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Frailty Syndrome in Adults Living With Type-2 Diabetes Mellitus: An Integrative Review of its Prevalence and Associated Factors

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Abstract

Frailty syndrome is a newly emerging complication in adults living with Type-2 Diabetes Mellitus (T2DM) associated with adverse health outcomes and decreased quality of life. This calls for investigation into its prevalence in T2DM adults, factors associated with it, and strategies to reduce the trajectory of frailty among T2DM adults. Therefore, this review aimed to assess frailty prevalence and its associated factors in T2DM adults and identify strategies to be implemented by nurses to mitigate frailty. An integrative review approach was used following the six steps of the Toronto and Remington framework. Relevant texts between 2017 and 2022 were extracted from Google Scholar, PubMed, CINAHL, and Cochrane Library using selected keywords, and the search strategy was presented using the PRISMA flow diagram. Sixteen cross-sectional studies on frailty that met the inclusion criteria after screening were reviewed. Results showed that the frailty prevalence ranged from 10.2% to 55% among T2DM adults. Frailty was primarily defined using the Fried Frailty Phenotype. Frailty was found to be mainly associated with diabetes, poor glycemic control, mobility limitations, age, depression, hypoalbuminemia, and nutritional factors. In individuals with T2DM, early detection, exercise, dietary and educational interventions, and glycemic management seem to be the most successful approaches to reducing frailty. The increasing prevalence of frailty calls for early diagnosis and management of frailty and its associated factors among adults with T2DM. Frailty should also be included in clinical guidelines for T2DM to target individualized interventions and therapeutic approaches.

Keywords: Frailty, Frailty scale, Prevalence, Type-2 diabetes mellitus, Type-2 diabetes mellitus adults.

Introduction

Diabetes mellitus (DM) is an escalating global public health challenge, contributing significantly to morbidity, disability, and mortality rates worldwide (Hossain & Islam, 2024). Among the estimated 537 million adults living with diabetes as of 2021, a staggering 95% are diagnosed with Type 2 diabetes mellitus (T2DM) (International Diabetes Federation, 2021). This number is projected to rise dramatically to 643 million by 2030 and 783 million by 2045, presenting an urgent need for targeted interventions. Beyond its direct complications, T2DM frequently coexists with frailty syndrome, a condition recognized as both a consequence and an independent predictor of diabetes development (Vaccaro et al., 2019). Frailty further amplifies the burden of T2DM, driving increased rates of hospitalization, disability, and mortality, while simultaneously straining healthcare systems through elevated costs and resource demands.

Frailty is characterized as a physiological state of heightened vulnerability to internal and external stressors (Fried et al., 2001, as cited in Tanikawa et al., 2019). Traditionally associated with aging populations, frailty syndrome is defined by the presence of three or more clinical features: low physical activity, muscle weakness, slow walking speed, self-reported exhaustion, and unintentional weight loss (Fried et al., 2001). Globally, its prevalence in older adults' ranges from 12% to 24% (Abd. Ghafar et al., 2022). However, recent evidence reveals that frailty is not confined to the aging population but increasingly

affects individuals with T2DM, with prevalence rates estimated to be 3-5 times higher in this group (Abd. Ghafar et al., 2022). This bidirectional relationship between T2DM and frailty underscores the need for deeper investigation, as hyperglycemia and poor glycemic control not only contribute to frailty onset but also exacerbate its severity and impact, leading to end-organ damage and other diabetes-related complications.

Despite increasing recognition of the relationship between frailty and type 2 diabetes mellitus (T2DM), much of the existing research on frailty has predominantly focused on older adults rather than diabetic populations (Ju et al., 2018; Marcos-Pérez et al., 2020; Orkaby et al., 2022; Gagesch et al., 2022). This limited focus overlooks a critical subgroup—individuals with T2DM—who may experience accelerated frailty progression due to the interplay of chronic hyperglycemia, inflammation, and comorbidities. The lack of sufficient studies targeting T2DM populations represents a significant gap in the literature, as these individuals face unique risks and vulnerabilities.

Emerging evidence underscores the preventable and reversible nature of frailty, particularly when identified and addressed in its early stages. Early identification and management of frailty in this population could yield substantial benefits, including improved clinical outcomes, enhanced quality of life, and a reduction in the economic and logistical burden on healthcare systems (Hanlon et al., 2018; Travers et al., 2019). Addressing this gap through targeted research and intervention development is essential to advancing care strategies for individuals with T2DM at risk of frailty.

