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Outcomes related to nutrition screening in community living older adults: a systematic literature review

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Publication Details

Hamirudin, A., Charlton, K. & Walton, K. (2016). Outcomes related to nutrition screening in community living older adults: a systematic literature review. *Archives of Gerontology and Geriatrics*, 62 9-25.

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Abstract

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Conclusions Timely nutrition screening of older adults living in the community, if followed up with appropriate intervention and monitoring improves the nutritional status of older adults. This indicates that nutrition intervention should be considered a priority following nutrition screening for malnourished and at risk older adults. Further evaluation of outcomes of nutrition screening and associated interventions, using structured pathways of care, is warranted.

Disciplines

Medicine and Health Sciences | Social and Behavioral Sciences

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Outcomes Related To Nutrition Screening In Community Living Older Adults: A Systematic Literature Review

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Introduction

Nutrition screening is an initial procedure in which the risk of malnutrition is identified. The aims of this review were to identify malnutrition risk from nutrition screening studies that have used validated nutrition screening tools in community living older adults; and to identify types of nutrition interventions, pathways of care and patient outcomes following screening.

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A systematic literature search was performed for the period from January 1994 until December 2013 using SCOPUS, CINAHL Plus with Full Text, PubMed and COCHRANE databases as well as a manual search. Inclusion and exclusion criteria were determined for the literature searches and the methodology followed the PRISMA guidelines.

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Fifty-four articles were eligible to be included in the review and malnutrition risk varied from 0 % to 83%. This large range was influenced by the different tools used and heterogeneity of study samples. Most of the studies were cross sectional and without a subsequent nutrition intervention component. Types of nutrition intervention that were identified included dietetics care, nutrition education, and referral to Meals on Wheels services and community services. These interventions helped to improve the' nutritional status of older adults.

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Timely nutrition screening of older adults living in the community, if followed up with appropriate intervention and monitoring improves the nutritional status of older adults. This indicates that nutrition intervention should be considered a priority following nutrition screening for malnourished and at risk older adults. Further evaluation of outcomes of nutrition screening and associated interventions, using structured pathways of care, is warranted.

Keywords: nutrition screening, malnutrition, community, older adults, nutrition intervention, outcomes

Highlights

- Nutrition screening is an initial step in malnutrition identification.
- Nutrition intervention and monitoring are essential components following nutrition screening.
- This cyclical process helps to improving patient outcomes.

1 INTRODUCTION

Older adults are susceptible to malnutrition due to physiological changes, chronic diseases, side effects of medication (Volkert, 2002), loss of appetite (Hickson, 2006), living alone (Hsieh et al., 2010), poor cognition and functional decline (Chen et al., 2009; Johansson et al., 2009), the biological process of ageing and socioeconomic factors (Meydani, 2001). Malnutrition has been defined as “Any disorder of nutrition status including disorders resulting from a deficiency of nutrient intake, impaired nutrient metabolism, or over nutrition” (Teitelbaum et al., 2005). In this review, malnutrition is referred to as under nutrition.

Malnutrition is a silent threat which develops in community settings (Russell and Elia, 2010). Globally the prevalence of malnutrition, and at risk of malnutrition amongst older adults is 38% (Kaiser et al., 2010). In the community, the prevalence of malnutrition in older adults aged 75-80 years is two-fold higher than the 65-74 age group (Ljungqvist et al., 2010). It is well-documented that malnourished older adults have higher mortality rates (Charlton et al., 2012), reduced quality of life (Neumann et al., 2005), reduced ability to perform activities of daily living (Inoue and Kato, 2007; Izawa et al., 2014), risk of additional illness (BAPEN Malnutrition Advisory Group, 2003a) and they experience longer recovery times than well-nourished peers (BAPEN Malnutrition Advisory Group, 2003a).

Timely malnutrition identification and management is required as malnutrition is not only a threat to patients’ health (Brotherton et al., 2011), but also to healthcare. Healthcare commissions around the world have highlighted the burden of malnutrition in health and social care costs and services; and hence timely malnutrition identification is recommended (Elia et al., 2010). Costs related to malnutrition in Europe are beyond the cost of obesity with approximately 170 billion Euros spent annually for malnutrition, but little attention is

given to combat this condition (Medical Nutrition Institute, 2012). In the UK, the cost of disease-related malnutrition exceeded £7.3 billion in 2003 (Elia, 2009), and was even higher in 2007 with a cost of £13 billion (Elia and Russell, 2009).

