Optimising nutrition in residential aged care: A narrative review

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Abstract

In developed countries the prevalence of protein-energy malnutrition increases with age and multi-morbidities increasing nutritional risk in aged care residents in particular. The purpose of this paper was to examine, synthesise and develop a narrative review of the current literature on the identification, prevalence, associated risk factors, consequences, and management of malnutrition in the residential aged care (RAC) setting. We performed searches of English language publications in Medline, PubMed, Ovid and the Cochrane Library from January 1 1990- November 25 2015. We found that, on average, half of all residents in aged care are malnourished as a result of factors affecting appetite, dietary intake and nutrient absorption. Malnutrition is associated with a multitude of adverse outcomes including increased risk of infections, falls, pressure ulcers and hospital admissions, all of which can lead to increased health care costs and poorer quality of life. A number of food and nutrition strategies have demonstrated positive nutritional and clinical outcomes in the RAC setting. These strategies extend beyond simply enhancing the nutritional value of foods and hence necessitate the involvement of a range of committed stakeholders. Implementing a nutritional protocol in RAC facilities that comprises of routine nutrition screening, assessment, appropriate nutrition intervention, including attention to food service systems, and monitoring by a multidisciplinary team can help prevent decline in residents' nutritional status. Food and nutritional issues should be identified early and managed on admission and regularly in the RAC setting.

Keywords: Malnutrition, Aged, Nutrition Assessment, Nutritional Support

1. Introduction

The proportion of the world's population aged 60 years and over is rapidly increasing (1). Whilst this population has doubled from 12% in 1950 to 23% in 2013, it is projected to triple to 32% by 2050 (1, 2). In developed countries improvements in healthcare have led to declines in mortality from conditions such as stroke and heart disease (3). However, increased longevity has resulted in an increased prevalence of chronic illness and multi-morbidities (defined as the presence of two or more diseases at the same time); along with a burgeoning demand for residential aged care (RAC) services to offer accommodation and support for older people with complex needs who can no longer live independently in their home (4, 5).

Malnutrition (or inadequate nutritional status) in older people is defined as undernourishment due to poor dietary intake consequently leading to involuntary weight loss and muscle wasting (6). Although frail older persons are at an increased risk of malnutrition, research indicates that nutrition often ranks low on the list of care priorities in RAC (7). Lack of knowledge and awareness, and the inability to identify malnutrition by care staff; rushed and task-focussed eating environments that are often accompanied by little communication and conversation between residents and staff assisting with feeding; and residents' own physical, clinical, and psychosocial issues have been identified as major barriers against the prevention and management of malnutrition in the elderly (7-12). In a recent poll conducted by the International Association of Gerontology and Geriatrics, RAC experts from eight countries identified "improving nutrition" as one of the top five international research priorities in this setting (13). To the best of our knowledge, previously published reviews in the RAC setting have summarised evidence regarding malnutrition prevalence (14), associated risk factors (15), and effective nutritional interventions (16-18). The purpose of this paper is to review and summarise existing evidence on these aspects of malnutrition in the RAC setting, along with including a synopsis of evidence-based methods to identify malnutrition in the RAC setting, highlight the consequences of malnutrition in this population and provide future directions for practice and research.

2. Methods

In the literature, depending on the geographical location, low care settings may also be referred to as “hostels”, “residential care homes”, or “assisted care”; whereas high care settings may also be referred to as “nursing homes”. For the purpose of this paper, the term RAC will encompass both low and high care settings. References for this narrative review were identified through searches of publications listed in electronic databases including Medline, PubMed, Ovid, and the Cochrane Library. The searches were limited to full-length articles, in the English language, and publications dated from 1 January 1990 to 25 November 2015. The titles and abstracts of articles were examined using the following keywords s: “nursing homes”, “residential aged care facility”, “elderly”, “older adults”, “malnutrition”, “nutritional status”, “multicentre”, “prevalence”, “aetiology”, “consequences”, “health-related outcomes”, “nutritional interventions”, “dietary intake”, and “enteral nutrition”. Retrospective searches were also conducted from relevant review articles, book chapters and relevant evidence-based guidelines. Further details of the search methods are available from the corresponding author.

