 2018; McGuckin et al., 2018; McIsaac et al., 2019; Myint et al., 2018; Parmar et al., 2019; Pelavski et al., 2017; Sikder et al., 2019; Sündermann et al., 2014) (seven specifically among general surgery inpatients (Engelhardt et al., 2018; Hewitt et al., 2015; Hewitt et al., 2016; Jokar et al., 2016; Khan et al., 2019; Mason et al., 2018; McGuckin et al., 2018); (of which six were specifically conducted among emergency general surgery inpatients (Engelhardt et al., 2018,

Hewitt et al., 2016, Jokar et al., 2016, Khan et al., 2019, Mason et al., 2018, McGuckin et al., 2018)); six specifically among cardiac surgery patients (Attisano et al., 2017; Drudi et al., 2018; Goldfarb et al., 2018; Hii et al., 2014; Kobe et al., 2016; Sündermann et al., 2014) (of which five were specifically among transcatheter aortic valve replacement surgery patients (Attisano et al., 2017; Drudi et al., 2018; Goldfarb et al., 2018; Kobe et al., 2016; Sündermann et al., 2014)); four specifically among abdominal surgery patients (Eamer et al., 2018; Kenig et al., 2015; Parmar et al., 2019; Sikder et al., 2019) (of which three were specifically among emergency abdominal surgery patients (Eamer et al., 2018, Kenig et al., 2015, Parmar et al., 2019)); four specifically among elective surgery patients (McIsaac et al., 2019; Pelavski et al., 2017; Sikder et al., 2019; Sündermann et al., 2014); and, two specifically among colorectal surgery patients (Chia et al., 2016, Crozier-Shaw, Joyce, 2018)). Twenty-three of the included studies were conducted among cardiac patients (Alonso Salinas et al., 2018; Attisano et al., 2017; Blanco et al., 2017; Bo et al., 2015; Drudi et al., 2018; Ekerstad et al., 2011; Goldfarb et al., 2018; Gullón et al., 2018; Hii et al., 2014; Induruwa et al., 2017; Kang et al., 2015; Kobe et al., 2016; Kusunose et al., 2018; Llaó et al., 2018; Nguyen et al., 2016; Papakonstantinou et al., 2018; Patel et al., 2018; Perera et al., 2009; Purser et al., 2006; Sánchez et al., 2011; Sanchis et al., 2015; Sündermann et al., 2014; Vidán et al., 2014) (seven specifically among acute coronary syndrome patients (Alonso Salinas et al., 2018; Blanco et al., 2017; Ekerstad et al., 2011; Kang et al., 2015; Llaó et al., 2018; Patel et al., 2018; Sanchis et al., 2015) (of which three were specifically among non-ST segment elevation myocardial infarction patients (Ekerstad et al., 2011, Llaó et al., 2018, Patel et al., 2018))); six specifically among atrial fibrillation patients (Bo et al., 2015; Gullón et al., 2018; Induruwa et al., 2017; Nguyen et al., 2016; Papakonstantinou et al., 2018; Perera et al., 2009); and, four specifically among aortic stenosis patients (Attisano et al., 2017; Drudi et al., 2018; Goldfarb et al., 2018; Kobe et al., 2016)); thirteen were conducted among emergency admissions patients (Eamer et al., 2018; Engelhardt et al., 2018; Hewitt et al., 2016; Jokar et al., 2016; Keevil et al., 2018; Kenig et al., 2015; Khan et al., 2019; Mason et al., 2018; McGuckin et al., 2018; Parmar et al., 2019; Pasqualetti et al., 2018; Sánchez et al., 2011; Wallis et al., 2015); eleven among general medicine patients (Andela et al., 2010; Dorner et al., 2014; Eeles et al., 2012; Gullón et al., 2018; Induruwa et al., 2017; Juma et al., 2016; Koyama, Öztürk et al., 2018, 2017; Papakonstantinou et al., 2018; Peel et al., 2017; Rose et al., 2014); eight among intensive care patients (Andrew et al., 2017; Baldwin et al., 2014; Guidet et al., 2018; Karlekar et al., 2017; Le Maguet et al., 2014; Muessig et al., 2018; Papageorgiou et al., 2018; Pollack et al., 2017); five among pulmonary patients (Andela et al., 2010; Andrew et al., 2017; Baldwin et al., 2014; Ma et al., 2013; Ticinesi et al., 2016); five among post-acute delayed transfer of care patients (Coleman et al., 2012; Dutzi et al., 2017; Ga et al., 2018; Heppenstall et al., 2011; Nolan et al., 2016); three among rehabilitation patients (Coleman et al., 2012; Dutzi et al., 2017; Nolan et al., 2016); two among oncology patients (Courtney-Brooks et al., 2012; Ferrero et al., 2017); two among neurological patients (Chew et al., 2017; Dutzi et al., 2017); two among fractures patients (Gleason et al., 2017; Valentini et al., 2018); two among urology patients (Dal Moro et al., 2017; Hilmer et al., 2011); two among psychiatric patients (Chew et al., 2017; Jacobs et al., 2017); and, two among pharmacology patients (Hilmer et al., 2011; Thai et al., 2015).