Nutrition intervention is particularly important for malnutrition management and defined as ‘a purposefully planned action(s) designed with the intent of changing a nutrition-related behaviour, risk factor, environmental condition, or aspect of health status’ (American Dietetic Association, 2008). Nutrition intervention can be implemented if malnutrition identification is being conducted. Identification of malnutrition can be performed through nutrition screening which is warranted across all settings and widely emphasised by various expert organisations worldwide (BAPEN Malnutrition Advisory Group, 2003a; Kondrup et al., 2003; National Institute for Health and Clinical Excellence, 2006; Tappenden et al., 2013; Volkert et al., 2006). Nutrition screening has been recognised as an initial step in nutritional care (Mueller et al., 2011). Nutrition screening can be summarised as a simple and quick process to identify malnourished or at risk individuals who require nutrition assessment by a dietitian and prioritised nutrition intervention (American Dietetic Association, 1994; BAPEN Malnutrition Advisory Group, 2003a; Kondrup et al., 2003; Teitelbaum et al., 2005; Watterson et al., 2009).

Green and Watson (2006) identified 21 screening and assessment tools specifically designed for older adults, each with different cut-off points and characteristics. Validity and reliability of the tools are essential criteria (Green and Watson, 2005). However, nutrition screening is poorly performed in community settings and malnutrition remains under recognised (Watterson et al., 2009). A compromised nutritional state increases frequency of visits to general practitioners (GPs) (BAPEN Malnutrition Advisory Group, 2003a); which ultimately

places a burden on primary health care services. This high risk group is also associated with greater hospital admissions, longer hospital stay and higher risk of falling compared to their well-nourished counterparts (Visvanathan et al., 2003). During hospitalization, their nutritional status deteriorates with evidence of greater weight loss (McWhirter and Pennington, 1994). There is a body of evidence that older patients are often discharged from hospital in a compromised nutritional state which will likely contribute to further deterioration when they return to the community (Charlton, 2010).

Malnutrition experts in the UK have highlighted the need for further appropriate nutritional care following a screening programme and stated that malnutrition identification does not reflect in outcomes improvement unless accompanied by effective care pathways to address the identified problem (Elia et al., 2005). Timely malnutrition identification and nutrition intervention in older adults whilst they are living in community settings should be a primary goal for healthcare professionals (Rist et al., 2012).

This review aimed to (1) identify malnutrition risk that has been identified from nutrition screening studies that used validated nutrition screening tools in community living older adults; and (2) identify types of nutrition interventions, pathways of care and patient outcomes following screening.

2 METHODS

Literature searches were performed electronically using SCOPUS, CINAHL Plus with Full Text, PubMed and COCHRANE databases. Searches included peer reviewed journal articles for the 20 year period from January 1994 until December 2013. The search was limited to

articles in English language and full text articles. Search terms used in the databases are shown in Figure 1:

Figure 1 Search algorithm used in the review

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("nutrition* risk" OR "malnutrition" OR "undernutrition" OR "nutrition* status") AND ("elder*" OR "older adult*" OR "older people" OR "senior*" OR "geriatric*" OR "veteran" OR "ageing" OR "aging") AND ("nutrition* screening" OR "nutrition* risk screen*" OR screen* ) AND ("community" OR "home" OR "general practice*" OR "clinic*" OR "primary care" ) NOT ("nursing home*" OR hospital )
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Inclusion criteria

Studies using validated nutrition screening tools for community living older adults, with a mean age of 65 years and above, who were community living and may have had the screening conducted within an outpatient clinic, at home, in a general practice or another primary care setting.