3. Identification of malnutrition in RAC

Although there is no gold standard for diagnosing malnutrition, it is generally accepted that the condition is characterised by unintentional weight loss with suboptimal dietary intake, thereby resulting in muscle wasting and/or loss of subcutaneous fat; or low BMI ($\leq$ 18.5kg/m^2) (19). However, in a recent meta-analysis evaluating the association of BMI and all-cause mortality in older adults, Winter and colleagues observed that when compared with a BMI reference range of 23.0-23.9 kg/m^2, a BMI of 21.0-21.9 kg/m^2 and a BMI of $\leq$ 20.0 kg/m^2 demonstrated a 12% and 28% greater risk of all-cause mortality respectively (20). This meta-analysis indicates that the healthy BMI range for adults (18.5-24.9 kg/m^2) as established by the World Health Organisation is not suitable for older adults and that individuals with a BMI of <23.0 kg/m^2 should be monitored for changes in weight and risk of malnutrition (20). Research also indicates that a moderately higher BMI is protective against morbidity and mortality (21, 22).

It is important to remain mindful that just like some laboratory parameters (albumin, transferrin, and lymphocyte count) are more indicative of illness rather than nutritional deficits, body weight is also affected by health status rather than nutrition exclusively (23). Therefore, rather than relying on a single parameter to identify malnutrition, it is believed that nutrition screening and assessment tools are more suitable to identify malnutrition risk and malnutrition as they take into account its complex multifactorial aetiology including biological, iatrogenic, socioeconomic, psychological and physical risk factors (24). Of the several nutrition screening tools available in the literature, many have been developed for older adults (25-31) and some have been specifically developed for use in the RAC setting (32-35). However, recent systematic reviews concluded that few tools have undergone rigorous reliability and validity testing; the ability of nutrition screening tools to screen nutritional status and predict outcomes in RAC residents ranges from fair-to-moderate; and that more items that are specific to development of malnutrition in this population (dietary factors, feeding dependence, oral health, environment, comorbidities) need to be included in the tools (24, 36, 37).

White et al have proposed that since no single parameter can define malnutrition, the diagnosis of malnutrition should be made with the identification of two or more of the following characteristics rather than depend on any particular nutrition screening tool (38):

- Inadequate energy intake: defined as consuming ≤75% of estimated energy requirements for at least one month;
- Weight loss: defined as unintended loss of at least 5% usual body weight within one month and/or at least 10% loss in usual body weight within six months;
- Loss of muscle mass: defined as mild-to-severe visible wasting of the temples, clavicles, shoulders, interosseous muscles, scapula, thigh and calf;
- Loss of subcutaneous fat: defined as mild-to-severe visible wasting orbital, triceps, and fat overlying the ribs;
- Localised or generalised fluid accumulation: in the extremities, vulvar/scrotal oedema, and ascites;

- Reduced functional capacity: determined by handgrip strength.

However, this proposed consensus definition for malnutrition is still to be tested for validity and is a work in progress. Comprehensive assessment of nutritional status by trained professionals, such as dietitians, is essential once malnutrition risk has been identified. Nutrition assessment uses a combination of medical history, nutritional data, physical examination, anthropometric measurements, and biochemical parameters to determine the individual's nutritional status (38). The Subjective Global Assessment (SGA) (39), scored Patient-Generated Subjective Global Assessment (PG-SGA) (40), and Mini-Nutritional Assessment (41) are multidimensional nutrition assessment tools validated for the RAC setting (42-45) and include a range of parameters to make a nutritional diagnosis and initiate nutritional management in older residents.

4. Prevalence of malnutrition in RAC

Bell et al recently published a systematic review on malnutrition prevalence in the RAC setting (14). The review included studies that were published from 1999-2011, single and multicentre studies, and cohorts ranging from 50–11,902 RAC residents (14). Various methods such as nutrition screening and assessment tools, body mass index (BMI), weight loss percentage, anthropometric measurements, and weight were utilised to determine malnutrition prevalence (14). Malnutrition risk and prevalence were estimated to range from 29-97% and 4-71% respectively, with the large variation attributed to selection bias and research methodology to define malnutrition (14). However, in most studies malnutrition risk and prevalence were reportedly between 47-62% and 20-39% respectively (14). The findings of this review are consistent with results from other multicentre studies since published from regions including Iran, Italy, Austria and Finland (46-50).