The overall pooled prevalence of frailty was 93% (95% CI 81.8–100%) among rehabilitation patients; 88.3% (95% CI 77.7–98.3%) among post-acute delayed transfer of care patients; 75.2% (95% CI 60.9.5–89.5%) among neurological patients; 66.8% (95% CI 61.5–72.2%) among psychiatric patients; 59.3% (95% CI 48.5–70.0%) among general (internal medicine) patients; 56% (95% CI 42.5–69.5%) among pulmonary patients; 50.0% (95% CI 32.4–67.6%) among fracture patients; 48.3% (95% CI 36.9–59.8%) among intensive care patients; 47.3% (95% CI 42.8–51.8%) among acute patients (40.9% (95% CI 33.2–48.5%) specifically among trauma patients); 45.8% (95% CI 38.3–53.4%) among cardiac patients (62.8% (95% CI 50.4–75.2%) specifically among atrial fibrillation patients; 45.9% (95% CI 38.3–53.4%) specifically among aortic stenosis patients; 34% (95% CI 27.9–40.2%) specifically among acute coronary syndrome patients (34.1% (95% CI 24.3–44%) specifically among non ST-segment elevation myocardial infarction patients)); 38.5% (95% CI 31–46.1%) among emergency admissions patients; 36.8% (95% CI 29.2–44.4%) among pharmacological patients; 32.4% (95% CI 28.9–36%) among surgical inpatients (44.1% (95% CI 36.1–52.1%) specifically among cardiac surgery patients (48% (95% CI 40–56%) specifically among transcatheter aortic valve replacement surgery patients); 34.8% (95% CI 29.7–40%) specifically among general surgery patients (36.1% (95% CI 30.5–41.6%) specifically among emergency general surgery patients); 31.3% (95% CI 17.1–45.5%) specifically among elective surgery patients; 26.1% (95% CI 13.3–38.9%) specifically among abdominal surgery patients (29% (95% CI 11.5–46.5%) specifically among emergency abdominal surgery patients); 22.5% (95% CI 17.9–27%) specifically among colorectal surgery patients); 32.3% (95% CI 9.5–55.1%) among urology patients, and; 23.2% (95% CI 10.2–36.3%) among oncology patients. Differences in the pooled prevalence estimates of frailty were statistically significant between clinical populations ($p < 0.001$) (Supplementary Figure J, Supplementary Table B). Additionally, with regard to two of the included studies, there was insufficient data to definitively determine a specific clinical population (further to initial distinction as geriatric hospital inpatients) (Oliveira et al., 2013), or insufficient data regarding the prevalence of frailty for different clinical populations within the study sample (Timmons et al., 2015) to facilitate inclusion in the above pooled prevalence analysis of frailty stratified by clinical population.

3.4. Association between the prevalence of frailty and economic indicators

A detailed list of all 96 included studies, reporting selected relevant study characteristics regarding the prevalence of frailty and economic indicators is displayed in Table 2:

3.4.1. Gross domestic product per capita purchasing power parity

As data were not normally distributed, a Spearman's rank correlation coefficient was employed to examine the association between the prevalence of frailty among geriatric hospital inpatients and GDP per capita PPP. No significant correlations were observed between the prevalence of frailty among geriatric hospital inpatients and GDP per capita PPP ($r = -0.081$, $p = 0.452$), the prevalence of pre-frailty among geriatric hospital inpatients and GDP per capita PPP ($r = 0.107$, $p = 0.423$), or a combination of prevalence of frailty and pre-frailty, and GDP per capita PPP ($r = 0.24$, $p = 0.857$).

3.4.2. Health care expenditure per capita purchasing power parity

Similar to the GDP per capita PPP analysis, these data were not normally distributed, and as such a Spearman's rank correlation coefficient was employed to examine the association between the prevalence of frailty among geriatric hospital inpatients and healthcare expenditure per capita PPP. No significant correlations were observed between the prevalence of frailty among geriatric hospital inpatients and healthcare expenditure per capita PPP ($r = 0–0.197$, $p = 0.071$), the prevalence of pre-frailty among geriatric hospital inpatients and healthcare expenditure per capita PPP ($r = 0.220$, $p = 0.097$), or a combination of prevalence of frailty and pre-frailty, and healthcare expenditure per capita PPP ($r = 0–0.146$, $p = 0.275$).