This review aims to bridge this knowledge gap by assessing the prevalence of frailty among adults living with T2DM and exploring the factors associated with its occurrence. Furthermore, it seeks to identify effective strategies for preventing and managing frailty in T2DM populations, providing critical insights for healthcare professionals—particularly nurses—who play a pivotal role in delivering timely and effective interventions. To guide this inquiry, the following research questions are addressed:

1. What is the prevalence of frailty in adults living with T2DM?
2. What factors are associated with frailty among adults living with T2DM?
3. What strategies can help curb frailty syndrome in T2DM adults?

By answering these questions, this review aspires to enhance the understanding of frailty within the context of T2DM and contribute to the development of tailored interventions to mitigate its impact.

Section 2: Methodology

Search strategy: This integrative review was conducted following the six-step framework proposed by Toronto and Remington (2020). The review, performed in November 2022, adhered to the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines to summarize the findings. The PRISMA framework illustrated the selection process, from the initial identification of records to the final inclusion of studies, as depicted in Figure 1. Electronic databases, including PubMed, CINAHL, Google Scholar, and the Cochrane Library, were systematically searched to identify relevant studies. The search employed the following keywords: “frailty syndrome,” “frailty level,” “frailty index,” “frailty,” “sarcopenia,” “physical frailty,” “cognitive frailty,” “type 2 diabetes,” “type 2 diabetes mellitus,” and “T2DM.” Boolean operators “OR” and “AND” were used to refine the search strategy. The search was restricted to full-text articles published in English between January 2017 and November 2022 that met the pre-defined eligibility criteria.

The inclusion criteria for this review were as follows: peer-reviewed articles indexed in the specified databases; studies published in English between January 2017 and November 2022; cross-sectional studies involving patients with type 2 diabetes mellitus (T2DM); and studies reporting the prevalence of frailty syndrome in T2DM patients and its associated factors. Exclusion criteria included articles still in press, grey literature, abstract-only citations, anonymous reports, news articles, editorials, qualitative research, systematic reviews, and meta-analyses.

Data extraction: Initially, the titles and abstracts of all identified articles were independently screened, followed by the removal of duplicate records. Subsequently, the full texts of the remaining articles were thoroughly reviewed, and only those that met the predefined eligibility criteria were included in the analysis. Key information was then extracted from each eligible study, including the author's name, publication date, research location, number of participants with type 2 diabetes mellitus (T2DM), prevalence of frailty, methods used to assess frailty, and strategies implemented to mitigate it.

Quality appraisal: The quality of the cross-sectional studies included in this review was assessed using the Newcastle-Ottawa Scale, which assigns a maximum of 10 points to each study: 5 points for selection, 2 points for comparability, and 3 points for the assessment of outcomes. Of the studies reviewed, 10 achieved scores greater than 8, while 6 scored between 7 and 8. Consequently, all 16 studies met the quality criteria and were included in this review.

Section 3: Results and Analysis

Nine hundred eighty-seven articles were identified from the four electronic databases between 2017 and 2022. Of these, 84 duplicates were excluded, and a further 827 were excluded based on unrelated titles and abstracts, leaving 76 full-text articles obtained for further screening. From these, 60 articles were excluded that failed to meet the eligibility criteria. Finally, 16 studies that assessed frailty and its associated factors among adults living with T2DM were included in the review. The results of the study are summarized in Table 1.

Characteristics of the studies included in this review

All 16 articles were cross-sectional studies on frailty syndrome among 23,763 male and female adults living with T2DM, of which 6236 were frail. The majority (13) were conducted in Asia, with the largest sample population of 18,010 from a study conducted in China. The results of the study are summarized in Table 1.

Prevalence of frailty syndrome among T2DM patients

Table 1 shows that the prevalence of frailty ranged from 10.2% to 55% among adults with T2DM. The highest prevalence of 55% was reported in Saudi Arabia (Al-Ali et al., 2021), and the lowest of 10.2% was reported in China (Tang et al., 2022).