5. Aetiology of malnutrition in RAC

The aetiology of malnutrition in older adults is complex and multifactorial. Inadequate dietary intake is the leading cause of malnutrition in older adults (51). A physiological reduction in appetite and energy intake, referred to as the "anorexia of ageing", occurs naturally with progressive aging and usually exceeds the reduction in energy expenditure, resulting in unintentional weight loss mainly in the form of lean body mass (52). Additionally, a multitude of factors often referred to as the "nine D's" (Figure 1) are commonly observed in older adults and are associated with difficulty with self-feeding; social and financial problems; impaired digestion, absorption, and excretion of nutrients; and gastrointestinal symptoms (such as nausea, constipation, vomiting, diarrhoea, loss of appetite, and early satiety); resulting in decreased food consumption and exacerbation of malnutrition (12, 15, 53-61). The use of plastic dishware has been associated with malnutrition due to its potential influence on taste of food items and residents' perception of being in hospital (62). Although not well explored in the literature, food insecurity (or the limited ability or uncertainty in accessing adequate, safe, and nutritious food that meets one's taste and cultural preferences in a socially acceptable manner) has also been implicated in the aetiology of malnutrition in the RAC setting (63, 64). RAC residents are particularly vulnerable to food insecurity due to their increasing age, presence of debilitating diseases, lack of control over food intake and preferences, declining physical and psychological health, and limited social and financial capacity (62, 64). Evidence also indicates that the inability of nursing staff to identify and recognise malnutrition as a formidable problem in the RAC setting results in them not prioritising nutrition care for the residents thereby adding to risk of RAC residents developing malnutrition (7, 10, 65).

6. Consequences of malnutrition in RAC

Malnutrition bears significant and diverse consequences including physiological, psychosocial and healthcare costs-related consequences.

6.1. Physiological consequences: The breakdown of liver protein during catabolism in malnourished older adults inhibits hepatic protein synthesis leading to a decrease in immune cells and serum proteins (66). This can cause anaemia, oedema, poor wound healing and impaired immunity with the consequence of increased susceptibility to infections and pressure ulcers. The loss of cardiac muscle decreases cardiac output thereby compromising heart function (67). The ability to control breathing becomes impaired due to the loss of respiratory muscle mass and strength as well as decreased production of surfactant (68). Malnutrition further affects lung structure, elasticity and immune defence and pulmonary oedema can result due to a decrease in colloidal osmolarity secondary to hypoproteinaemia (68). The combination of sarcopenia, loss of fat, impaired cardiac and respiratory function and impaired thermoregulation contribute to a significantly increased risk of falls (69). Malnutrition-related decreasing physical function in multiple organ systems is also associated with an increased risk of mortality (70). Malnutrition was found to be independently associated with a 3- to 6-fold increased risk of mortality in RAC (71-73). Furthermore, significant weight loss within six months and/or eating problems in RAC residents has also been found to increase the risk of 3 month mortality by 20% (74).

6.2. Psychosocial consequences: Depression is prevalent in older adults, with rates of up to 45% in the institutionalised elderly (75, 76). Depression is associated with weight loss and although the association between depression and nutritional status is multifactorial it is unclear if it is a cause and/or consequence of malnutrition in older residents (77-81). As a result of these physiological and psychosocial outcomes, malnutrition in the individual leads to decreased physical functioning and quality of life (82).

6.3. Healthcare costs-related consequences: Beyond the burden of malnutrition to the resident, malnutrition also contributes significantly towards the economic burden in RAC facilities. While

the additional cost of malnutrition in the RAC setting has been estimated in excess of €450 million (USD$489 million) (83), the cost of treating malnourished patients in RAC in the UK has been estimated at £2.6 billion (USD$3.9 billion) (84).

Based on the foregoing it can be inferred that early identification and management of malnutrition is imperative not only to manage the associated physiological and psychosocial consequences for residents but also to minimise associated health-related costs.

7. Nutritional management of malnutrition in RAC

Malnutrition is preventable and treatable, and in some instances completely reversible. The goals of managing the nutritional status of long term RAC residents include not only the treatment of malnutrition but also the prevention of decline in nutritional status (85, 86). Although mealtimes are recognized as 'the highlight of the day' for many RAC residents (87) admission to RAC is known to come with challenges for residents including adjusting to specific meal times and choices, and dining companions and environments; and depending on RAC menus solely for their nutritional intake (88). It has been suggested that malnutrition may be caused iatrogenically by dietary accreditation standards that are either inadequate at meeting nutritional requirements of elderly residents (89) or extremely limited in offered choices related to menu selection (90, 91). Therefore, to alleviate the issue of malnutrition in the RAC setting, there is increasing recognition for (a) revising existing menu guidelines to address nutritional requirements of elderly residents likely to have limited food intake (89); (b) accommodating residents' preferences based on cultural diversity and special dietary requirements (92); (c) improving mealtime choices and variety offered to residents (88). Furthermore, staff education, regular monitoring for nutritional risk and weight, with prompt and individualised triage for malnourished residents is crucial in the management of malnutrition (93-95). In addition, the training and appointment of a staff member as a nutrition coordinator or champion has also demonstrated positive results in managing malnutrition in RAC (96). Evidence highlighting the use of various strategies to improve residents' nutritional status is as below:

