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Review



Recent developments in frailty identification, management, risk factors and prevention: A narrative review of leading journals in geriatrics and gerontology

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ABSTRACT

Frailty is an age-related clinical condition characterised by an increased susceptibility to stressors and an elevated risk of adverse outcomes such as mortality. In the light of global population ageing, the prevalence of frailty is expected to soar in coming decades. This narrative review provides critical insights into recent developments and emerging practices in frailty research regarding identification, management, risk factors, and prevention. We searched journals in the top two quartiles of geriatrics and gerontology (from Clarivate Journal Citation Reports) for articles published between 01 January 2018 and 20 December 2022. Several recent developments were identified, including new biomarkers and biomarker panels for frailty screening and diagnosis, using artificial intelligence to identify frailty, and investigating the altered response to medications by older adults with frailty. Other areas with novel developments included exercise (including technology-based exercise), multidimensional interventions, person-centred and integrated care, assistive technologies, analysis of frailty transitions, risk-factors, clinical guidelines, COVID-19, and potential future treatments. This review identified a strong need for the implementation and evaluation of cost-effective, community-based interventions to manage and prevent frailty. Our findings highlight the need to better identify and support older adults with frailty and involve those with frailty in shared decision-making regarding their care.

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1. Introduction

Frailty is a clinical state characterised by heightened vulnerability to adverse health outcomes as the result of physiological decline in multiple organ systems (Clegg et al., 2013). The condition is a non-compulsory part of the ageing process and is a major threat to the quality of life and functional independence of older adults (Dent et al., 2019a). Older adults with frailty are less resilient to external stressors such as illness and injury (Clegg et al., 2013) and have an increased likelihood of admission to long-term care, hospitalisation, and pre-mature mortality (Dent et al., 2019a; Hoogendijk et al., 2019). Individuals with frailty can additionally face unmet care needs due to an absence of continuity of care (eg post-hospital care), and difficulties accessing health and social care services (Hoogendijk et al., 2014).

Frailty is common, with up to 12% of community dwelling older adults are living with frailty (O’Caoimh et al., 2021) with this prevalence increasing up to over 40% in long-term care settings (Hoogendijk et al., 2019). Globally, there is an increasing recognition of frailty as a public health priority (Gwyther et al., 2018; Harvey et al., 2022; Hoogendijk et al., 2019; Pérez-Zepeda et al., 2021). Yet, frailty continues to remain a global public health concern due to population ageing and increases to life expectancy (Thillainadesan et al., 2020).

Identifying frailty in older populations has several advantages. In clinical practice, frailty assessment can be incorporated into treatment decision making and outcome prediction for older persons, and in turn guide appropriate management (Rane and Orkaby, 2021; Rodríguez-Mañas and Rodríguez-Sánchez, 2021). Monitoring frailty can also be used to design individually tailored interventions, and in turn prevent the progression, and in some cases, reverse frailty (Travers et al., 2019). In addition, knowing the prevalence of frailty in older populations can inform the development, implementation and evaluation of community-based interventions targeting the condition’s prevention and management (Dent et al., 2019a; Hoogendijk et al., 2019).

Research into frailty has never been more prominent as it is now (Hoogendijk and Dent, 2022). Progress regarding the identification, treatment and prevention of frailty has grown exponentially in recent years. The aim of this narrative review was to identify recent developments and emerging practices in the care of older people with frailty, including the identification of evidence-based gaps in both research and clinical practice. We look at developments in the past five years (2018–2022) in research on the identification, management, risk factors, and prevention of frailty in older adults in both the community and hospital settings. We did not restrict our literature search to a specific frailty model, so it includes literature on any frailty model, including the two dominant conceptual models of frailty, which are Fried’s frailty phenotype (Fried et al., 2001) and Rockwood’s frailty index (FI) of accumulated deficits (Mitsitski et al., 2001). Findings from our review can be used to navigate areas of research need, raise awareness of health service needs for older adults with frailty, inform healthcare policy and practice, and facilitate the development of future evidence-based clinical practice guidelines.

2. Methods

This narrative review identified recent developments and emerging practices in the field of frailty, including potential directions for further research. We followed the methodology of Keller and colleagues’ (Keller et al., 2021). Our review included Quartile 1 and Quartile 2 journals in ‘Geriatrics and Gerontology’ (based on their 2021 Impact Factor from Clarivate Journal Citation Reports). Only journals which focused on human studies of frailty were included, totally 23 journals (see Appendix A). We searched the PubMed database (all identified journals were indexed in PubMed) for articles from 01 January 2018–20 December 2022 using the key search terms ‘frail’, ‘frailty’, and ‘frail elderly’ in combination with journal names (see Appendix B). Four overarching inclusion/exclusion criteria were considered: article type (reviews,

research articles, editorials, commentaries, and opinion pieces), population type (≥ 65 years with (pre)frailty but without specific diseases), solution-focused, and presenting novel findings (see Table 1). To synthesise findings, articles were categorised into themes based on their main subject matter.

3. Results

Fig. 1 outlines the number of publications per year on the topic of ‘frailty’ identified in the top 50% journals in geriatrics and gerontology from 1 January 2018–22 December 2022. Only 15 of the included journals contained relevant articles. Table 2 provides a summary of novel findings, article type(s) and future research needed.

3.1. Frailty identification

3.1.1. Implementation of frailty screening

Frailty screening instruments should be simple, cost-effective, and able to identify the early onset of frailty (Thillainadesan et al., 2020). Areas of emerging research include the feasibility of widespread screening for frailty, including how to address the stigma attached with being labelled ‘frail’, what factors affect the accuracy of screening instruments, and consumer and staff perspectives of frailty screening (Thillainadesan et al., 2020). One study suggested the need to identify potentially modifiable frailty and emphasised the importance of frailty screening for the purposes of designing a cost-effective healthcare system (Fan et al., 2021). Simple screening instruments (eg which use tape measures or stopwatches) are re-emerging in popularity (Jung et al., 2018). Similarly, affordable wearable technologies for the early identification of frailty are gaining increased attention in research and clinical practice (Anabitarte-García et al., 2021).

3.1.2. Identification of frailty using electronic medical records or claims data

Population stratification involves identifying a group of older adults in which frailty is likely, allowing for further assessment of frailty in the individual. For example, the electronic frailty index (eFI) is nowadays a common population stratification tool derived from electronic medical records (EMRs).

Several novel studies used artificial intelligence and other data-driven approaches to develop eFIs, as for example the Primary Care Frailty Index (PC-FI) (Zucchelli et al., 2020), and other tools developed across medical specialties (Callahan et al., 2021; Nghiem et al., 2020; Rejeski et al., 2022). Similarly, the recently developed Pathfield’s tool was developed by reprogramming primary care information technology

Table 1
Study inclusion and exclusion criteria.

	Inclusion Criteria	Exclusion Criteria
Type of Study	Review Research articles Editorials Commentaries Opinion Pieces	All other study types
Participant Eligibility	≥ 65 years with (pre) frailty	Co-morbid chronic disease (eg diabetes, arthritis, dementia) Receiving palliative care/end-of-life care Critical care patients Frailty sub-types (eg cognitive, social, nutritional and oral frailty)
Solution-focused Novel Topics	Focused on a solution to an identified issue. Provides new findings, insights, ideas, or perspectives	Prevalence studies Validation studies Articles which are not informative, and add no new insights or analyses to improve current understanding.

Based on the inclusion and exclusion criteria of Keller and colleagues’ (Keller et al., 2021)

to systematically identify older patients likely to be living with undiagnosed frailty (Attwood et al., 2020).