Methods used to measure frailty syndrome

Table 1 shows that seven different frailty scales were used to measure frailty in T2DM adults. Seven of the studies measured frailty syndrome using the Fried Frailty Phenotype (Kang et al., 2021; García-de-Alba-García et al., 2019; Kong et al., 2021; Thein et al., 2018; Nguyen et al., 2022; Al-Ali et al., 2021; de Lima Filho et al., 2020). The FRAIL scale was used in 2

studies (Al-Ali et al., 2021; Lu et al., 2022), while Tang et al. (2022) used a modified frail scale version. Other scales used include the Chinese version of the Tilburg Frailty Indicator (Lin et al., 2021; Liu et al., 2020), the Clinical Frailty Scale (Yanagita et al., 2020), the Edmonton Frail Scale (Karsli et al., 2022), a 35-item Frailty Index (Castrejón-Pérez et al., 2018; Zeng et al., 2022) and the Obu Study Health Promotion for the Elderly Frailty Scale (Tanikawa et al., 2019).

Factors Associated with Frailty Syndrome among Adults living with T2DM

The studies reviewed also identified the factors associated with frailty syndrome among adults living with T2DM as shown in Table 1. The most common associated factors were diabetes/increased glycosylated hemoglobin levels/poor glycemic control (Thein et al., 2018; Castrejón-Pérez et al., 2018; Karsli et al., 2022; Al-Ali et al., 2021; Kong et al., 2021; de Lima Filho et al., 2020), followed by older age (Karsli et al., 2022; Nguyen et al., 2022; Al-Ali et al., 2021; Lu et al., 2022), depression (Lin et al., 2021; Liu et al., 2020; de Lima Filho et al., 2020; Kong et al., 2021), mobility/ADL limitations (Kang et al., 2021; Kong et al., 2021; Zeng et al., 2022; de Lima Filho et al., 2020) and hypoalbuminemia and nutritional status (Yanagita et al., 2020; Kong et al., 2021; Nguyen et al., 2022; Tanikawa et al., 2019). Others include gender (García-de-Alba-García et al., 2019; Kang et al., 2021) and comorbidities and previous hospitalization (Castrejón-Pérez et al., 2018; Tang et al., 2022; Zeng et al., 2022).

Strategies to Curb Frailty Syndrome in T2DM Adults: The Way Forward

The studies included several strategies to curb the increasing prevalence of frailty among adults living with T2DM, as shown in Table 1. The majority prescribed early diagnosis and management of frailty and rehabilitation (Zeng et al., 2022; Lu et al., 2022; de Lima Filho et al., 2020; Lin et al., 2021; Kang et al., 2021; Kong et al., 2021; Karsli et al., 2022). Other measures include routine screening for frailty among T2DM patients (Thein et al., 2018; Al-Ali et al., 2021), promotion of awareness of frailty among T2DM adults and health literacy (Zeng et al., 2022; Liu et al., 2020), and social support (Liu et al., 2020). Further diagnostic and longitudinal studies are also required to assess the causal relationship between T2DM and frailty (Tang et al., 2022; Zeng et al., 2022; Nguyen et al., 2022; Tanikawa et al., 2019).

Section 4: Discussion

Prevalence of frailty syndrome among T2DM patients

The review reveals that frailty syndrome is a significant and growing concern among adults living with Type 2 diabetes mellitus (T2DM), with a reported prevalence of up to 55%. This finding aligns with the report by Abd-Ghafar et al. (2022), which noted a frailty prevalence that is 3-5 times higher in individuals with T2DM compared to the general population (12-24%). These results underscore the urgent need for targeted public health and clinical interventions, as frailty exacerbates the health burden of T2DM by increasing risks of disability, morbidity, and healthcare costs.

The findings highlight significant regional variations in frailty prevalence among T2DM populations, with some countries reporting notably higher rates. For instance: Turkey (40.9%), China (42.4%), Brazil (47.8%), and Saudi Arabia (44% - 55%). These figures are substantially higher than the 7–24% prevalence rates reported in other studies (Ida et al., 2019; Villani et al., 2021). Notably, these variations may reflect differences in healthcare access, socioeconomic factors, lifestyle, and cultural attitudes toward managing diabetes and

frailty risk factors (Richards et al., 2022). Countries with higher prevalence rates likely face systemic challenges, such as inadequate early screening for frailty, insufficient patient education about diabetes self-care, or limited access to preventive interventions. Therefore, there is a need for healthcare systems in high-prevalence regions to implement standardized frailty assessment tools during routine diabetes management visits to detect early signs, empower patients with T2DM through education about lifestyle modifications (e.g., physical activity, nutrition) that reduce frailty risk and incorporate physical therapists, dietitians, and geriatric specialists into diabetes care teams to address frailty holistically (Bristol, North Somerset, and South Gloucestershire Integrated Care Board (BNSSG ICB), 2024).