7.1 Evidence for the use of modifications to food and mealtimes in the RAC setting:

Since inadequate food intake is the most prominent risk factor contributing to malnutrition in the elderly it is logical to implement strategies that improve food intake in the treatment of malnutrition.

(i) Meal enrichment: The provision of energy- and protein-enriched meals and snacks is a low-cost, 'food first' approach to improving nutrient intake without increasing the amount of food offered,

and may prevent decline in nutritional and functional status for at risk populations (97-99). Therefore, the provision of a high energy-high protein diet, such as through the addition of milk powder, egg yolk, nuts, oil and cream, as well as dairy-based mid-meals, should be provided to older RAC residents who are found to be at risk of malnutrition (98, 100-103). However, research also suggests that food fortification is unlikely to provide sufficient nutritional support to treat residents with overt malnutrition or significantly improve physical function (100-102, 104). This may be due to the poor intervention adherence of residents and staff, short intervention periods, insufficient nutrition support, and insufficient physical activity in a largely frail and immobile population (100-102, 105, 106).

(ii) Therapeutic diets: An Australian study comprising of 199 residents from 18 RAC facilities found that whilst residents' nutritional intake was inadequate in meeting their energy and protein requirements, their sodium intake was three times higher than the recommendation (106). Sugar intake was also high and mainly contributed by excessive serves of 'extras' (including cakes, biscuits, confectionery, soft drinks, and ice-cream) (106). Research demonstrates that prescriptive therapeutic diets, often used in aged care for conditions such as diabetes and cardiovascular diseases, may increase the risk of malnutrition due to their restrictive nature (12, 107). To prevent excessive intake of sodium, the use of herbs and spices as flavour enhancers is recommended to improve flavour perception that may be affected by age-related sensory deficits. Regular physical activity is also a beneficial alternative to food restriction due to its multifactorial effect including increased insulin sensitivity, improved cardiovascular profile, improved muscle mass, and enhanced quality of life.

(iii) Texture modified diets: It is estimated that over half the RAC population is affected by degenerative conditions such as dementia, stroke, Parkinson's disease and Alzheimer's disease that commonly results in dysphagia, or a dysfunctional swallow (108). Texture modified diets are therefore often prescribed to residents with dysphagia and/or poor dentition (108, 109). However, texture modified diets are known to be nutritionally dilute due to the addition of fluid to achieve

desired consistency, are limited in choice, and visually unappetizing thereby contributing towards reduced intake and thus malnutrition (88, 109-111). To manage these issues, Germain et al used a technology that reformed the appearance of smoot homogenous pureed food to look like its natural form, without altering the nutritional content of the food (108). When malnourished residents with dysphagia were offered this food over a 12-week period a significant improvement was observed in their energy intake (+ 600kcal) and weight (+ nearly 4kg) from baseline (108). This study demonstrated that with careful planning and execution, texture modified foods can have an improved appearance, which can result in better nutritional intake by residents in RAC facilities.

(iv) Mealtime ambience: In the RAC setting, meal ambiance, delivery method, choice over the meals and overall diet liberalisation may promote appetite and thereby have a significant impact upon the total dietary intake of residents (14, 90, 112). A Dutch cluster randomised, controlled trial revealed that when meals were provided "family style", energy intake improved by 991kJ (95%CI: 504-1479kJ), which was both statistically and clinically significant, leading to an improvement in global nutritional status (112). Other successful strategies to promote mealtime ambiance include restaurant style seating and involving the residents in cooking the meals on the ward (51).

7.2 Evidence for the use of oral nutritional supplements in the RAC setting

The provision of ONS has shown to significantly improve energy and protein intake beyond that provided by a regular or high energy-high protein diet (113, 114). Although ONS consumption may decrease the total amount of energy and protein consumed by meals and snacks, the supplements still result in an overall increased energy and protein intake in malnourished RAC residents (114, 115).