4. Discussion and conclusions

In this systematic review and meta-analysis, 96 studies were identified with an overall pooled sample of 467,779 geriatric hospital inpatients aged ≥ 65 years, which utilised a validated operational

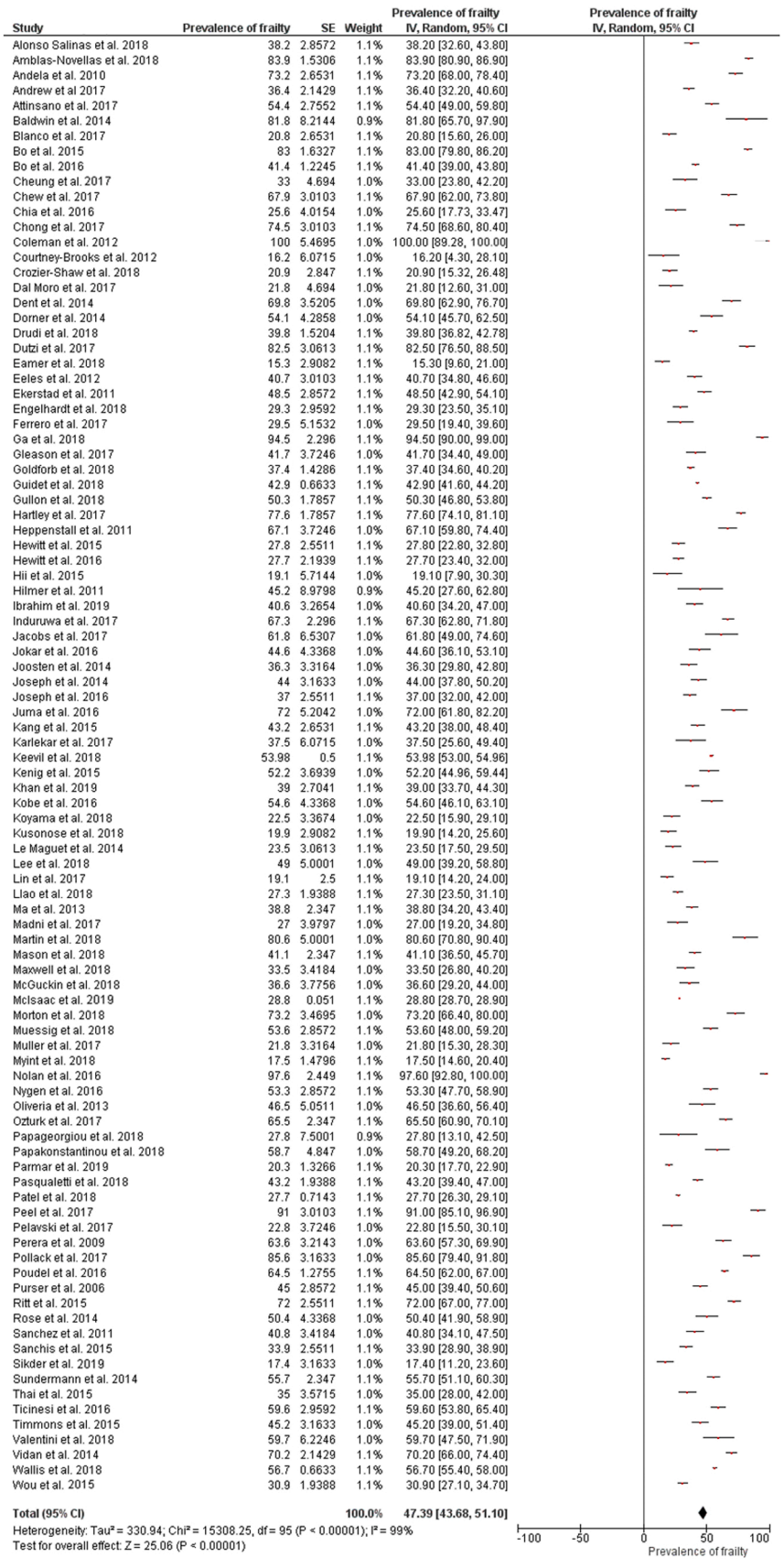

Fig. 2. Forest plot of the prevalence of frailty in the 96 studies identified through the systematic review process, including a total of 467,779 geriatric hospital inpatients.

Table 2
Selected study characteristics relating to economic analysis of included studies.