An emerging research area is the development of a claims-based FI (Joynt Maddox et al., 2019; Kim et al., 2020; Pajewski et al., 2019). Claims-based FIs are developed from government claims-based health data that is collected after patient encounters and are a promising avenue for additional research. Importantly, it is not yet known to what extent claims-based FIs are more susceptible to the limitations of EMR-based approaches (eg dependency on data quality).

3.1.3. Clinical assessment of frailty

Innovations included telephone-based frailty assessment (Sison et al., 2022), using artificial intelligence (AI) to assess frailty (Roller-Wirnsberger et al., 2020), and the development of frailty profiles (sub-types of frailty) (Segaux et al., 2019). Sub-types include ‘weight-loss, slowness, and osteoporosis’ and ‘impaired balance, cognitive function, and depression’ amongst others (Segaux et al., 2019). One article stated the necessity for frailty to be part of surgical pre-assessment (McCarthy and Hewitt, 2020). An emerging debate in the literature is whether frailty should be separated into age-related frailty and disease-related frailty (Cesari, 2019), with differences between the two frailty sub-types noted (Angioni et al., 2020).

3.1.4. Screening and diagnostic biomarkers

Biomarkers for frailty can be considered as ‘proxies for physiological dysregulation’ (Picca and Calvani, 2020), for instance endocrine dysfunction, immune system impairment, and increased inflammation. These biomarkers can be circulating (eg CRP, haemoglobin, albumin, 25-hydroxy vitamin D (25OHD), free testosterone (Mailiez et al., 2020), tumor necrosis factor alpha (Picca et al., 2022), and serum angiotensin-converting enzyme 2 activity (Sanz et al., 2022)), salivary (eg salivary α-amylase (Furtado et al., 2020)), urinary (eg hippuric acid (De Simone et al., 2021) and the oxidative stress biomarker urinary 8-oxo-7,8-dihydroguanosine (8-oxo-Gsn) (Jiang et al., 2020)), detected on skin (eg advanced glycation end-products detected by skin autofluorescence) (Waqas et al., 2022), or identified by brain magnetic resonance imaging (eg white matter hyperintensities) (Siejka et al., 2020). Other newly identified physiologic biomarkers for frailty included gait plasticity (Noguerón García et al., 2020), and respiratory muscle strength (Vidal et al., 2020). One lipidomic study identified a panel of five metabolites (the ceramides Cer (40:2), Cer (d18:1/20:0), Cer (d18:1/23:0), cholesterol, and phosphatidylcholine (PC

(14:0/20:4)) which could be used to identify frailty in hospitalised older adults (Ramírez-Vélez et al., 2022).

It was proposed by one article that the frailty phenotype was best suited for studies of biomarkers of frailty screening, given that the FI incorporates chronic conditions (Zampino et al., 2020). However, we observed that the FI and frailty phenotype were both frequently used in articles of screening and diagnostic biomarkers for frailty.

Some of the frailty-associated biomarkers are also known for their links with biological ageing. As such, they can be organised into one of several categories (which include, amongst several other categories): endocrine dysfunction, immune system impairment, mitochondrial dysfunction/genomic instability, cellular senescence, epigenetic alterations, loss of proteostasis, impaired nutrient signalling, stem cell exhaustion, and altered communication (by inflammation) (Gonçalves et al., 2022). Crucially, given that biomarkers can also be used to detect other chronic conditions, no single biomarker can solely detect frailty (Zampino et al., 2020). Thus, biomarker panels which combine several biomarkers may be the future preferred method for identifying frailty (Cardoso et al., 2018). For example, combining muscle, endocrine, and immune biomarkers were proposed as potential biomarker panel for frailty identification (Pillatt et al., 2021).

Genetic features of frailty can potentially be used as biomarkers for frailty identification, with research beginning to focus on this topic. Twin studies can be used to assess the proportions of variance arising from environmental and genetic (ie. quantitative genetics) sources for a trait of interest. Such studies in UK and Swedish twin samples have demonstrated frailty is moderately heritable, the estimates ranging from 25% to 52% for the FI (Livshits et al., 2018; Mak et al., 2021b). One of these studies also looked at sex differences and found that the heritability of frailty is slightly higher in women than in men (52% vs 45%) (Mak et al., 2021b). Other genomic features, such as epigenetics have been studied for their associations with frailty. Epigenetic clocks refer to composite measures of DNA methylation levels across several sites in the genome and measure individual’s biological age. We identified two studies which did not find that higher epigenetic clock values were associated with higher frailty/change in frailty (Bacalini et al., 2021; Seligman et al., 2022). Given that genetic research into frailty is a very new topic, more evidence is understandably required to verify and extend findings, including with large-scale studies with more frequent frailty measurement (Seligman et al., 2022). Of note, molecular genetics of a trait are nowadays studied using genome-wide association studies (GWASs), which are considered the only reliable source of molecular

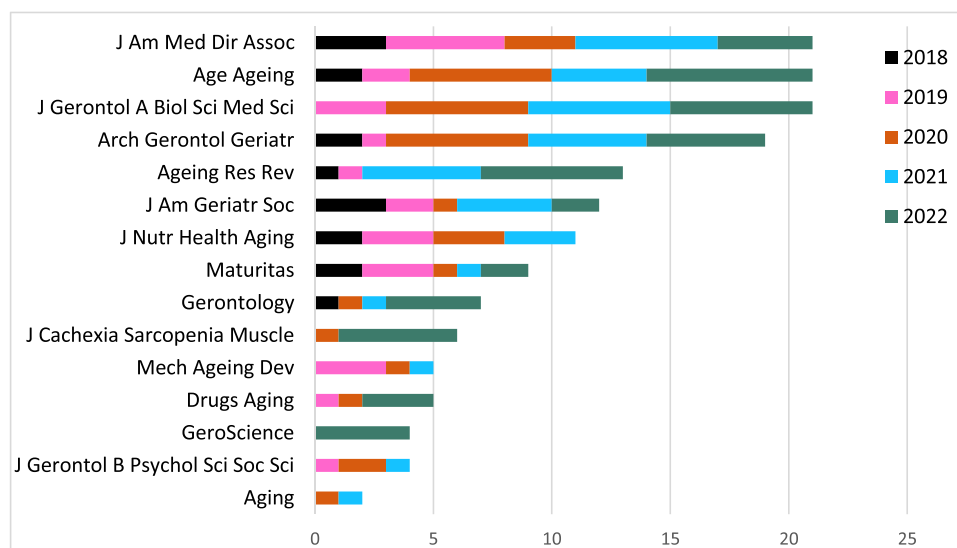


Fig. 1. Number of human studies of frailty on recent developments and emerging practices published in Q1 and Q2 journals in ‘geriatrics and gerontology’ per journal per year between 1st January 2018–20 December 2022. Journals not listed did not contain articles on frailty which were included in this review.

Table 2

Summary of novel findings and future research needed for studies of the identification, management, risk factors and prevention of frailty in older adults.