The provision of ONS in the RAC setting has shown to be effective in promoting weight gain and mid-arm and calf circumference and health-related quality of life in residents at risk or malnourished, and therefore may improve nutrition status in malnourished groups (17, 116-119). Only one study reported an improvement in global nutrition status with the provision of ONS (119); however, it must be acknowledged that very few studies have included global nutrition status as an

outcome (17). Although some ONS interventions have shown improvements in physical function (17, 119, 120), others have shown no improvement in physical function unless ONS was combined with resistance training (116, 121, 122). Physical activity combined with ONS and oral care was also shown to have additional beneficial effects on social engagement in one study (122).

Resident adherence in consuming ONS is positively associated with improvements in nutritional parameters, such as weight and mid-arm circumference (118, 123). Adherence has been found to improve when ONS is provided as a nutrient dense, low volume option, of approximately 50 - 125ml with accompanying dietary counselling (116, 118, 123). Adherence is also shown to be higher in residents who are malnourished or have chewing difficulties, but lower in residents who are depressed, are immobile or report gastrointestinal distress, indicating residents with these characteristics will require increased individualised support (118).

Residents with dementia present a unique challenge in the treatment of malnutrition due to increased difficulty with ONS adherence. A 2010 systematic review found that residents with dementia had increased levels of adherence when they received the ONS as part of medication rounds, between meals, and when they received encouragement by carers (124). However, carer compliance with providing the prescribed ONS was still found to be a significant problem (124). Although there is limited research into the health-related outcomes of ONS prescription in RAC residents with dementia, some studies have shown an improvement in weight status and nutrition status (124), which aligns with findings in the general RAC population.

Overall, evidence suggests that individualised ONS in low volumes (50-125ml) may be effective in treating malnutrition in residents by promoting weight gain and resident adherence (116, 118). Oral nutrition supplements may prevent a decrease in physical function, but should be used in combination with resistance exercise in frail residents (17, 115, 119-121). Measures to increase adherence will significantly improve the resident outcomes as well as decrease waste, especially in residents with dementia (118, 120, 124). These findings further emphasise the need for policy

which promotes regular malnutrition screening and nutrition assessment of residents, so that intervention can be needs-based.

7.3 Evidence for the use of enteral and parenteral nutrition in the RAC setting

Few studies have investigated the efficacy of enteral nutrition in the RAC setting for the purpose of preventing or treating malnutrition, despite a large number of residents having a feeding tube (125). One study found that dysphagic residents (predominately with dementia) who were fed by percutaneous endoscopic gastrostomy (PEG) were more likely to have a low BMI but failed to have anthropometric improvement with PEG feeding despite increased energy and protein intake compared with orally-fed dysphagic residents (126). Although biochemical nutritional parameters improved, the findings suggest the need for enteral nutrition to be combined with physical activity in order to improve body composition (126). Conversely, an earlier study showed that residents with dementia who received enteral nutrition had a significant improvement in weight; however, were also more likely to have aspiration pneumonia (127). No intervention studies were identified which examined the role of parental nutrition for the prevention or treatment of malnutrition in the RAC setting.

It can be argued that all older adults admitted to RAC facilities are at risk of malnutrition in the long term, and there may be a cost-benefit to the RAC facilities to provide a liberalised, prophylactic, high energy-high protein diet as the standard menu, as this may prevent the significant costs associated with malnutrition and/or frailty (107, 128, 129). Although little research has been done into the cost-effectiveness of nutritional interventions in RAC, a Dutch study showed that the cost of managing a resident at risk of malnutrition was an additional €8,200 (USD$8,800), and an additional €10,500 (USD$11,300) for a malnourished resident per year (130). Conversely, the provision of a high energy-high protein diet via food fortification was found to cost €40 (USD$43) per resident per year in Sweden (104).

8. Implications for practice and future research

A collaborative multidisciplinary approach to developing effective and systematic strategies that help with identifying, diagnosing and treating malnutrition is imperative to the management of malnutrition in the RAC setting (131). Adequate staffing along with provision of nutrition education, support and adequate time allowance for offering daily care must be given due consideration by policy makers and government authorities (9).