Author/Year	Country	Continent	Recruitment start date	Recruitment end date	Recruitment duration	Five-year average GDP per capita PPP (current international $) (years preceding the study*)	Five-year average healthcare expenditure per capita PPP (current international $) (years preceding the study*)	Prevalence of frailty (%)	Prevalence of pre-frailty (%)
Alonso Salinas et al. (2018)	Spain	Europe	October 2013	December 2015	30 months	32,520	2,914	38.2%	29.8%
Amblàs-Novellas et al. (2018)	Spain	Europe	January 2014	December 2014	12 months	32,208	2,913	83.9%	14.6%* *
Andela et al. (2010	)Netherlands	Europe	2009	2009	6 months	41,787	3,721	73.2%	N/A
Andrew et al. (2017)	Canada	North America	November 2011	May 2012	7 months	39,165	3,845	36.4%	45.3%
Attisano et al. (2017)	Italy	Europe	January 2016	December 2016	12 months	35,408	–	54.4%	–
Baldwin et al. (2014)	United States of America	North America	February 2012	July 2012	6 months	48,278	7,684	81.8%	18.2%
Blanco et al. (2017)	France	Europe	May 2014	July 2015	15 months	38,738	4,283	20.8%	28.8%
Bo et al. (2015)	Italy	Europe	January 2014	April 2014	4 months	34,839	3,195	83.0%	N/A
Bo et al. (2016)	Italy	Europe	January 2012	April 2012	4 months	35,198	3,056	41.4%	–
Cheung et al. (2017)	Australia	Australasia	March 2014	July 2014	5 months	43,268	3,779	33.0%	27.0%* *
Chew et al. (2017)	Singapore	Asia	December 2010	August 2012	21 months	65,975	1,982	67.9%	–
Chia et al. (2016)	Singapore	Asia	January 2007	December 2014	84 months	62,564	2,012	25.6%	–
Chong et al. (2017)	Singapore	Asia	November 2015	December 2015	2 months	78,401	2,732	74.5%	25.2%* *
Coleman et al. (2012)	Ireland	Europe	September 2009	December 2009	4 months	42,700	2,732	100.0%* *	0%* *
Courtney-Brooks et al. (2012)	United States of America	North America	March 2011	December 2011	10 months	47,555	7,540	16.2%	27.0%
Crozier-Shaw, Joyce (2018)	Ireland	Europe	2012	2016	180	47,616	4,623	20.9%	N/A
Dal Moro et al. (2017)	Italy	Europe	January 2014 * *	April 2015 * *	16 months* *	34,839	3,195	21.8%	16.7%* *
Dent et al. (2014)	Australia	Australasia	October 2010	December 2011	14 months	39,384	3,244	69.8%	26.2%
Dorner et al. (2014)	Germany	Europe	June 2011	October 2011	5 months	39,305	3,877	54.1%	21.8%
Drudi et al. (2018)	Multiple (United States of America, Canada, France)	Multiple (North America, Europe)	November 2011	April 2016	54 months	–	–	39.8%	–
Dutzi et al. (2017)	Germany	Europe	February 2011	December 2011	11 months	39,305	3,877	82.5%* *	13.0%* *
Eamer et al. (2018)	Canada	North America	January 2014	September 2015	21 months	42,109	4,300	15.3%	17.3%
Eeles et al. (2012)	Australia	Australasia	January 2001 * *	June 2001 * *	6 months* *	26,598	–	40.7%	N/A
Ekerstad et al. (2011)	Sweden	Europe	October 2009	June 2010	10 months	38,869	2,388	48.5%	25.4%
Engelhardt et al. (2018)	United States of America	North America	October 2016	December 2016	2.5 months	53,241	8,764	29.3%	N/A
Ferrero et al. (2017)	Italy	Europe	2006	2014	108 months	33,584	2,818	29.5%	N/A
Ga et al. (2018)	South Korea	Asia	March 2011	February 2017	72 months	30,504	1,911	94.5%* *	2.5%* *
Gleason et al. (2017)	United States of America	North America	August 2015	May 2016	9 months	51,568	8,451	41.7%	41.7%
Goldfarb et al. (2018)	Multiple (Canada, United States of America, France)	Multiple (North America, Europe)	2012	2017	72 months	–	–	37.4%	–

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Table 2 (*continued*)

Author/Year	Country	Continent	Recruitment start date	Recruitment end date	Recruitment duration	Five-year average GDP per capita PPP (current international $) (years preceding the study*)	Five-year average healthcare expenditure per capita PPP (current international $) (years preceding the study*)	Prevalence of frailty (%)	Prevalence of pre-frailty (%)
Guidet et al. (2018)	Multiple (Ireland, Great Britain, Portugal, Spain, France, Belgium, Denmark, Norway, Switzerland, Netherlands, Sweden, Russia, Germany, Austria, Poland, Czech Republic, Italy, Ukraine, Romania, Greece, Cyprus)	Europe	October 2016	February 2017	5 months	–	–	42.9%* *	19.4%* *
Gullón et al. (2018)	Spain	Europe	October 2014	May 2015	8 months	32,208	2,913	50.3%	–
Hartley et al. (2017)	United Kingdom	Europe	December 2014	May 2015	6 months	37,301	3,223	77.6%	10.0%* *
Heppenstall et al. (2011)	New Zealand	Australasia	–	–	–	–	–	67.1%* *	21.5%* *
Hewitt et al. (2015)	United Kingdom	Europe	May 2013	June 2013	2 months	36,808	3,012	27.8%	18.6%
Hewitt et al. (2016)	United Kingdom	Europe	July 2014	October 2014	4 months	37,301	3,223	27.7%	19.9%
Hii et al. (2014)	New Zealand	Australasia	February 2014 * *	March 2014 * *	1 month* *	32,445	3,098	19.1%	23.4%* *
Hilmer et al. (2011)	Australia	Australasia	February 2008	September 2009	19 months	34,406	2,713	45.2%	–
Ibrahim et al. (2019)	United Kingdom	Europe	March 2014	March 2016	25 months	37,929	3,349	40.6%	46.2%
Induruwa et al. (2017)	United Kingdom	Europe	January 2014	March 2014	3 months	37,301	3,223	67.3%	14.3%
Jacobs et al. (2017)	Netherlands	Europe	June 2014	December 2014	7 months	46,305	4,887	61.8%	–
Jokar et al. (2016)	United States of America	North America	2013	2014	24 months	49,689	8,053	44.6%	N/A
Joosten et al. (2014)	Belgium	Europe	January 2010 * *	November 2010 * *	10 months* *	38,015	3,360	36.3%	55.4%
Joseph et al. (2014)	United States of America	North America	June 2011	February 2013	21 months	48,824	7,540	44.0%	N/A
Joseph et al. (2016)	United States of America	North America	2013	2014	24 months	49,689	8,053	37.0%	37.8%
Juma et al. (2016)	Canada	North America	April 2013 * *	February 2014 * *	10.5 months* *	40,603	4,121	72.0%	6.7%
Kang et al. (2015)	China	Asia	December 2014	May 2015	6 months	10,280	3,098	43.2%	18.8%* *
Karlekar et al. (2017)	United States of America	North America	March 2015	May 2015	3 months	51,568	8,451	37.5%	32.8%
Keevil et al. (2018)	United Kingdom	Europe	October 2014	November 2016	26 months	38,531	3,454	54.0%	17.3%* *
Kenig et al. (2015)	Poland	Europe	January 2013	July 2014	19 months	21,761	1,378	52.2%	–
Khan et al. (2019)	United States of America	North America	2014	2016	24 months	51,659	8,497	39.0%	–
Kobe et al. (2016)	Multiple	Europe	September 2011	November 2014	39 months	–	–	54.6%	N/A
Koyama et al. (2018)	Japan	Asia	November 2016	December 2017	14 months	38,756	4,191	22.5%	37.7%
Kusunose et al. (2018)	Japan	Asia	December 2015	July 2016	8 months	37,755	3,958	19.9%	61.3%
Lee et al. (2018)	United States of America	North America	January 2014	August 2015	20 months	50,808	8,325	49%	N/A
Le Maguet et al. (2014)	France	Europe	November 2011	May 2012	7 months	36,485	3,715	23.5%	31.6%