Category	Number of Articles (n)	Novel findings	Areas for Future Research
Identification			
Implementation of frailty screening	4	Simple frailty screening instruments are showing a resurgence, and there is an emerging awareness of the stigma of being labelled 'frail' by frailty screening instruments.	The feasibility and acceptability of widespread screening, including the perspectives of healthcare professionals and older adults (ie do older adults want frailty screening, or see it as important?).
Identification using electronic medical records or claims data	8	Novel methods include the use of artificial intelligence to identify individuals with frailty from electronic medical records.	The accuracy and clinical applicability of new frailty case-finding methods.
Clinical Assessment of Frailty	6	Recently developed frailty assessment methods include artificial intelligence-based assessment, frailty profiles and telephone-based assessment.	The validation and feasibility of novel methods for frailty assessment.
Screening and diagnostic biomarkers	26	Several novel biomarkers for frailty are under investigation, including skin autofluorescence, salivary α -amylase, and genetic features of frailty. Machine learning is being used to detect frailty biomarkers.	Biomarker panels, sex differences in biomarkers, and the overlap of frailty and biological ageing biomarkers. Genome-wide association studies should be used for future biomarker research.
Management			
Exercise and Physical activity	12	Strength-based training remains the most effective strategy to combat frailty. Intervention costs are balanced by lower healthcare use. Exercise modes improving frailty outcomes include computerised-based training, exergames, inspiration and body vibrational training, muscle power training, and dance. ADL/QoL may only improve if physical outcomes improve.	Evaluation of exercise adherence, understanding how to overcome barriers to adherence, identifying which delivery mode is best (eg home-based, group classes and/or technology-based exercise), and incorporating exergames into multicomponent interventions. Larger scale and longer duration studies are needed.
Oral Health	3	There is a call for all older adults with frailty to be screened for oral disease, paired with referral for dental care.	Development and implementation of oral disease screening programs, and identification of oral health indicators associating with poor nutrition in people with frailty.
Nutrition	3	Protein supplementation appears to not improve physical outcomes, unless combined with resistance training. HMB supplementation may improve physical outcomes.	The benefits of protein supplementation combined with resistance training.
Management of medications	10	Inappropriate medications are often prescribed for those with frailty, and frailty associates with medication harm, although the quality of supporting evidence is low.	Variations in medication response, the clinical effectiveness of different deprescription tools, and the relationship between frailty and medication harm.
Geron-technology	6	Promising technologies include robots for navigational assistance, and information and communicative technologies	Acceptability, costs, and whether gerontechnologies improve QoL and improve/reduce current activity levels.
Education of Healthcare Professionals	1	No studies found according to a systematic review on the topic	An understanding of which educational strategies are best for specific healthcare professionals
Multi-dimensional Interventions	6	Multidimensional interventions might prevent progression to frailty (from pre-frailty) in those ≥ 80 years. Home-based exercises combined with health education and telephone support can reduce sedentary time.	A greater number of improved quality trials are needed, eg assessor-blinded RCTs.
Integrated care	3	Integrated care appears to improve physical function in older adults with frailty except when usual care is of high quality.	Scaled-up research to determine whether integrated care programs are effective, sustainable, cost-effective, and improve QoL, and patient-reported outcomes.
Future treatments	6	Emerging treatments include complementary therapy, and mesenchymal stem cell and stromal cell therapy. Myokines and denervation may reduce frailty.	Effectiveness of potential emerging treatments Can frailty progression be delayed by medications which target DNA damage?
Guidelines	5	Since 2018, there have been 5 clinical practice guidelines/consensus statements for frailty .	Evidence-based clinical practice guidelines which incorporate oral health and cost-effectiveness of interventions; implementation and evaluation of current guidelines.
Risk Factors and Prevention			
Understanding frailty progression or development	15	Frailty status can fluctuate substantially, and this change is more predictive of mortality than current frailty status. Distinct frailty trajectory groups have been found.	Longitudinal studies with frequent repeated measures of frailty.
Factors delaying or driving frailty progression	48	Frailty progression is influenced by multiple factors including lifestyle (eg sedentary behaviour and diets high in processed food), genetics, co-morbidities, and environmental factors (eg air pollution). Residing in an area with green space and a Mediterranean diet delay frailty.	Studies to understand the development of frailty over time, including further investigation into what factors drive or delay this development; built environment studies as 'natural experiments'. clinical trials to discern whether food intake patterns can prevent frailty.
Primary prevention of frailty	2	No intervention studies to prevent (pre)frailty in healthy older adults were found.	Older adults with frailty need to be incorporated into clinical trials. A standard set of outcomes for frailty will allow for comparison of studies.
Others			
	19	There is a current drive for frailty to have its own International Classifications of Disease code. Emerging practices with promise at improving frailty include meaningful activities, resilience training, optimistic orientation, social participation and horticulture. Older adults with frailty face an increased likelihood of elder abuse and suicide.	Needed in trials of frailty are sex-specific interventions (eg females respond differently to interventions than males), economic evaluations, and culturally-specific interventions. More evidence is needed regarding ethnic disparities, and the effect of seasonality on frailty.
COVID-19			
	17	Frailty predicts COVID-19 mortality. Emerging practices include geriatric care teams, protocols in long-term care to prevent widespread infection, and frailty measurement in hospitals as a triage strategy. Use of the CFS for patient triage was questioned. Frailty impacts on vaccine effectiveness. Inactivity and poor diet were concerns during COVID-19 lockdown periods.	Further understanding of the impact of COVID-19 on those with frailty, including interventions to reduce the likelihood of adverse events. Accuracy of CFS in predicting short-term hospital outcomes. Vaccination trials incorporating older adults with frailty.

Legend: ADL = activities of daily living; QoL = quality of life; CFS = clinical frailty scale; RCT = randomised clinical trial

genetic findings. We did not identify any studies on GWASs and frailty the articles appraised in the present review.

A recent development has been the use of machine learning to identify frailty biomarkers, including routinely collected biomarkers, and omic (genomic, metabolomic and proteomic) factors (Gomez-Cabrero et al., 2021). Three key biomarkers linked with risk of frailty (after excluding individuals with disability) have been identified by machine learning: pro-BMP, cardiac troponin T (a regulatory protein which controls contraction of cardiac cells), and Soluble Receptor for Advanced Glycation End Products (sRAGE), which is an ‘immune receptor for proinflammatory mediators’ (Gomez-Cabrero et al., 2021). Using the principles for developing a frailty index, one study developed a DNA methylation index using machine learning algorithms to predict mortality (Kim et al., 2021c).

Given the heterogeneity of frailty, identifying biomarkers is challenging. Future biomarker research needs to investigate sex differences in biomarkers, biomarkers included into composite panels, and overlap of biomarkers regarding frailty versus biological age (Kane and Sinclair, 2019). There is also a noticeable need for longitudinal studies on biomarkers for frailty identification, with the majority of the studies in the literature cross-sectional (Gonçalves et al., 2022). The source of biomarkers (eg serum, saliva and other sources) should be considered and requires further exploration. Whether there are ‘core’ biomarkers linking to frailty and its various components remains unclear. More comprehensive research is needed to determine whether different combinations of biomarkers may be associated with different aspects of frailty. Lastly, as many of the biomarker associations may arise due to reverse causality, such that the level of the marker changes in response to changes in frailty (and not the other way around), when establishing actionable biomarker targets to mitigate frailty, causal inference studies should be performed. One such study that used Mendelian randomisation found that lower interleukin-6 (IL-6) signalling is associated with a lower risk of frailty, suggesting that IL-6-mediated inflammatory signalling could be one of such targets (Mourtzi et al., 2023).

3.2. Management

3.2.1. Exercise and physical activity

Exercise programs for older adults with frailty can include balance and flexibility training, aerobic exercise, and resistance-based training activities such as lifting dumbbells, performing machine-based and body-weight exercises, and utilising a resistance band (Dent et al., 2019b). A network meta-analysis reported that exercise was the most effective intervention for the prevention and management of frailty, although emphasised that the quality of the supporting literature was low-very low (Negm et al., 2019). A systematic review reported that activities of daily living (ADLs) and quality of life (QoL) only improved in older adults with frailty if the exercise intervention was sufficient to improve physical outcome (Campbell et al., 2021). In addition, a recent randomised controlled trial (RCT) reported that exercise improved the physical functioning of hospitalised older adults, particularly those with advanced frailty (Pérez-Zepeda et al., 2022). A further RCT observed that the financial cost of exercise was balanced by savings from lower health and social-care service usage (Suikkanen et al., 2021).