It is imperative to have a consistent approach when defining malnutrition in the RAC setting as this will prevent the issue of potential misdiagnosis and facilitate improved correlation between effective nutritional interventions and health-related outcomes thereby influencing advocacy for the development and implementation of suitable policies, regulations and legislations (38). Residents found to be at risk of malnutrition should undergo comprehensive nutrition assessment by a dietitian or physician. A dietitian is ideally placed to provide nutrition assessment and individualised nutrition intervention due to not only their expertise in malnutrition, but also because many physicians in the RAC setting have insufficient time to dedicate solely to developing and implementing a nutrition care plan. However, in an RAC setting, the nutrition care plan involving a multidisciplinary team is critical for resident improvement, and should involve the dietitian, physician, carers and physical therapists.

There is evidence to suggest that in RAC residents, although the volume of intake at main meals remains unchanged regardless of menu type, energy intake is 50% higher with enriched meals Odlund Olin (104). To increase the energy density of meals, fat is usually added for its higher per gram energy content (37kJ/g) in comparison to protein (17kJ/g) and carbohydrate (16kJ/g). While fat has a lower degree for satiety per calorie, it has the ability to improve food palatability and acceptance, reinforcing the idea that low-volume, energy dense foods are a valid strategy to increase energy intake without affecting appetite in older adults. The provision of a high energy and high protein liberalised diet as the standard menu is likely to improve the nutrition status and quality of life of the resident. However, these enriched meals should be provided in a manner which increases

meal ambience, meal quality and resident choice in order to are increase dietary intake and reduce waste, thereby also contributing to the prevention and possibly treatment of malnutrition. Oral nutritional supplements will help to improve the weight status and health-related quality of life in some malnourished residents, but should be combined with resistance exercise in frail older adults to improve physical function. Furthermore, strategies should be employed to increase staff and resident adherence with ONS, which will improve resident outcomes as well as cost-effectiveness. The evidence for enteral nutrition as a method of malnutrition treatment in RAC residents is controversial and insufficient, and no studies have examined the role of parental nutrition.

Since malnutrition is associated with inadequate nutritional intake, and given its high prevalence in the RAC setting, it can be concurred that food availability in RAC facilities is not synonymous with food security for RAC residents (64). However, this aspect has not been well documented in the literature and offers scope for further investigation in the RAC setting, particularly in residents with various forms of cognitive impairment.

Further research is required to examine the role of residents and their family members/carers having a greater input into food, improved meal time ambience combined with a prophylactic high energy-high protein liberalised diet and a nutrition coordinator in the prevention and treatment of malnutrition. Evidence is also required for the cost-effectiveness and acceptability of nutrition interventions, with an emphasis on improving compliance and minimising food insecurity. Furthermore, to improve the quality of evidence available, nutrition interventions should report outcomes on global nutrition status as determined by a validated method of nutrition assessment in this setting.

9. Conclusion

Unfortunately malnutrition remains unacceptably high in the RAC setting, with at least half the RAC population at risk of developing malnutrition and approximately one-in-three residents assessed as malnourished. Identifying and managing malnutrition in the RAC setting will not only

likely improve associated health-related outcomes for individual residents but also possibly extend to benefitting the institutions and health care system economically. Although nutritional interventions which modify the method of food provision and/or provide ONS have demonstrated better outcomes for at risk and malnourished aged care residents, further research is required to improve the evidence base and inform aged care policy.

Contributors

All co-authors have contributed and agree to the content of the paper.

Conflict of interest

None

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Figure 1: Aetiology of malnutrition in the elderly (Adapted from 15, 33)