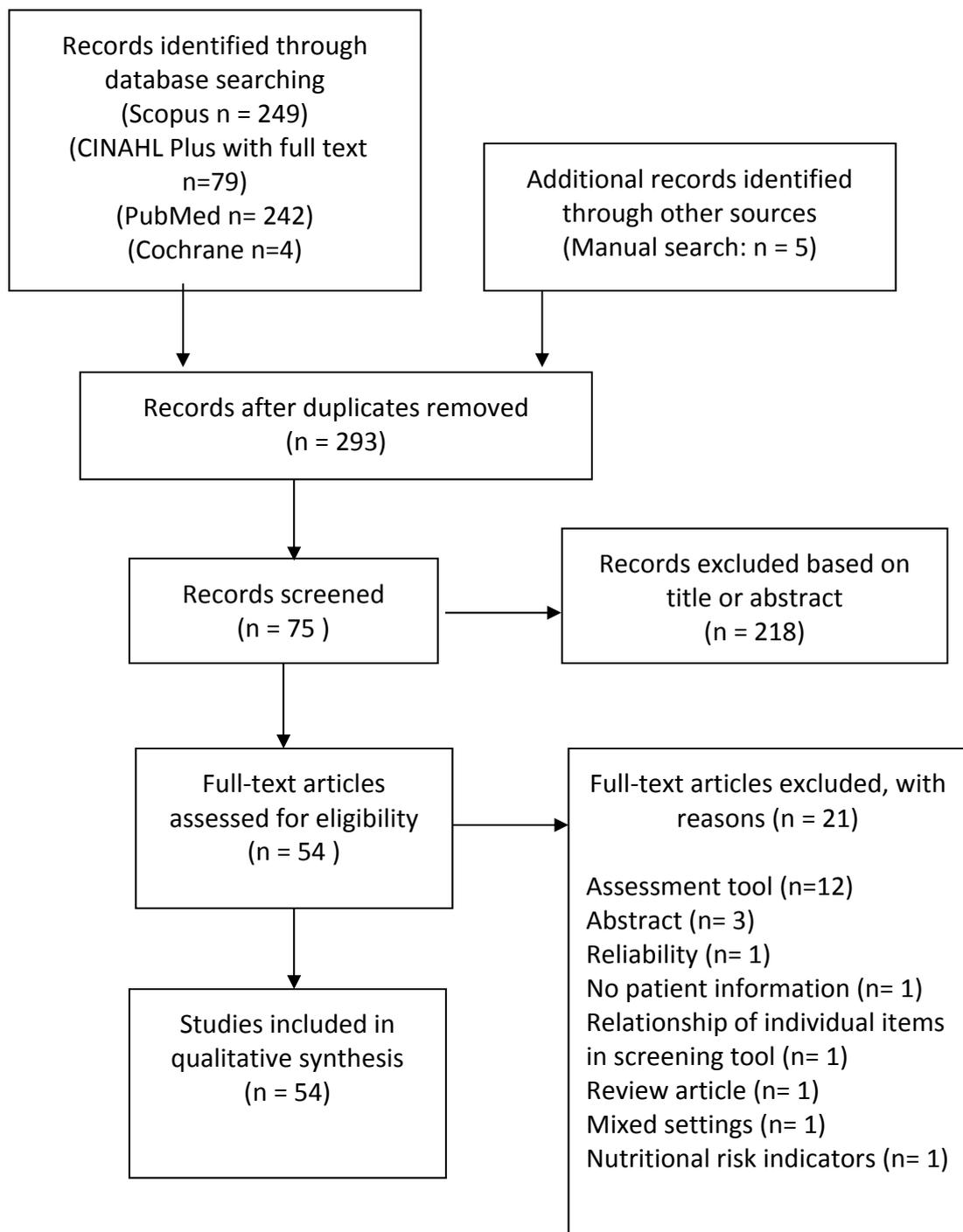
Exclusion criteria

Exclusion criteria included studies of older adults in institutions, nursing home, residential aged care/ care homes, retirement villages and hospital; those with mental illness or impairment or specific diseases or clinical states; comparative studies of nutrition screening tools; studies that assessed validity, inter-rater reliability, evaluation and development of instruments; nutrient or biomarker studies; multiple settings; review articles; cost analyses studies; perception and practices related to screening tools.

Figure 2 illustrates the number of journal articles retrieved from the databases, included and excluded in the review, as well as the reasons for any exclusions. Articles were included for review based on assigned inclusion and exclusion criteria and followed the PRISMA

guidelines (Moher et al., 2009). The articles were ranked according to the National Health and Medical Research Council (NHMRC) levels of evidence: I – IV (NHMRC, 2012). Level I is the highest ranking of evidence, whilst level IV is the lowest. Five articles were identified through manual searching.

Figure 2 Journal articles retrieved, included and excluded in the review based on PRISMA guidelines



3 RESULTS

3.1 Nutrition screening tools used in the studies

The identification of malnutrition requires the use of a validated and easily administered nutrition screening tool (Vellas et al., 2006). Instruments that were used in the included studies were the Australian Nutritional Screening Initiative (ANSI), Elderly Nutrition Screening (ENS[®]), Mini Nutritional Assessment-Short Form (MNA[®]-SF), Malnutrition Screening Tool (MST), Malnutrition Universal Screening Tool (MUST), Nutrition Screening Initiative (NSI) (including the DETERMINE Checklist, Level I and II Screen), Nutritional Risk Index (NRI), Nutritional Form For the Elderly (NUFFE), Seniors in the Community: Risk Evaluation for Eating and Nutrition I (SCREEN[®]) and Seniors in the Community: Risk Evaluation for Eating and Nutrition II (SCREEN[®]II). Characteristics of each of the nutrition screening tools are described in Table 1.