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Table 2 (*continued*)

Author/Year	Country	Continent	Recruitment start date	Recruitment end date	Recruitment duration	Five-year average GDP per capita PPP (current international $) (years preceding the study*)	Five-year average healthcare expenditure per capita PPP (current international $) (years preceding the study*)	Prevalence of frailty (%)	Prevalence of pre-frailty (%)
Lin et al. (2017)	Australia	Australasia	July 2014	January 2015	7 months	43,268	3,779	19.1%	36.6%
Llaó et al. (2018)	Spain	Europe	March 2016 * *	September 2016 * *	7 months* *	33,038	2,994	27.3%	–
Ma et al. (2013)	China	Asia	October 2009	September 2010	12 months	6344	254	38.8%	13.8%
Madni et al. (2018)	United States of America	North America	April 2009	December 2014	69 months	47,787	7,487	27.0%	34.1%
Martín et al. (2018)	Spain	Europe	March 2014	July 2014	5 months	32,208	2,913	80.6%	19.4%
Mason et al. (2018)	United Kingdom	Europe	November 2016	July 2017	9 months	40,188	3,724	41.1%	17.5%* *
Maxwell et al. (2018)	United States of America	North America	October 2013	March 2014	6 months	49,015	7,936	33.5%	37.8%
McGuckin et al. (2018)	United Kingdom	Europe	June 2012	January 2013	8 months	36,503	2,907	36.6%	14.0%
McIsaac et al. (2019)	Canada	North America	April 2002	March 2015	156 months	35,285	–	28.8%	–
Morton et al. (2018)	United Kingdom	Europe	June 2017 * *	July 2017 * *	1 month* *	40,781	3,850	73.2%	–
Muessig et al. (2018)	Germany	Europe	October 2016	February 2017	5 months	45,468	4,944	53.6%	22.7%
Müller et al. (2017)	Switzerland	Europe	March 2016	June 2016	4 months	57,295	4,944	21.8%	59.6%
Myint et al. (2018)	United Kingdom	Europe	May 2013	June 2014	14 months (only recruited for 4 months within this time frame)	37,301	3,012	17.5%	12.6%
Nolan et al. (2016)	Ireland	Europe	August 2013	January 2014	6 months	37,301	3,012	97.6%	2.4%
Nguyen et al. (2016)	Australia	Australasia	October 2012	January 2014	16 months	41,762	3,531	53.3%	–
Oliveira et al. (2013)	Brazil	South America	November 2010	November 2010	1 month	12,435	1,019	46.5%	49.5%
Öztürk et al. (2017)	Turkey	Europe	March 2015	October 2015	8 months	20,092	951	65.5%	26.2%
Papageorgiou et al. (2018)	Greece	Europe	June 2016	May 2017	12 months	26,015	2,221	27.8%	22.2%
Papakonstantinou et al. (2018)	Greece	Europe	June 2015	June 2016	12 months	26,521	2,324	58.7%* *	30.8%* *
Parmar et al. (2019)	United Kingdom	Europe	March 2017	June 2017	3 months	40,781	3,850	20.3%	21.2%
Pasqualetti et al. (2018)	Italy	Europe	May 2015	December 2016	20 months	35,300	3,235	43.4%	25.2%
Patel et al. (2018)	Australia	Australasia	2009	2016	96 months	41,664	3,557	27.7%	–
Peel et al. (2017)	Australia	Australasia	July 2012	June 2013	12 months	41,150	3,479	91.0%	5.6%
Pelavski et al. (2017)	Spain	Europe	October 2011	October 2015	49 months	32,414	2,821	22.8%	51.2%
Perera et al. (2009)	Australia	Australasia	April 2007	July 2007	4 months	34,406	2,713	63.6%	–
Pollack et al. (2017)	United States of America	North America	February 2012	February 2016	49 months (only recruited for 29 months within this time frame)	50,125	8,069	85.6%	12.8%* *
Poudel et al. (2016)	Australia	Australasia	May 2005	July 2010	59 months	35,202	2,801	64.5%	–
Purser et al. (2006)	United States of America	North America	May 2003	February 2004	10 months	35,744	–	45.0%	–
Ritt et al. (2015)	Germany	Europe	–	–	–	–	–	72.0%	21.8%
Rose et al. (2014)	Australia	Australasia	May 2012	June 2012	2 months	41,150	3,479	50.4%	17.3%
Sánchez et al. (2011)	Spain	Europe	February 2008	March 2008	2 months	29,823	2,210	40.8%	–
	Spain	Europe			17 months	31,869	2,622	33.9%	58.8%* *