Temporal patterns also emerged in the data, with some countries experiencing declining frailty prevalence and others showing increases: In China, frailty prevalence decreased from 42.4% in 2020 to 10.2%-20.8% in 2022; in Mexico, a similar decline was noted, from 28.6% in 2017 to 17% in 2019; and in Japan, an opposite trend was observed, with prevalence rising from 21.4% in 2019 to 35.8% in 2021. These fluctuations could be attributed to several factors, including advancements in diabetes management practices, public health initiatives, and differences in frailty assessment methods. The increasing prevalence in Japan, for example, may indicate a growing aging population or changes in diabetes complications over time. Meanwhile, the declining rates in China and Mexico suggest the positive impact of enhanced diabetes care programs or preventative measures targeting frailty.

Variations in frailty prevalence across countries and over time can be partly attributed to differences in the frailty assessment scales employed. A systematic review analyzing data from 62 countries found that frailty prevalence estimates varied significantly depending on the assessment tool used, with overall estimates ranging from 17% to 45%. The study concluded that methodological differences, including the choice of frailty scales, contribute to the heterogeneity in prevalence rates observed across different populations (Sezgin et al., 2021). Establishing globally accepted frailty assessment protocols (e.g., Fried Frailty Phenotype or Frailty Index) would allow for better cross-comparisons and monitoring of trends.

A critical observation in the review is the variability in frailty prevalence (5–48%) when different diagnostic criteria or frailty scales are applied (Perkisas & Vandewoude, 2016). This highlights the methodological inconsistency that complicates efforts to understand the true burden of frailty in T2DM populations. The lack of a universally accepted frailty assessment tool limits the comparability of findings and may lead to under- or overestimation of frailty prevalence, affecting resource planning and clinical interventions (Boreskie et al., 2022). Barriers to implementing frailty assessments in clinical settings still exist, including a lack of consensus on the assessment tool best suited in each context, uncertain cost-effectiveness, and few established interventions for frailty (Boreskie et al., 2022). Thus, global adoption of validated, user-friendly frailty assessment tools, such as the Fried Frailty Phenotype, particularly in primary care settings is advocated. Also, there is a need to train clinicians, especially in diabetes care, to recognize and assess frailty using these tools consistently.

Methods used to measure frailty syndrome

The review highlights the methods used to assess frailty syndrome, particularly in adults with T2DM, emphasizing the variability in frailty prevalence due to differing measurement tools. Frailty, especially in its pre-frail stage, is a critical condition to identify early since it is reversible with appropriate interventions. Tools like the Fried Frailty Phenotype and the

FRAIL scale play a significant role in this process. Early detection could help in reducing the progression to full-blown frailty, which is associated with adverse outcomes like reduced quality of life, increased hospitalizations, and mortality (Sezgin et al., 2020).

The variability in frailty prevalence among T2DM adults across studies could stem from the heterogeneity in tools used. While the Fried Frailty Phenotype is a widely validated standard, other tools may differ in sensitivity, specificity, or the dimensions of frailty they assess. This inconsistency highlights a need for standardization in frailty assessment methodologies within specific populations, such as T2DM adults, to allow better comparison of results across studies (Hanlon et al., 2020).

T2DM itself is linked with accelerated aging and an increased risk of frailty due to factors like chronic inflammation, insulin resistance, and sarcopenia (Ricci et al., 2021). Reliable assessment tools are thus essential for tailoring management strategies (Strain et al., 2021). There is therefore a need to adopt standardized tools like the Fried Frailty Phenotype in research and clinical settings involving T2DM patients. This would help reduce variability in frailty prevalence rates and enhance comparability across studies. Also, developing diabetes-specific frailty tools tailored to the unique challenges and risks associated with T2DM should be considered. This would improve the relevance and sensitivity of frailty assessments in this population.

Factors associated with frailty syndrome among adults living with T2DM

Diabetes (DM) is identified as the most associated factor with frailty, and this is in line with multiple studies (Kitamura et al., 2019; Assar et al., 2019; Yanase et al., 2019). Diabetes exacerbates metabolic, vascular, and inflammatory pathways, which may accelerate the decline in physical function and resilience. The chronic nature of DM likely creates a physiological environment conducive to frailty through mechanisms such as glycemic dysregulation and systemic inflammation. Thus, efforts to manage frailty in T2DM populations should begin with optimized DM management. This includes regular blood glucose monitoring, patient education, and adherence to treatment plans.