Regarding resistance-based training, a meta-analysis reported that older adults with (pre)frailty who undertook strength training, with or without other exercise modalities, generally improved in maximal strength, muscle mass, power output and functional capacity, although not all studies showed improvement in all components (Lopez et al., 2018). Gait velocity was not found to significantly change with strength training according to a 2022 systematic review (Weng et al., 2022). One trial reported that a simple 12-week program involving repeated sit-to-stand exercise (3x weekly) resulted in increased knee extensor strength in older adults with frailty, with almost full attendance (Fujita et al., 2019). Two studies reported on the cellular training effects of 10 weeks of heavy-load strength training in older adults with frailty; results

included increases in muscle density and area (Aas et al., 2020a), with no increases in the basal rate of protein degradation (Aas et al., 2020b) – the latter likely due to insufficient length of training.

Novel exercise modes reported to improve physical functioning included dance (Meng et al., 2020), inspiration and body vibration training (de Souza et al., 2022), muscle power training (high speed resistance training) (Cadore and Izquierdo, 2018), computerised-based programs (eg delivered on a tablet computer) (Belleville et al., 2022), Tai Chi (Huang et al., 2022) and exergames (Zheng et al., 2020). Exergames involve technology-based exercise in which participants need to exercise or be physically active to play – for instance, with Nintendo Wii Fit Plus™ interactive video games (Gomes et al., 2018; Zheng et al., 2020), and were reported to be feasible, safe and acceptable by individuals with frailty (Gomes et al., 2018), and to increase muscle strength and functional capacity in women with pre-frailty at low, moderate, and high exercise intensity (Santos et al., 2019). Incorporating exergames as part of multicomponent interventions (eg combining with protein supplementation (Vojciechowski et al., 2018)) is a topic identified for subsequent research.

Additional areas for exercise research include improving adherence to programs, maintenance of benefits post-participation, and identifying which delivery methods and settings are most effective - for example home-based interventions, community-based group classes, acute or post-acute health care settings, and/or technology-based interventions. Further research using larger-scale and longer duration studies is needed.

3.2.2. Oral health

Emerging interventions included oral health management (Kossioni et al., 2018), and the identification and targeting of oral health indicators such as low teeth number, difficulties chewing and swallowing, saliva disorders, a decline in oral motor skills, and pain (Dibello et al., 2023). Given the strong relationship found between poor oral health and nutritional disorders in older adults with frailty (Rapp et al., 2021), two articles called for older adults with frailty to be specifically targeted for oral disease screening referral programs paired with referral for dental care (Kossioni et al., 2018; Rapp et al., 2021). The development of such referral programs is an important topic for further research.

3.2.3. Nutrition

Nutritional management for older adults with frailty was a relatively small topic compared to prevention of frailty via nutrition (see Section 3.3.2). A systematic review reported that protein supplementation by itself did not significantly improve functional outcomes (strength, function, or muscle mass) in older adults with frailty (Oktaviana et al., 2020), although there is the possibility that individuals in these studies were unlikely to have low protein intake at baseline (self-reported protein intake was self-assessed in many studies), thus additional protein supplementation may not make a difference. On the other hand, when combined with resistance-based training, protein supplements appeared to aid resistance training benefits (Kang et al., 2019). High protein oral nutrition shakes supplemented with β -hydroxy- β -methylbutyrate (HP-HMB) improved physical function and muscle mass in those with pre-frailty (Peng et al., 2021).

3.2.4. Management of medications

Medication management for older adults with frailty involves appropriate prescription and deprescription, maintaining an updated medication list for patients, regularly reviewing medication, simplifying medication lists where possible, acknowledging an individual’s ability to self-manage medications, and reducing medication harm – for example, by awareness that medication effectiveness can vary according to geriatric syndromes (Liau et al., 2021). There is currently an extensive effort in clinical practice to appropriately manage medications in older adults with frailty (Fournier et al., 2020; Liau et al., 2021; O’Caoimh et al., 2019; Thiruchelvam et al., 2021). A common concern was that

inappropriate medications were often prescribed to older persons with frailty (Fournier et al., 2020; Liao et al., 2021; O’Caoimh et al., 2019; Thiruchelvam et al., 2021), including prescription sedatives and analgesics (Bergen et al., 2022). High anticholinergic burden was also an issue (Naharci and Tasci, 2020). There appears to be a relationship between frailty and medication harm, although the overall quality of studies is too low to make a firm conclusion (Lam et al., 2022).

New research has found that the community pharmacist plays a crucial role in the identification of frailty in older persons (Rhalimi et al., 2021), and that healthcare professionals’ experience working with patients with frailty notably correlated with efforts to deprescribe (O’Caoimh et al., 2019). Recently developed are tools to help clinicians with deprescribing in older people with frailty, although uptake of these tools in clinical practice has not yet been properly investigated (Thompson et al., 2019b). An avenue for further investigation is the variation in response to medications for older adults with frailty (Liao et al., 2021) for reasons such as increased vulnerability to external stressors, organ dysfunction, and altered body composition (Hilmer et al., 2019). For example, paracetamol pharmacokinetics has been found to be altered in individuals with frailty, with high inter-individual variability (van der Heijden et al., 2022).

3.2.5. Gerontechnology

Gerontechnology refers to assistive technologies designed to support older people with independent living – for instance medication reminders, monitoring (eg for vital signs), personal alarms and remote controlled systems (Noublanche et al., 2020). Two articles focused on robots, including an RCT which reported that a robotic roller designed for navigation assistance was successful at improving navigation in real-life environments for individuals with frailty – for example by reducing walking distance and stopping time (Werner et al., 2018). Another study interviewed older adults with frailty to identify what tasks they would require a service robot (a semi-autonomous and remotely controlled robot used for domestic activities) for; user requirements included support with ADL and IADLs, monitoring, and cognitive and social support (García-Soler et al., 2018). Privacy, adaptation of the robot and safety were all flagged as concerns by study participants (García-Soler et al., 2018). Two further articles focused on hospital-based gerontechnologies and described a ‘living lab’ wherein older adults with frailty participated in the co-design of devices alongside the developers (Noublanche et al., 2020).

One novel study found that information and communication technologies such as smart cities and the ‘internet of things’ (IoT)-based systems (eg transport usage patterns and activity levels) can successfully be used to monitor the activity of older adults, which has the potential to identify risk of frailty and functional decline, and thus deliver early intervention (Abril-Jiménez et al., 2020). Yet, older adults with frailty often have insufficient support to improve their involvement in the digital world, for instance, looking up resources on the internet, accessing digital health interventions (ie monitoring with sensor-based technologies) and videoconferencing (Linn et al., 2021). Those with frailty who used information and communication technology (ICT) were more likely to participate in exercise compared with non-ICT users (Satake et al., 2021). More evidence is needed regarding the feasibility, acceptability, feasibility, and costs of gerontechnologies for older adults with frailty.

3.2.6. Education of healthcare professionals

A systematic review focused on the importance of training healthcare professionals in the prevention and management of older persons with frailty – yet no relevant articles were identified in their review after a literature search covering multiple databases (Windhaber et al., 2018). Accordingly, there is a major knowledge gap in the education and training of healthcare professionals, including which specific educational strategies (if any) are best for various healthcare professionals (Windhaber et al., 2018).