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Table 2 (*continued*)

Author/Year	Country	Continent	Recruitment start date	Recruitment end date	Recruitment duration	Five-year average GDP per capita PPP (current international $) (years preceding the study*)	Five-year average healthcare expenditure per capita PPP (current international $) (years preceding the study*)	Prevalence of frailty (%)	Prevalence of pre-frailty (%)
Sanchis et al. (2015)			October 2010	February 2012					
Sikder et al. (2019)	Canada	North America	–	–	–	–	–	17.4%	60.4%
Sündermann et al. (2014)	Germany	Europe	September 2008	March 2010	19 months	36,095	3,413	55.7%* *	N/A
Thai et al. (2015)	Australia	Australasia	July 2014	October 2014	2.5 months	43,268	3,779	35.0%	–
Ticinesi et al. (2016)	Italy	Europe	January 2015	October 2015	10 months	35,136	3,225	59.6%* *	24.1%* *
Timmons et al. (2015)	Ireland	Europe	May 2012	February 2013	10 months	43,849	4,308	45.2%	20.6%
Valentini et al. (2018)	Italy	Europe	March 2014	March 2015	13 months	34,839	3,195	59.7%	21.0%
Vidán et al. (2014)	Spain	Europe	May 2009	May 2011	25 months	31,205	2,476	70.2%	–
Wallis et al. (2015)	United Kingdom	Europe	August 2013	July 2014	12 months	37,248	3,152	56.7%	17.8%
Wou et al. (2013)	United Kingdom	Europe	January 2009	November 2010	23 months	34,809	2,585	30.9%	–

* = 5 years prior to commencement of data collection for the study. Each calendar year of the study was also be included provided recruitment continues through to > 6 months in the preceding year. **= Data not initially reported, or possible to derive from available data. Obtained, or derived, from correspondence with study authors.

definition of frailty, attempted to assess the whole ward/clinical population, occurred in a hospital setting, in or including hospital inpatients, and reported, or provided sufficient information to allow the calculation of, the prevalence of frailty. Included studies were conducted in 21 countries, across five continents. The overall pooled estimate of frailty was 47.4%; although this varied significantly based on prevalent morbidities, age, ward type, clinical population, and the operational definition utilised for the classification of frailty. To the authors' knowledge, this is the largest and most comprehensive systematic review and meta-analysis of the prevalence of frailty among older adults conducted in any setting, and the first well-evidenced systematic review and meta-analysis among geriatric hospital inpatients.

The overall pooled prevalence estimate of frailty of 47.4%, places the prevalence of frailty among geriatric hospital inpatients between that reported for community-dwelling older adults at 10.7% (Collard et al., 2012), and older adults in nursing homes at 52.3% (Kojima, 2015); outlining an increase in the relative prevalence of frailty with progression through the healthcare system. The overall pooled prevalence of pre-frailty of 25.8% is lower than that reported for both community-dwelling older adults at 41.6% (Collard et al., 2012), and nursing home residents at 40.2% (Kojima, 2015); while the combined prevalence estimates of both frailty and pre-frailty increase from 52.3% among community-dwelling older adults, to 73.2% among geriatric hospital inpatients, and to 92.5% among nursing home residents. This underlines that differences in the relative prevalence of frailty status between community, and hospital inpatient settings, are the result of an increase in the relative prevalence of frailty, and similar reductions in the relative prevalence of both pre-frailty and robustness. However, differences in the relative prevalence of frailty status between hospital inpatient and nursing home settings, these data show, are primarily the result of a relative increase in the prevalence of pre-frailty, and reductions in the prevalence of robustness.