Higher levels of glycosylated hemoglobin (HbA1c) also significantly increase the risk of frailty, as reported by multiple studies (Liu et al., 2024; Aguayo et al., 2019; Yanigita et al., 2018). Poor glycemic control leads to complications such as neuropathy and vascular damage, which contribute to frailty. Long-term hyperglycemia may weaken both physical and cognitive functions, thereby elevating frailty risk. Tight glycemic control (avoiding hyperglycemia while minimizing hypoglycemia) is essential. Early interventions such as lifestyle modifications, individualized diet plans, and pharmacotherapy can help mitigate the impact of poor glycemic control (Bristol, North Somerset, and South Gloucestershire Integrated Care Board (BNSSG ICB), 2024).

Diabetic complications, including neuropathy, nephropathy, and retinopathy, are revealed to be associated with reduced mobility and frailty. This is consistent with findings as the systemic effects of chronic complications has been reported to lead to progressive physical deterioration (Kulkarni et al., 2024). Thus, screening and early management of diabetic complications should be prioritized in clinical practice. This includes regular check-ups for kidney function, eye health, and peripheral neuropathy.

Age, as revealed in the review, is a well-documented factor for frailty, as physiological reserves naturally decline with aging. T2DM amplifies age-related frailty by accelerating muscle mass loss and reducing functional capacity. Older adults with T2DM are at higher risk of frailty compared to their non-diabetic peers (Strain et al., 2021). Implementing comprehensive geriatric assessments for older adults with T2DM to identify early signs of frailty. Tailored exercise programs focusing on strength and balance may help delay frailty progression.

Depression and nutritional deficits, including hypoalbuminemia are reported to be strongly linked to frailty, as depression can impair motivation for physical activity, reduce appetite, and disrupt social interactions, and malnutrition can impair muscle maintenance and immune function (Laura et al., 2022; Aprahamian et al., 2019; Soysal et al., 2017). Malnutrition and low protein intake also contribute to sarcopenia, a key component of frailty. Screening for depression should therefore be integrated into routine care for T2DM patients. Psychosocial support, counseling, and treatment for depression (e.g., cognitive-behavioral therapy or antidepressants) can improve outcomes. Nutritional interventions, including protein-rich diets and supplementation, should be implemented. Dietitian-guided meal planning can address deficiencies and optimize nutritional intake (Laura et al., 2022).

Reduced mobility and limitations in activities of daily living (ADLs) are reported to be strongly associated with frailty, as physical inactivity accelerates muscle loss and functional decline. Mobility issues contribute to a feedback loop where inactivity worsens physical health, further increasing frailty risk (Caballero Mora & Rodriguez Mañas, 2018). Thus, structured physical activity programs, such as resistance training and aerobic exercises, should be encouraged. Rehabilitation services may also benefit individuals with severe mobility impairments (Caballero Mora & Rodriguez Mañas, 2018). Factors such as living alone, poor social support, low health literacy, and poor economic status are also revealed to be associated with frailty. This is in line with findings from several studies (Maharani et al., 2024; Ye et al., 2021; Wallington et al., 2019; De Labra et al., 2018). Social and economic vulnerabilities exacerbate health disparities, reducing access to care and resources that promote resilience. Community-based support programs, affordable healthcare services, and health education initiatives can address these socio-economic challenges. Regular follow-ups and home-based care models may also benefit socially isolated individuals (Wallington et al., 2019).

Both low body mass and abdominal obesity are revealed to be associated with frailty. Obesity can lead to metabolic dysfunction, while low body mass reflects malnutrition and sarcopenia (Jayanama et al., 2022; Yuan et al., 2021). A U-shaped relationship exists between body mass and frailty, with both extremes posing risks. Weight management programs should aim for a healthy body mass index (BMI) while maintaining muscle mass through adequate nutrition and physical activity (Jayanama et al., 2022; Yuan et al., 2021).

The review indicates that gender-specific differences may exist, with women often being more prone to frailty due to differences in muscle mass and hormonal changes. These gender differences in frailty has also been reported in literature (O'Brien et al., 2024; Mielke et al., 2022). Gender-specific approaches may enhance the effectiveness of interventions. Research into tailored interventions for men and women can help address frailty disparities (Reid et al., 2022). Multiple comorbidities and previous hospitalizations further increase frailty risk. These factors reflect the cumulative burden of illness, which accelerates frailty progression.

Integrated care plans addressing comorbidities holistically and strategies to prevent hospital readmissions (e.g., home monitoring, patient education) are critical.