3.2.7. Multidimensional interventions

Multidimensional (multimodal) interventions combine exercise/physical activity and/or nutritional intervention with one or more of additional interventions such as medication management, pharmacotherapy, and psychosocial intervention (Negm et al., 2019). In pre-frail adults aged 80 years and over, multidimensional interventions prevented progression to frailty (Gené Huguet et al., 2018), with this intervention shown to reduce healthcare costs compared to usual care (Gené Huguet et al., 2022). Home-based exercises combined with health education and telephone support reduced sedentary behaviour in older adults with frailty (Tosi et al., 2021), whereas computerised-based training for exercise and cognition improved cognition of participants (Bellville et al.). A RCT on whey protein supplementation combined with social network intervention improved functional status in those with frailty (Kim et al., 2021a). An increase in the quality of trials of multidimensional interventions is needed, particularly robust and assessor-blinded RCTs (Teh et al., 2019).

3.2.8. Integrated care

Integrated care involves an efficient and co-ordinated approach to care that responds to a person’s health and social care needs (Pérez et al., 2019; Yu et al., 2020). Two studies of community-based older adults found a significant improvement in physical function/frailty due to the integrated care intervention (Pérez et al., 2019; Yu et al., 2020), yet a hospital-based RCT reported that a nurse-led transitional care intervention (supported by GPs) showed none-to-worse performance than usual care (geriatric care intervention) (Hansen et al., 2021), likely because of the high-quality of usual care. Overall, very little research into integrated care for older persons with frailty was found, despite the effectiveness of this strategy for other population groups. Thus, more research into the feasibility, effectiveness (including cost-effectiveness) of integrated care is needed for older people with frailty.

3.2.9. Future treatments

Several emerging potential treatments for frailty were identified, including mesenchymal stem cell (Florea et al., 2019) and stromal cell therapy (Hoang et al., 2022). A systematic review identified that complementary therapies (particularly Tai Chi), may improve QoL in older adults with (pre)frailty, although the evidence-base was small (Buto et al., 2020). In older women with (pre)frailty, denervation was found to modulate skeletal muscle mitochondrial function, the latter of which is implicated in age-related muscle wastage (Sonjak et al., 2019). Myokines (anti-inflammatory cytokines produced by muscle in response to acute or chronic exercise) may play a role in counteracting frailty although there are only very few studies on the topic, all with conflicting findings (Barros et al., 2022). In the future, drugs to delay the progression of frailty could potentially target Deoxyribonucleic acid (DNA) damage accumulation in older cells caused by oxidative stress or remove damaged cells (Grasselli et al., 2022). Additionally, once article discussed the role of geroprotectors (a new medication class designed to target ageing mechanisms) in delaying frailty development and progression (Trendelenburg et al., 2019).

3.2.10. Guidelines

Since 2018, there have been several new clinical practice guideline publications and consensus statements for the identification, prevention and management of older adults with frailty (Dent et al., 2019b), including on oral health (Kossioni et al., 2018), medication management (Liao et al., 2021), and the perioperative care of people with frailty undergoing elective or emergency surgery (Partridge et al., 2022). Topics common to all guideline publications include the routine screening of frailty in older adults using a validated instrument, and the importance of multidisciplinary care. The development of these guideline publications indicates the growing importance of frailty in current clinical practice.

The European Collaborative and Interprofessional Capability

Framework for Prevention and Management of Frailty (developed and endorsed by the European Medicine Society (EuGMS) and Joint Action ADVANTAGE) proposed, to our knowledge, the world's first collaborative framework for healthcare professionals regarding standardised procedures for the screening, assessment, and management of older persons with frailty (Roller-Wirnsberger et al., 2020). This framework focuses on person-centred care, communication and interprofessional collaboration. (Roller-Wirnsberger et al., 2020).

3.3. Frailty risk factors and prevention

3.3.1. Understanding frailty progression or development

Older populations were consistently found to have dynamic and bidirectional changes in their frailty state (pre-frailty, frailty and robust) (Kojima et al., 2019b). Those with pre-frailty were more likely to transition to robust than those with frailty (Kojima et al., 2019b), and those with improved score (either with the frailty phenotype or FI) showed the same mortality risk as those who remained robust/pre-frail (Hwang et al., 2022). One study reported that after 65 years of age, there was a rapid increase in the development of frailty (measured by FI) at around twice the rate as those younger than this (Raymond et al., 2020). Using clinical meaningful change of frailty measures was flagged as important for future frailty transition research (Jang et al., 2020).

Several studies focused on frailty trajectories. The term 'trajectories' refers to observed changes in a continuous measure of frailty, such as the FI, over multiple time points and across the full spectrum of the respective frailty instrument (Stolz et al., 2021; Stolz et al., 2022). Several distinct frailty trajectory groups have been identified (Jung et al., 2022; Tange et al., 2022; Ward et al., 2021), all of which are influenced by SEP and lifestyle factors such as regular exercise and current alcohol consumption (Jung et al., 2022). Distinctive physical frailty trajectories include worsening frailty status predominantly due to physical mobility decline and the tendency to remain pre-frail (Tange et al., 2022). An eFI recovery trajectory was also identified (Ward et al., 2021). On average, around half the time was spent in a pre-frail state (by the frailty phenotype) for those aged 85–90 years (Mendonça et al., 2020).

In addition to frailty trajectories as outcomes, recent research has also tackled the question whether frailty changes predict negative health outcomes such as all-cause mortality above and beyond one-time frailty assessments, that is, whether there is added value in monitoring frailty changes for risk stratification. Four studies (Shi et al., 2021; Stolz et al., 2021; Stolz et al., 2022; Thompson et al., 2019a) that FI changes were predictive in addition to baseline or current frailty level, whereas one study (Bai et al., 2021) found no effect of the rate of change when the current or last frailty index assessment was taken into account.

There has been increasing research interest in incident frailty and in differences of frailty over time, with new statistical modelling techniques applied. Bayesian multivariate mixed-effects location scale modelling, when applied to a FI, revealed that an individual's long-term frailty does indeed fluctuate up and down, which is reflective of health status instability (Stolz et al., 2019). In addition, Bayesian network methodology revealed the inequality in component health deficits to the FI, because several variables (eg mobility deficits) cluster together whilst other variables remain non-connected (García-Peña et al., 2019); the most central nodes were self-reported health, and difficulty walking a block (García-Peña et al., 2019). Future studies into incident frailty needs to ensure that competing risk for mortality has been accounted for.

3.3.2. Factors delaying or driving frailty progression

There were a high number of novel articles reporting on factors which either delay or drive frailty progression ($n = 48$). Several life-course factors were associated with transitions to frailty in older age, including early life determinants (such as being small at birth (Haapanen et al., 2018) and poor childhood health status (Li et al., 2020)),

life-course violence exposure (Dos Santos Gomes et al., 2018), and several midlife factors such as high BMI (Ho et al., 2019; Raymond et al., 2020) and systematic inflammation (Walker et al., 2019). One study observed that differences in physical and mental functioning were observable in individuals 25-years prior to the onset of frailty in older age (Landré et al., 2023).