The overall pooled frailty, and pre-frailty, prevalence estimates of 47.4% (95% CI 43.7–51.1%), and 25.8% (95% CI 22.0–29.6%) respectively, are relatively consistent with, though more precise than, estimates reported within a recent systematic review and meta-analysis which examined the prevalence of frailty and pre-frailty among hospitalised older adults in 11 studies which also assessed undernutrition risk, at 47% (95% CI 37–57%) and 36% (95% CI 29–44) respectively (Ligthart-Melis et al., 2020). Similarly, the pooled prevalence estimates of frailty on acute wards of 51.1% (95% CI-35.9–66.2%), as well as among all acute hospital inpatients, of 47.3% (95% CI 42.8–51.8%), are relatively consistent with findings of a recent scoping review, which reported a median frailty prevalence of 49% (range 34–69%) in acute care hospital settings (Theou et al., 2018). Further, no significant differences in the prevalence of frailty were observed in stratified analyses by sex. This is in contrast to systematic reviews and meta-analysis of the prevalence of frailty among community-dwelling older adults (Collard et al., 2012; Siriwardhana et al., 2018; He et al., 2019). However, consistent with the findings of systematic reviews and meta-analysis among other clinical populations of older adults such as nursing home residents (Kojima et al., 2015). These findings contribute to the literature illustrating sex differences in the prevalence of frailty among community dwelling older adults, may dissipate among clinical geriatric populations.

No significant associations were observed between the prevalence of frailty among geriatric hospital inpatients and GDP per capita PPP, and healthcare expenditure per capita PPP. This contrasts with previous research among community-dwelling older adults within 14 European countries, and Israel, conducted utilising data from the Survey of Health, Ageing, and Retirement in Europe (SHARE). This cross-sectional analysis examined the association between GDP per capita PPP, and health expenditure as a percentage of GDP, and the prevalence of frailty among community-dwelling older adults assessed by the frailty index. Fifteen observations of the weighted national prevalence of frailty for community-dwelling older adults in each country were correlated with both national economic indicators, and reported strong correlation between GDP per capita PPP ($r = -0.71$, $p < 0.01$), and healthcare expenditure as a percentage of GDP ($r = -0.63$, $p < 0.05$), and the prevalence of frailty among community-dwelling older adults (Theou et al., 2013).

It is possible that these associations, while present in the community,

are not present in inpatient hospital settings. Given the inherent nature of hospital inpatient settings, i.e., institutions for chronically or acutely unwell patients, this association may be more sensitive among the general population of community-dwelling older adults; however, more large-scale and comprehensive studies are required in a variety of settings. Given the lack of statistically significant differences in the pooled prevalence of frailty stratified by continent within this present review alone, this may not be surprising, however, significant differences in the prevalence of frailty were observed between countries. In this regard, an additional limitation of these analyses is that included studies were predominantly from economically-developed countries, as there is presently limited evidence regarding the prevalence of frailty in low-income countries; an issue which has been observed previously in a meta-analysis of the prevalence of frailty among community-dwelling older adults in middle-, and low-income countries (Siriwardhana et al., 2018). To the authors' knowledge, this present review is the first study of any design to examine the association between the prevalence of frailty among geriatric hospital inpatients and national economic indicators. It has been postulated that increases in economic prosperity may limit the prevalence and burden of frailty within national health systems (Theou et al., 2013). However, these findings bring this postulation into question among geriatric hospital inpatients, and as such reliance of non-direct intervention such as economic development, to improve the prevalence and burden of frailty on health systems alone, appears, at least partially, to be misplaced. As such the findings of this review further suggests the need for more direct interventions to address the burden of frailty among this population. Future research examining the prevalence of frailty among geriatric hospital inpatients in low-income countries may facilitate further elucidation of this relationship, as these data become available for less economically developed regions of the world. Although, it may be that this relationship does not exist in the same capacity as it appears to among community-dwelling older adults, to the authors' knowledge the study by Theou et al. (2013) is the only study to previously examine this relationship. As such, additional studies, in a variety of settings, may aid in elucidating this relationship further.

This systematic review and meta-analysis had many strengths, including extensive systematic searches of 17 databases; manual screening of the reference lists of all included articles (and relevant studies or systematic reviews captured within platform and database searches); the screening of grey literature, including in process publications, and conference abstracts, which were followed up with study authors to ascertain if a full text relating to these data were available; employment of three independent reviewers during the screening phase of the review, ensuring high internal reliability and consistency of included articles; the utilisation of meticulously defined eligibility criteria; the employment of two independent data extractors and quality assessors; an extensive data procurement strategy, including contacting 517 authors to obtain additional information relevant to inclusion within different aspects of the review; robust analysis of the prevalence of frailty stratified by clinically useful variables; and a comprehensive record of all information pertaining to the review process available as supplementary materials.