Strategies to curb frailty syndrome in T2DM adults: The way forward

Studies have suggested that frailty is preventable and reversible if timely interventions are taken (Wang et al., 2024). Seven studies reviewed recommended that early diagnosis and management is the most common preventive measure to curb frailty in T2DM adults. This is in line with reviews that suggest that early detection of frailty through clinical assessments and the use of validated frailty scales is a cornerstone in managing frailty among T2DM patients. Incorporating frailty evaluation into routine diabetes management aligns with clinical guidelines (American Diabetes Association, 2021; Cosentino et al., 2019).

Regular frailty screening enables healthcare providers to intervene at the early stages of functional decline, reducing the risk of disability and adverse health outcomes (LeRoith et al., 2019). These are identified by assessing critical factors associated with frailty, including physical performance, mental health, cognition, and nutrition. Nurses can also utilize validated frail scales or criteria in clinical settings for early diagnosis of frailty in T2DM adults. Routine screening for frailty in T2DM was also suggested by 2 of the studies reviewed. This is in line with several reports that suggested that the assessment of frailty must become part of the routine evaluation of DM patients (Strain et al., 2018; Sinclair et al., 2018). Therefore, including frailty screening protocols as a mandatory component of T2DM management in primary care settings and training nurses and clinicians in using frailty scales like the FRAIL scale or Edmonton Frailty Scale to standardize assessments is of essence.

Another measure cited is increasing or promoting awareness of frailty among T2DM patients and enhancing health literacy. This is important for nurses to implement. Vaccaro et al. (2019) emphasized promoting awareness among T2DM patients about frailty and its risk factors (e.g., malnutrition, sarcopenia) can empower them to adopt preventive behaviors. Enhanced health literacy will equip patients and the general public with knowledge about age-related illnesses and frailty to make informed decisions about nutrition, exercise, and lifestyle changes. Conducting educational programs focusing on the risks and prevention of frailty, tailored to individuals with T2DM will be useful.

Nutrition is also reported to play a critical role in preventing frailty. Diets like the Mediterranean diet and adequate calorie and protein intake are protective against frailty, sarcopenia, and weight loss (Ni Lochlainn et al., 2021; Abdelhamid et al., 2020). So, optimizing dietary quality reduces the risk of frailty and supports overall metabolic and physical health in T2DM patients and this can be done by collaborating with dietitians to design personalized meal plans for T2DM patients, emphasizing whole foods, fruits, vegetables, and lean protein and encouraging patients to minimize consumption of processed foods and sugary beverages (Ni Lochlainn et al., 2021; Tamura et al., 2020). As frailty in T2DM is characterized by malnutrition, sarcopenia, and weight loss, and factors such as hypoalbuminemia, nutritional factors, and body mass/body mass index have been reported to be associated with frailty, clinicians need to also focus on weight maintenance (Strain et al., 2021).

Exercise has also been cited as a protective factor for frailty. According to Abd. Gafar et al. (2022), resistance and balance training have demonstrated benefits in reducing falls, improving functional ability, and mitigating frailty risks in T2DM patients. Exercise interventions tailored to individuals' physical capabilities improve strength and mobility,

reducing dependency and fall risks. Developing community-based exercise programs for T2DM patients focusing on resistance and balance training and educating patients on home-based exercises they can incorporate into daily routines, ensuring they are low-impact and safe for older adults can be beneficial.

The review highlights that frailty prevention requires a multi-faceted comprehensive strategy addressing physical, cognitive, and nutritional health. Integrated care approaches enhance the likelihood of reversing frailty and improving quality of life, and this requires multidisciplinary care teams, including nurses, physicians, dietitians, and physiotherapists, to provide holistic care and regular review and adjustment of interventions to match T2DM patients' evolving needs and frailty status. Findings further highlight the need for a paradigm shift in the management of frailty among T2DM adults. Moving forward, policymakers should advocate for frailty assessment to be included in national diabetes guidelines, healthcare systems must allocate resources to train staff and implement routine frailty screening, and long-term studies should evaluate the impact of combined dietary and exercise interventions on reversing frailty.

By prioritizing early intervention, fostering health literacy, and promoting tailored lifestyle changes, the burden of frailty among T2DM adults can be significantly reduced. This approach will not only enhance patient outcomes but also alleviate the broader healthcare burden associated with frailty.

Section 5: Conclusion and Recommendations

The high prevalence of frailty syndrome among adults with T2DM presents a significant public health challenge. Regional and temporal variations further emphasize the need for tailored approaches to frailty prevention and management. Standardizing frailty assessment, implementing targeted interventions in high-prevalence areas, and conducting longitudinal studies are essential steps toward mitigating the burden of frailty.