Nutritional factors and frailty transitions were widely studied. Older adults with (risk of) malnutrition (as undernutrition) were more likely to become frail than those who were well nourished (Wei et al., 2018). Promising healthy dietary patterns associated with lowered risk of frailty development included the Mediterranean diet (Ntanasi et al., 2022), 'healthful' plant-based diets (containing whole grains, nuts, legumes, fruit and vegetables) (Maroto-Rodriguez et al., 2022; Sotos-Prieto et al., 2022), diets high in protein intake (Mendonça et al., 2019), plant-based protein diets (Struijk et al., 2022a), higher fruit and vegetable intake (together by not separately) up to 3.5 servings per day (Ghoreishy et al., 2021), and oils – including olive oil (Donat-Vargas et al., 2022). On the other hand, consumption of diets high in either red meat (either processed or unprocessed) (Struijk et al., 2022b) or ultra-processed food (Sandoval-Insauti et al., 2020) were associated with higher risk of frailty. Low dose Vitamin D supplementation was found not to associate with any decrease in frailty over 8-years (Bolzetta et al., 2018). A review reported that functional nutrients (which are required for optimal physiological functioning and disease reduction risk in addition to their known nutritional role) were reported to play a role in preventing frailty, including several minerals (specifically Zinc, Magnesium, Selenium, and calcium), Vitamins D and E, carotenoids, polyphenols, and prebiotics and probiotics (Davinelli et al., 2021).

Lifestyle risk factors included smoking (Rodríguez-Laso et al., 2022), poor sleep (Nemoto et al., 2021), poor oral health (Dibello et al., 2023), low physical activity (Raymond et al., 2020; Rodríguez-Laso et al., 2022), prolonged bed rest (Kehler et al., 2019), sedentary behaviour (Kehler et al., 2018; Mañas et al., 2020). Breaks in sedentary time were found to associate with reduced future frailty (Mañas et al., 2021). There was inconsistency concerning alcohol consumption as a lifestyle risk factor. One study reported that high current alcohol intake associated with the development of frailty (Jung et al., 2022), yet other research found high alcohol intake either did not associate with incident frailty (Kojima et al., 2019a) or even associated with lower incident frailty compared with no alcohol intake (Kojima et al., 2018). Discrepancies in finding were suggested by study authors to be potentially the result of poorer baseline health status (Kojima et al., 2019a) and/or either survival bias, a 'sick' quitter effect, or residual confounding (Kojima et al., 2018). A further life-course study (30-year follow-up) reported that high alcohol intake in midlife predicted frailty in older age, whilst zero consumption associated with frailty in older age – likely due to reverse causality (Strandberg et al., 2018).

Social determinants of frailty were reported to include low education (Jung et al., 2022; Vafaei et al., 2022), low socioeconomic position (SEP) (Li et al., 2020) (Jung et al., 2022; Vafaei et al., 2022), food insecurity (Muhammad et al., 2022), and residing in an unsafe neighbourhood (Seo et al., 2021). Specifically, working as a manual labourer or belonging to a lower-middle income group was linked with frailty development compared with high-income individuals (Haapanen et al., 2018). In addition, the likelihood of developing frailty in older age was substantially higher for individuals without a high school education (Li et al., 2020). Regarding food insecurity – older adults with frailty were found to be particularly susceptible to food insecurity (the ability to safely access nutritious food) due to factors such as COVID-19 pandemic effects in various countries (Otaki et al., 2021), and in Africa – the ongoing conflict and drought (Muhammad et al., 2022). Environmental factors associated with frailty development included exposure to air pollution (Di Ciaula and Portincasa, 2020; Guo et al., 2022), whilst on the other hand, residential green space (Zhu et al., 2020), and positive built environments (eg areas with access to parks and sidewalks) both associated with reduced risk of frailty.

Genetic features associated with the development of frailty have been identified in preliminary research to include those related to inflammation, energy metabolism, cognition, and the regulation of biological processes (Inglés et al., 2019). Epigenetic Age Acceleration (age-related changes in Deoxyribonucleic acid (DNA) methylation) was found not to associate with change in frailty, although larger scale studies with more frequent measurements are needed to confirm this finding (Seligman et al., 2022). An age-related factor associated with frailty and gathering increased research interest is lowered gut microbiota composition (Rashidah et al., 2022).

Comorbidities and their complications were associated with frailty, including congestive heart failure, hearing impairment (Lorenzo-López et al., 2019), cognitive impairment (Rodríguez-Laso et al., 2022), sarcopenia (Álvarez-Bustos et al., 2022), and polypharmacy (Lorenzo-López et al., 2019). In the oldest-old, dementia and the number of chronic conditions were associated with frailty (Hajek et al., 2020). Sex differences in incident frailty over time were reported, with neuroendocrine and CVD diseases behind the frailty process in women, and for men, sustaining factors for frailty were musculoskeletal problems, socioeconomic position (SEP), low weight, and CVD (de Oliveira et al., 2022). Acute infections were closely associated with the development of frailty, and vice versa (Vetrano et al., 2021). One study reported that individuals with specific multimorbidity profiles, particularly cardiovascular and neuropsychiatric disease patterns, were more likely to develop physical frailty (Tazzeo et al., 2021).

Psychological risk factors included depression (Rodríguez-Laso et al., 2022) and fear of falling (Vafaei et al., 2022). A new concept was the link between personality and frailty, with low conscientiousness and high neuroticism both associated with increased frailty levels (Hajek et al., 2021).

Compared with the multitude of studies on risk factors, relatively few studies investigated factors associated with frailty improvement (Kojima et al., 2019c). A combination of healthy behaviours (not smoking, vigorous to moderate physical activity, healthy diet, adequate sleeping duration, not being sedentary, and daily social interaction) was associated with a lower risk of frailty (Duppen et al., 2020). Other factors associated with frailty improvement were identified as never smoking, no history of stroke/COPD/diabetes, and younger age (Kojima et al., 2019c). In addition, support with physical therapy services was associated with frailty improvement (Tsay et al., 2021).

3.3.3. Primary prevention of frailty

We identified no intervention studies which investigated strategies to prevent frailty in older populations. A pressing issue in the literature is that we need frailty as an outcome measure in clinical trials (Kuchel, 2018) so that we know what interventions prevent frailty. Theoretically, addressing risk factors will prevent frailty, but the effectiveness of this strategy (including cost-effectiveness) needs to be evaluated. In addition, older people with frailty are needed in clinical trials, and frailty status should be considered as an effect modifier in trials of older adults, particularly in medication trials (Liau et al., 2021). Furthermore, we need to develop a standard set of outcomes for frailty to make comparison of trials easier (Kuchel, 2018; Liau et al., 2021).

3.4. Others

Social participation is needed to address the social isolation and loneliness common to older adults with frailty (Cohen-Mansfield et al., 2019; Duppen et al., 2020; Xie and Ma, 2021). Meaningful activities (Maruta et al., 2022), resilience training (Lu et al., 2022), optimistic orientation (Kim and Won, 2022) and horticulture (Lai et al., 2018) are emerging practices with promising benefits for older adults with frailty. Important yet understudied topics include cultural engagement (Rogers and Fancourt, 2020), ethnic disparities (Usher et al., 2021), and the influence of seasonality (eg weather extremes) on older adults with frailty (Dent et al., 2020).

On the clinical front, a developing research trend is sex-specific frailty interventions (Reid et al., 2022). One study emphasised the importance of translation of evidence-based knowledge into clinical practice, which is often overlooked for older adults with frailty (Huising-Scheetz et al., 2019). There is a current drive for frailty to have its own International Classifications of Disease (ICD) code (Gautam et al., 2021). Moreover, to inform clinical practice on a large scale, we need studies using large-scale, routinely-collected health datasets (Kuchel, 2018). Importantly, a 2021 mapping review emphasised that only a small proportion of research into frailty shows direct applicability to clinical practice (Nguyen et al., 2021) – something which future research into frailty needs to address.

An older person's frailty status impacts on expenditures related to medications (Buckinx et al., 2019) and greatly increases healthcare costs (Kim et al., 2021b). We need to devote more research into economic evaluation of interventions to prevent and manage frailty, which will promote more meaningful comparison between alternative approaches to the prevention and management of frailty in older adults (Gené Huguet et al., 2022).