This review also had a number of important limitations that should be considered when interpreting these findings. Firstly, only studies with a full text available in the English language were eligible for inclusion, as this was the only shared language between the three independent reviewers. As such included studies may be relatively over-representative of Western nations (Europe, Australasia, and the Americas), and there is a possibility that this review does not include otherwise eligible studies whose full texts are not available in the English language. However, in this regard, any potentially eligible studies, with an English translated abstract, and full text in other languages, were followed up with study authors in an attempt to obtain an English full text to facilitate thorough screening. Secondly, high heterogeneity was reported across many analyses, and persisted across many univariate stratification analyses. Thirdly, a strength, but also a limitation of this review, was with regard to the specific eligibility criteria employed within this present review, requiring prospectively eligible studies to either assess (or attempt to assess) the whole ward, department, unit, hospital, or specific clinical population, or employ some form of randomised selection of participants. Any exclusion criteria employed within individual studies, in order to meet this criterion, had to meet one of two stipulations: (1) the criterion was essential to defining the clinical population; (2) the criterion is related to insurmountable impracticalities which precluded inclusion of certain individuals. Provided all of a study's exclusion criteria adequately met either of these two stipulations during screening, they were deemed to have sufficiently satisfied the above eligible criterion for the review of having either assessed, or attempted to assess, the entire ward/department/unit/clinical population or employed some form of randomised selection of participants. While such comprehensive stipulations prevented inclusion of any studies with active bias in the recruitment process, those that could be not be recruited in some studies due to impracticalities of inclusion, may also in many cases, be more likely to be frail e.g., those receiving end of life care in a study utilising an objective operational definition for the classification of frailty. Fourtly, an important limitation regarding the economic analyses, is that these data while collected in a systematic manner, incorporating all relevant data which exist in this regard, are unlikely to be precisely nationally representative as they have not (1). assessed the entire population of geriatric hospital inpatients within each country; or (2). been weighted against for example a hypothetical nationally representative databases of geriatric hospital inpatients with regard relevant variables in each country. Future research should further attempt to determine and examine precisely nationally representative data. However, availability of nationally representative data employing appropriate weighting for geriatric hospital inpatients by relevant variables may be difficult, and likely pose substantial feasibility issues regarding accurate facilitation, particularly across nations, without considerable resource investment. Finally, while contributing substantially to the obtainment of further data for these analyses, contacting several hundred authors for these additional data added to the timeline for this review beyond the initial search period.

Through providing a highly detailed analysis of the prevalence of frailty among older people within this setting, the aim of this present review was to provide a resource, which can aid in the facilitation of improvements in the planning, and orientation of organisational structures and resources, to meet the needs of this population, and ultimately enhance the care of older adults with frailty in inpatient hospital settings. Future research, particularly in developing countries, may help to further elucidate any potential relationship regarding national economic indicators and the prevalence of frailty among geriatric hospital inpatients. As frailty is a relatively new concept, particularly as an operationally defined one, with most studies cited within this review published in the past 20 years, it is the intention of the authors to update this review periodically, to examine the potential change in frailty over time, particularly as it relates to national policy directives, and economic indicators as data become available for less developed regions of the world.

More generally the authors have several recommendations with regard to improving reporting in future frailty research among hospitalised older adults, as well as within other settings. These recommendations arise from the following issues which are persistent in the frailty literature, and were continually observed during the screening process for this review (Appendix 3–6): (1) studies often reported participants as frail without a frailty assessment; (2) studies often claimed to utilise validated operational definitions for the classification of frailty, however, adapt these definitions, or classification criteria, which resulted in the definitions becoming not only non-standardised, but also non-validated; (3) the use of the nomenclature for different operational definitions of frailty varied widely, even among studies utilising the same operational definition; (4) often, useful data regarding

the prevalence of frailty (such as pre-frailty, a sex breakdown of frailty, or occasionally the overall prevalence of frailty itself) were not reported.

Reporting in this regard may be improved by a brief standardised checklist for studies reporting frailty data. The authors suggest the following items for inclusion: (1) accurate citation of the validation study for the specific operational definition utilised for the classification of frailty; (2) accurate use of the nomenclature of the operational definition of frailty utilised in accordance with the initial validation study to maintain reliability and validity, or prominent subsequent study establishing the nomenclature; (3) reporting of the number of frail, pre-frail (if applicable), and robust participants; (4) a sex breakdown of the number of frail, pre-frail, and robust participants.

Given the association of frailty at the individual level with increased healthcare costs, combined with projected population demographics, future research should focus on interventions to reduce the prevalence of frailty among geriatric hospital inpatients. Particularly as hospitalisation is associated with a further decline in functional capacity, interventions to mitigate this decline, and reduce the rate of subsequent rehospitalisation of older adults with frailty are important issues to be addressed. This is particularly the case as future demographic trends predict the overall number of frail older adults to increase dramatically in developed countries in the coming decades as the population ages (Hoogendijk et al., 2019). This will be further exacerbated by declining fertility rates in economically developed countries, which are projected to cause an increase in dependency ratios across the developed world (Murray et al., 2018; United Nations Department of Economic and Social Affairs Population Division, 2019; Vollset et al., 2020). It is in this context that frailty, particularly in older age, has been described as *"without question, one of the most serious public health challenges we will face in this coming century"* (Dent et al., 2019).

In summary, this systematic review and meta-analysis found that approximately half of all hospital inpatients aged $\geq$ 65 years are frail, and approximately another 25% are pre-frail. These patients may benefit from interventions targeted at improving frailty status and preventing the functional decline associated with hospitalisation in this population, which can lead to further functional deterioration, recurrent readmission, and adverse health outcomes among these patients.

Registration

PROSPERO registration number 79202.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.arr.2022.101666.

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