Healthcare systems should integrate frailty assessment into routine T2DM care, focusing on prevention, early detection, and management strategies. This will ultimately improve patient outcomes, enhance quality of life, and reduce the socioeconomic burden associated with T2DM and frailty. Frailty among adults with T2DM is multifactorial, influenced by clinical, psychological, nutritional, and socio-demographic factors. A comprehensive, multidisciplinary approach is necessary to address these interlinked factors effectively among T2DM populations. Key recommendations include:

1. Early screening for frailty using validated tools.
2. Routine assessment of frailty.
3. Optimized diabetes management, including glycemic control and complication prevention.
4. Targeted nutritional and physical activity interventions.
5. Mental health support and social engagement programs.
6. Policies promoting equitable access to care and resources for vulnerable populations.

By implementing these strategies, healthcare systems can mitigate the impact of frailty, improve quality of life, and reduce healthcare burdens for adults living with T2DM.

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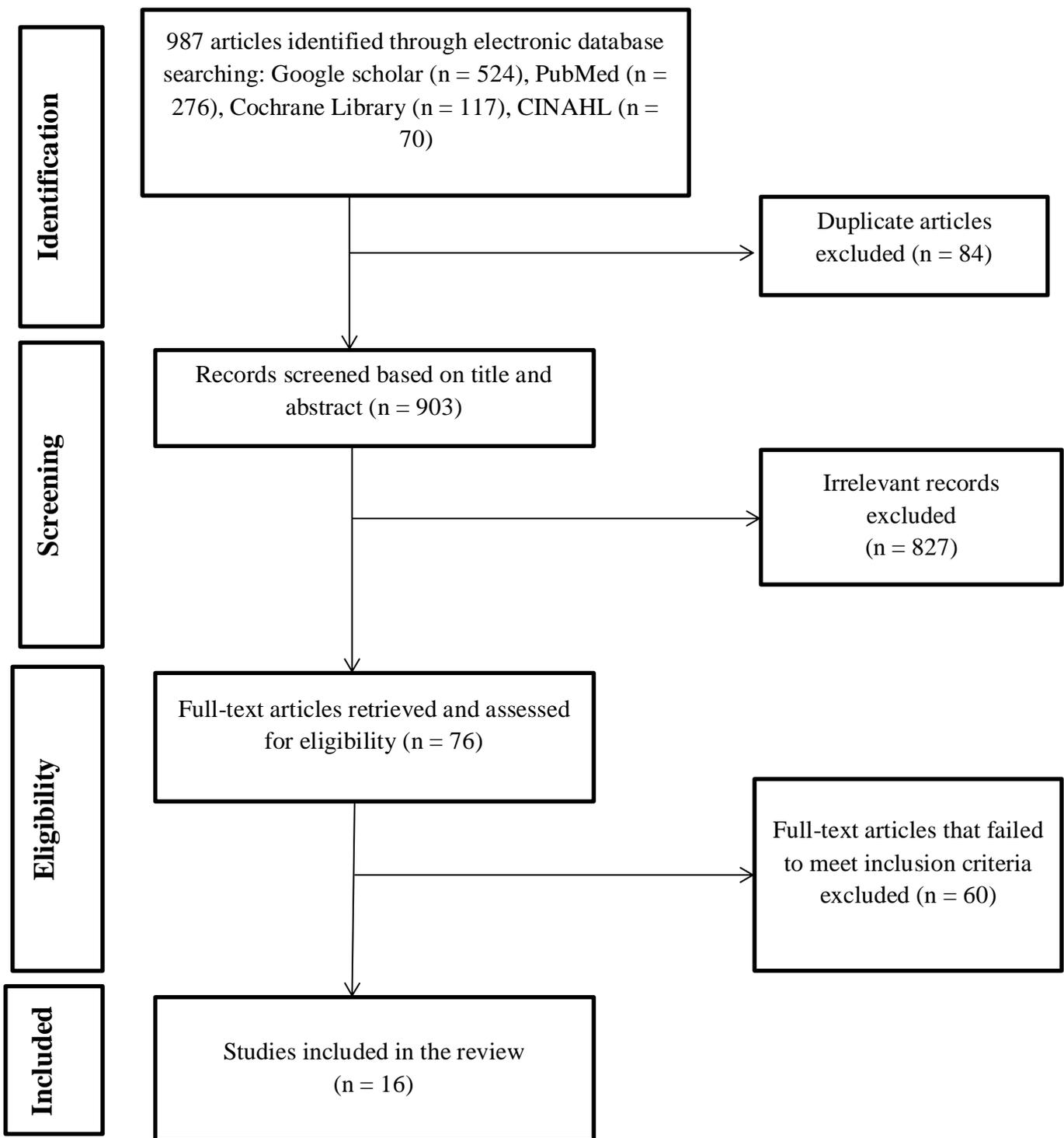