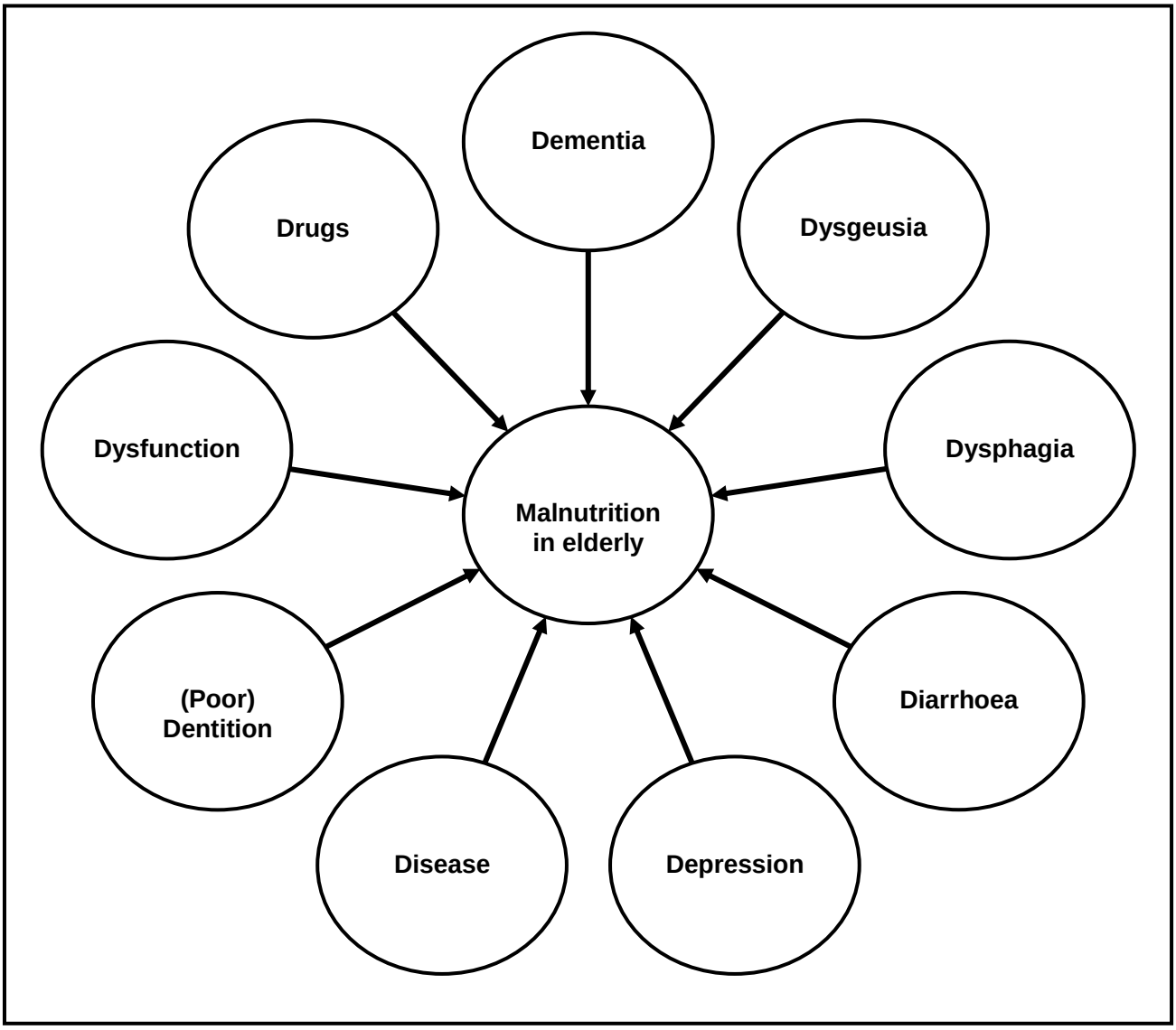

Table 1: Cause and consequences of malnutrition (Compiled from 32, 38, 52, 71-75, 79, 80, 87, 102, 132-134)

Cause	**Consequence**
Physiological	
Impaired immune response	Increased susceptibility to infection and impaired recovery from infection
Impaired wound healing	Surgical wound dehiscence, anastomotic breakdowns, post-surgical fistulae
Reduced muscle mass and strength	Limited physical function, increased disability, increased risk of falls, pressure ulcers, decreased activity leading to increased risk of thromboembolism
Reduced subcutaneous fat for cushioning	Increased risk of fractures in accidents, falls
Reduced respiratory function	Poor cough pressure, increased susceptibility to respiratory infection, fatigue, poor breathing control, pulmonary oedema
Water and electrolyte imbalances	Depletion of potassium, magnesium and phosphate stores combined with excess sodium and water leading to increased risk of re-feeding syndrome and iatrogenic sodium and water overload
Impaired thermoregulation	Hypothermia and increased risk of falls
Vitamin and mineral deficiencies	Specific deficiency states including scurvy and Wernike-Korsakoff syndrome, iron-deficiency and pernicious anaemia or magnesium deficiency
Reduced hepatic function	Anaemia, fatigue, oedema
Reduced cardiac muscle	Decreased cardiac output

	Mortality
Psychosocial	
Lower quality of life	Apathy, depression, self-neglect, hypochondriasis, poor self-efficacy, poor body image, confusion, decreased interest in food, loss of libido, less engagement in social activities due to the overall physiological burden of malnutrition