A worrying finding is that an older person with frailty can face an increased likelihood of elder abuse (Torres-Castro et al., 2018). One article looked at suicide and frailty, and discusses strategies to address this often overlooked and undiscussed issue (Shah et al., 2022).

3.5. COVID-19

We identified extensive research on SARS-COV-2 infection (COVID-19) and frailty. Frailty increased mortality risk in older adults with COVID-19 (Dumitrascu et al., 2021; Mak et al., 2022; Mak et al., 2021a; Vlachogiannis et al., 2022; Welch, 2021), including both before and after vaccination roll-out (Mak et al., 2022), and independent of either age (Welch, 2021) or acute infection (Vlachogiannis et al., 2022). Other adverse outcomes attributed to frailty included longer hospital LOS (Mak et al., 2022) and the increased need for home-care support in survivors (Welch, 2021). COVID-19 survival was found to be associated with transition to frailty (Ferrara et al., 2022). A meta-analysis emphasised the need for outcomes relevant to older adults with frailty affected by COVID-19, via assessment of patient reported outcome measures (PROMs) (Dumitrascu et al., 2021).

Healthcare services were under heavy demand during the COVID-19 pandemic, which highlighted an urgent need for healthcare system improvements so that older adults with frailty do not miss out on appropriate care (Chase, 2020; Landi et al., 2020; Lewis et al., 2021; Volpato et al., 2020). Emerging practices included the incorporation of geriatric care teams in the management of older patients with COVID-19 (Landi et al., 2020; Volpato et al., 2020), the implementation of protocols in residential care facilities to prevent widespread COVID-19 infection (such as telehealth consultations) (Volpato et al., 2020), and the implementation of frailty measurement into hospitals as a triage strategy for limited critical care services. However, use of the Clinical Frailty Scale (CFS), which was rapidly rolled out into UK hospitals during the pandemic, has been questioned, with more research needed to ascertain its accuracy in predicting short-term adverse outcomes, and investigation needed regarding its acceptability by older people as a triage tool (Lewis et al., 2021).

Poor diet quality (Otaki et al., 2021) and low physical activity (Aubertin-Leheudre and Rolland, 2020) were identified concerns during COVID-19 lockdown periods, with access to technology associated with an increased likelihood of exercise participation for older adults with frailty (Santos et al., 2019). A potential public health strategy may be to use frailty screening to identify individuals who may benefit from health and social care interventions (Griffith et al., 2022).

Biomarkers of frailty can predict COVID-19 severity, and on the other hand, biomarkers linked with disease tolerance are predictive of COVID-19 resistance in relation to health and social factors such as healthcare access (Wanhella and Fernandez-Patron, 2022). Individuals with frailty

were found to show a dampened antibody response to COVID-19 vaccination (Dyer et al., 2022; Semelka et al., 2022), with a call for vaccination trials to consider frailty.

4. DISCUSSION

This is, to our knowledge, the first narrative review to comprehensively report on research developments and emerging practices in the field of frailty. Frailty is a multidisciplinary research field incorporating several disciplines including clinical medicine, social sciences, informatics, genetics, and statistics. We identified several recent developments across the topics of identification, management, risk factors, and prevention of frailty in older adults. Common threads across all topics were the need for large scale and higher quality research and that comparative research was impeded by the varying definitions of frailty. Most included studies used one of the two dominant models for frailty – Rockwood’s FI of accumulated deficits (Mitnitski et al., 2001) and Fried’s frailty phenotype (Fried et al., 2001).

4.1. Identification

Identifying frailty using biomarkers was a popular trend, with newly identified biomarkers including skin autofluorescence (Waqas et al., 2022) and salivary α -amylase (Furtado et al., 2020). In the clinical setting, emerging practices included the use of telephone-based frailty assessment. Automated frailty indices developed using artificial intelligence (machine learning) was an emerging frontline technology used to case-find older adults with undiagnosed frailty from electronic medical records (Attwood et al., 2020; Callahan et al., 2021; Zucchelli et al., 2020). Omic-based biomarkers show promise at identifying frailty, although more rigorous research is needed to confirm this observation (Gomez-Cabrero et al., 2021). Frailty assessment has increasingly been adopted by various medical specialties, and more evidence-based research is required to understand the clinical implications of this trend.

4.2. Management

Our review highlights the importance of exercise as the current optimal strategy to prevent and manage frailty in older adults (Negm et al., 2019). Exergames and computerised training were novel developments found to improve the physical functioning in older adults with frailty. An indirect observation was the relatively large number of review studies of exercise compared with RCTs, which could potentially be explained by COVID-19 lockdown periods across various countries (from 2020 until recently) impeding the ability to conduct exercise-based RCTs.

Protein supplementation appeared not to improve physical functioning in those with frailty, unless taken in conjunction with regular strength-based training (Kang et al., 2019). Importantly, future nutritional research needs to state whether the population was deficient in the nutrient to begin with – for instance, supplementation with vitamin D to individuals sufficient in this nutrient will net no additional benefit. Oral health emerged as a key component in the management of older adults with frailty, yet it does not receive sufficient attention in current frailty guidelines. We found that multidimensional interventions were effective at improving physical outcomes in older adults with frailty (Negm et al., 2019), yet most trials were small and showed study biases (Teh et al., 2019). Thus, an improvement in research quality is justified.

Medication management, including how to deprescribe inappropriate medications, was a very popular research trend. Deprescription tools have been developed for older adults with frailty, although not yet robustly trialled in the clinical setting (Thompson et al., 2019b). Efforts to deprescribe were correlated with health professional’s experience working with older adults with frailty (O’Caoimh et al., 2019), thus emphasising the importance of knowledge of frailty in healthcare professionals. Indeed, awareness of frailty by healthcare professionals

through education was reported to be crucial for the appropriate management of older adults with frailty – despite there being no identified research on the topic (Windhaber et al., 2018). We suggest that a potential strategy moving forward is to incorporate education on frailty into the training curricula of trainee nurses and doctors, similar to education on malnutrition in older adults (Dent et al., 2023).

Similarly, multidisciplinary, and integrated care interventions into the future could focus on providing self-management education to older adults with frailty, including advice on how to navigate the healthcare system (Robinson et al., 2021). These strategies could potentially improve the equity of care for older adults with frailty. Although our review found that integrated care interventions showed promise at improving the outcomes of older adults with frailty, if usual care was already of high quality, then no improvement was observable (Hansen et al., 2021). Overall, little is known regarding which interventions are most accessible for individuals with frailty. Unarguably, more research into multidisciplinary and integrated care interventions is warranted, with a focus on trial quality, the incorporation of cost-effectiveness analyses, and the utilisation of person-centred outcomes such as PROMs and Patient Reported Experience Measures (PREMS), which we noticed were very rarely included in research studies of frailty.

Regarding gerontechnology, although using robots for navigation assistance is beneficial to older adults with frailty, it is important to consider that individuals may become too reliant on these robots in the long-term, and in turn may become less physically active. Additional research on this topic is needed. Utilisation of Mhealth (mobile health technologies such as mobile phones and tablets) also requires more comprehensive research, and we importantly need to acknowledge that many older adults with frailty are not technology savvy and have difficulty accessing online programs.

In this review, we identified a need to update clinical practice guidelines for frailty using an objective, evidence-approach (rather than consensus-based guidelines). These guidelines need to incorporate the cost-effectiveness of various interventions to inform high-value, cost-effective care (Gené Huguet et al., 2022). Yet to do this, studies of frailty need to assess cost-effectiveness of interventions – something which is still rather rare in this research field. We also urgently need large-scale, quality trials in the future in order to improve the evidence-base, which in turn can inform clinical practice guidelines for frailty.