Figure 1: PRISMA Flow Diagram for Frailty Syndrome Study Search Strategy

Table 1: Characteristics of the Cross-sectional Studies Included in the Review

S/N	Author (Year)	Country	No T2DM adults	Methods for measuring frailty	Prevalence of frailty	Associated factors of frailty	Strategies to reduce frailty (way forward)
1.	Lin et al. (2021).	China	248	The Chinese version of the Tilburg frailty indicator	26.6%	Depression	Early detection via routine screenings for symptoms of depression during diabetes care
2.	Kang et al. (2021)	Korea	670	Fried frailty phenotype criteria	15%	Gender, limitations in mobility, and increased mortality	Early assessment of sarcopenia and frailty and timely interventions
3.	Yanagita et al. (2020)	Japan	148	The Clinical frailty scale	38.5%	Hypoalbuminemia, low aspartate aminotransferase (AST) activity and low body mass (BM), serum DHEA-S and cortisol	Need for interventions to modify the risk factors of frailty for the achievement of optimal life expectancy in T2DM adults
4.	Tang et al. (2022).	China	558	Modified FRAIL scale	10.2%	Multimorbidity, \geq three chronic diseases, and hospitalization in the past year	Further research is needed on enhancing self-care activities to delay the onset of frailty and clarify possible causal relationships between them.
5.	García-de-Alba-García et al. (2019)	Mexico	200	Fried frailty phenotype criteria	17%	Gender	Establishment of strategies and policies to achieve the promotion of a happy old age and to prevent the frailty syndrome
6.	Karsli et al. (2022).	Turkey	149	Edmonton Frail Scale	40.9%	Diabetes, gender, quality of life,	Need to take necessary precautions against frailty
7.	Castrejón-Pérez et al. (2018)	Mexico	1236	35-item frailty index (FI)	28.6%	Hospitalization in the past year, type of treatment, peripheral neuropathy, and diabetic coma	Implementation of strategies to delay its frailty in T2DM adults
8.	Kong et al. (2021).	China	291	Fried frailty phenotype criteria	19.2%	Alcohol, glycated hemoglobin, nutritional status, depressive symptoms, and exercise behavior	Frailty identification and multifaceted interventions should be developed for T2DM adults
9.	Liu et al. (2020).	China	637	The Chinese version of the Tilburg frailty indicator	42.4%	Health literacy, social support, depression	Measures that provide social support and enhance health literacy while alleviating depression
10.	Thein et al. (2018).	Singapore	486	Fried frailty phenotype criteria	19.8%	Diabetes	Frailty identification using simple and brief instruments in DM patients
11.	Tanikawa et al. (2019)	Japan	178	Obu Study Health Promotion for Elderly Frailty Scale	21.4%	Low serum albumin and IGF-2 levels, polypharmacy	Further longitudinal studies to identify associations between frailty and its associated factors
12.	Nguyen et al. (2022).	Vietnam	638	Fried frailty phenotype criteria	28.2%	Older age, body mass index	Further longitudinal studies to clarify associations between frailty and its associated factors
13.	Al-Ali et al. (2021)	Saudi Arabia	47	Fried frailty phenotype criteria and FRAIL scale	Group II= 44% Group III= 55%	Poor glycemic control, older age	Further diagnostic studies on frailty are required
14.	Zeng et al. (2022).	China	18010	35-item frailty index (FI)	22.7%	Activities of daily living (ADL) disabilities, comorbidities, living alone, poor socio-economic status	Increase awareness of frailty and advance early diagnosis and interventions
15.	Lu et al. (2022).	China	154	FRAIL scale	20.8%	Age, activities of daily living	Early intervention for cognitive frailty is needed
16.	de Lima filho et al. (2020)	Brazil	113	Fried frailty phenotype criteria	47.8%	Glycated hemoglobin, depression, mobility, social participation, schooling	Further, focus on rehabilitation and care/management programs in DM

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