Findings from our review highlight the importance and clinical need for frailty to be recognised as a clear medical condition with its own WHO International Classifications of Diseases (ICD) code. With an ICD-10 code, frailty could assist health practitioners in their identification and management of older adults with frailty (Gautam et al., 2021).

4.3. Risk factors and prevention

Prevention of frailty firstly involves identification of risk factors, which was among the most common areas of research identified in this review. Identified factors included life-course risk factors (such as early-life determinants), environmental influences, lifestyle factors, psychological aspects, genetics, and both acute and chronic disease. Although there were multiple longitudinal studies investigating nutritional risk factors for frailty, nutritional research was complex to navigate due the heterogeneity of studies covering a varied range of topics such as whole foods, dietary patterns, and supplements. In terms of research into alcohol as a risk factor, we noted that no studies separate out alcohol type. A potential topic for future research is to separate out the effects of red wine (which contains polyphenols) to see if this differs in its association with frailty compared with spirits and beer.

On the flip side, an identified need for further research is identifying factors associated with frailty improvement (Kojima et al., 2019c), such as physical therapy support (Tsay et al., 2021). Another trend was the investigation of frailty trajectories and transitions using longitudinal datasets with frequent repeated measures of frailty. Relevantly, the vast majority of the identified frailty biomarkers originated from

observational studies and may thus work well when used purely for predictive or identification purposes, however we need more rigorous research on causal inference studies, such as RCTs and Mendelian randomisation, which can provide us actionable targets for prevention. In addition, we need further evidence on preventative interventions that influence ageing biology (Thillainadesan et al., 2020).

A need for further evidence is required on the epidemiological profile of older populations, such as those who are socioeconomically disadvantaged, reside in long-term care facilities, are homeless, or have substance abuse disorders. These populations are often underrepresented in research studies, and more evidence is required to understand the risk these populations face in developing frailty. Once we know more about potential risk factors for frailty, appropriate interventions to prevent frailty can be developed and trialled.

4.4. Strengths and limitations

There were several advantages to this review. The methodology we used was thorough and resulted in the incorporation of a wide range of article types, including qualitative and quantitative research, as well as editorials. This broad range of included articles allowed for an in-depth insight into recent developments occurring in the literature, as well as contextual information relating to clinical practice, health systems research, and biological sciences. In addition, our findings will be a valuable source of information for researchers and clinicians alike, informing future research needs for the prevention, identification, and management of older people with frailty.

A limitation was that articles were restricted to top impact factor journals in geriatrics and gerontology, and we limited our literature search to only 'frailty' in the title. It is therefore understandable that we are missing important articles on frailty published in other journals, including those in other geriatrics and gerontology journals, medical specialty journals and general medical journals. Therefore, the findings of our narrative review should be considered in conjunction with an awareness that additional articles on frailty exist, including papers preceding our inclusion timeframe. Yet we feel our tight literature search criteria allowed us to direct attention to quality articles which objectively measured frailty and were the ideal source of novel developments in the field. It was notable that only 15 out of 23 journals included in our search contained articles on novel developments and emerging practices. Journals without relevant articles did publish about frailty, but studies were mainly confirmative of previous work or not solution-focused.

This review did not distinguish between different frailty models (Fried's frailty phenotype and FI) when examining included articles, thus our findings are not specific to either frailty model. Future studies could potentially distinguish results according to different frailty models when sufficient new literature becomes available. Other directions for future research could be a focus on recent developments in frailty research in specific populations, such as for populations residing in low-middle income countries, women, and those with specific medical conditions (or in specific medical disciplines). More research is also needed to fully understand the ethical and social consequences of identifying and managing frailty in older adults. In addition, although our review did not directly cover new knowledge in the underlying pathophysiology of frailty, this is a topic gaining research momentum alongside new developments in technology.

4.5. Conclusion

In conclusion, this narrative review provided a comprehensive overview of research developments and emerging practices in the field of frailty from 2018 to 2022, with a focus on identification, management, risk factors, and prevention. We believe that this review will help to establish a future research agenda by identifying emerging topics, and those topics which are understudied.

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Declaration of Competing Interest

The authors declare that they have no competing interests.

Data Availability

No data was used for the research described in this review.

APPENDIX A. : Journals Searched (abbreviations), n = 23

Ageing Res Rev.
 Age Ageing.
 Journal of Cachexia Sarcopenia and Muscle.
 Aging Dis.
 Immun Ageing.
 Am J Geriatr Psychiatry.
 J Am Med Dir Assoc.
 GeroScience.
 J Am Geriatr Soc.
 Int Psychogeriatr.
 Eur Rev Aging Phys Act.
 J Gerontol A Biol Sci Med Sci.
 Innov Aging.
 Aging.
 Gerontology.
 Mech Ageing Dev.
 J Nutr Health Aging.
 Maturitas.
 J Gerontol B Psychol Sci Soc Sci.
 Aging Clin Exp Res.
 Drugs Aging.
 Exp Gerontol.
 Arch Gerontol Geriatr.

APPENDIX B. : PubMed Search

Search: (frail [title] OR frailty [title] OR frail elderly [title]) AND ('Age Ageing' [Journal] OR 'Journal of Cachexia Sarcopenia and Muscle' [Journal] OR Ageing Res Rev [Journal] OR Aging Dis [Journal] OR Immun Ageing [Journal] OR Am J Geriatr Psychiatry [Journal] OR J Am Med Dir Assoc [Journal] OR GeroScience [Journal] OR J Am Geriatr Soc

[Journal] OR Int Psychogeriatr [Journal] OR Eur Rev Aging Phys Act [Journal] OR J Gerontol A Biol Sci Med Sci [Journal] OR Innov Aging [Journal] OR 'Aging' [Journal] OR Gerontology [Journal] OR Mech Ageing Dev [Journal] OR J Nutr Health Aging [Journal] OR Maturitas [Journal] OR J Gerontol B Psychol Sci Soc Sci [Journal] OR Aging Clin Exp Res [Journal] OR Drugs Aging [Journal] OR Exp Gerontol [Journal] OR Arch Gerontol Geriatr [Journal]) Filters: from 2018/1/1–2022/12/20 Sort by: Most Recent.

((("frail"[Title] OR "frailty"[Title] OR "frail elderly"[Title]) AND ("age ageing"[Journal] OR "cachexia sarcopenia muscle"[Journal] OR "ageing res rev"[Journal] OR "aging dis"[Journal] OR "immun ageing"[Journal] OR "am j geriatr psychiatry"[Journal] OR "j am med dir assoc"[Journal] OR "geroscience"[Journal] OR "j am geriatr soc"[Journal] OR "int psychogeriatr"[Journal] OR "eur rev aging phys act"[Journal] OR "j gerontol a biol sci med sci"[Journal] OR "innov aging"[Journal] OR ("npj aging"[Journal] OR "aging"[Journal] OR "aging milano"[Journal] OR "aging albania ny"[Journal]) OR "gerontology"[Journal] OR "mech ageing dev"[Journal] OR "j nutr health aging"[Journal] OR "maturitas"[Journal] OR "j gerontol b psychol sci soc sci"[Journal] OR "aging clin exp res"[Journal] OR "drugs aging"[Journal] OR "exp gerontol"[Journal] OR "arch gerontol geriatr"[Journal])) AND (2018/1/1:2022/12/20[ptdat]).

Note: We included 'Frail Elderly' as this was a MeSH term in PubMed for articles before 2019.

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