Table 1 Screening tools in alphabetical order and score indicators

Nutrition screening tools	Characteristics
Australian Nutrition Screening Initiative (ANSI) (adapted from NSI)	- 12 items - High risk ≥ 6 , Moderate risk 4-5, Good 0-3
Elderly Nutrition Screening[®] (ENS[®])	- 10 items tool - Score ≥ 3 shows elevated risk
Mini Nutritional Assessment-Short Form (MNA[®]-SF) (original)	-6 items -At risk ≤ 11 , Well-nourished 12-14
Mini Nutritional Assessment-Short Form (MNA[®]-SF)	-6 items -Malnourished 0 -7 , At risk 8-11, Well-nourished 12-14
Malnutrition Screening Tool (MST)	-At risk ≥ 2 -Not a risk: 0 or 1
Malnutrition Universal Screening Tool (MUST)	-3 categories -Low risk (score=0), medium risk (score =1), high risk (score ≥ 2)
Nutritional Risk Index (NRI)	-16 items -Low to moderate risk: 0-7 -High risk: 8-16
Nutrition Screening Initiative (NSI) DETERMINE Checklist	- 10 items - High risk ≥ 6 , Moderate risk 3-5, Good 0-2
Nutritional Form For the Elderly (NUFFE)	-15 three-point items - Maximum score is 30, higher score shows high risk - High risk ≥ 13 , medium risk 6-12, low risk < 6
Seniors in the Community: Risk Evaluation for Eating and Nutrition questionnaire I (SCREEN[®])	- 15-item questionnaire - High risk (score ≤ 45), moderate risk (score= 46-49), low risk (score= 50 -60).
Seniors in the Community: Risk Evaluation for Eating and Nutrition questionnaire II (SCREEN[®]II)	- 17-item multiple choice - High risk (score= 15 -49), moderate risk (score= 50 -53), low risk (score ≥ 54 and 64).

The American Nutrition Screening Initiative (NSI) DETERMINE checklist was developed in the United States in the 1990s and has been widely used to identify nutrition risks in older adults (White et al., 1992). The DETERMINE was initially used as a screening and educational tool, thus its sensitivity as a nutritional screening tool has been argued. SCREEN[©] was adapted in Canada from the DETERMINE (Keller et al., 2007) and targeted for use in adults aged 50 years and above (Keller et al., 2000). SCREEN[©] was further developed into SCREEN[©]II (Keller et al., 2005). The Australian Nutrition Screening Initiative (ANSI) checklist was another community based tool formulated for older adults aged 65 years and older that was based on the DETERMINE and was widely promoted for use by Australian healthcare practitioners in the 1990s (Lipski, 1996).

In Europe, the NUFFE originated from Sweden for older adults (Söderhamn and Söderhamn, 2002), whilst MUST was developed and widely used in the UK across different settings. The MNA[®] (Guigoz et al., 1996) and its shortened version, MNA[®]-SF (Rubenstein et al., 2001) have been performed worldwide and have been translated into different languages. Meanwhile, the Elderly Nutrition Screening (ENS[®]) tool was developed in Canada for older adults (Payette et al., 1995).

A systematic literature review of nutritional screening tools in community living older adults emphasised that screening tools should be tested for validity and reliability to ensure their sensitivity and specificity (Phillips et al., 2010). The review evaluated nutrition screening tools used for older adults in the community and reported that the MNA[®]-SF was the most appropriate nutrition screening tool for identification of malnutrition risk in community living older adults (>65 years) because of it has demonstrated high sensitivity and specificity (Phillips et al., 2010). The MNA[®]-SF, which consists of 6 items (Rubenstein et al., 2001) was derived from the 18-item full MNA[®] (Kaiser et al., 2009; Rubenstein et al., 2001). Ease of

use and quick screening is highly favourable to ensure wide acceptance among health care personnel. Thus, the MNA[®]-SF is favoured as the most practical instrument (Bauer et al., 2010) as it can be completed in less than 5 minutes (De La Montana and Miguez, 2011; Skates and Anthony, 2012).

3.2 Malnutrition risk in community living older adults

Studies identifying malnutrition risk in community living older adults indicate a wide nutritional risk range for studies without nutrition intervention (Table 2), and in those that were accompanied by an intervention (Table 3). This was due to different nutrition screening tools being used and the heterogeneity of study participants. Some of the studies included frail older adults, homebound, older adults receiving home care and very old older adults, which contributed to a higher malnutrition risk as compared to other community living older adults.

All of the studies were observational, either cross sectional (n= 43) (Level IV) or cohort (n=11) (Level III-2), with duration of up to 5 years. No randomised controlled trials were identified.

3.2.1 Nutrition Screening Initiative (NSI)

Twenty-one studies were identified that used the Nutrition Screening Initiative. Eighteen studies used the DETERMINE checklist, whilst another three studies used modified Level I and II screens. There is no standardized scoring algorithm for the original Level I and II screen, thus the modified version scores are based on the DETERMINE checklist (Sharkey and Haines, 2002). One study scored the NSI Level II screen outcomes according to the number of undesirable responses for individual items included in the screening tool (Ledikwe et al., 2003). Meanwhile, Jensen and colleagues (1997) have reported results for responses obtained using the modified Level I and II items, without a cut-off scoring system.

Three level III-2 cohort studies were identified (Benedict et al., 1999; Klein et al., 1997; Wunderlich et al., 2011). According to the NSI, up to 83% of community-dwelling older adults were at high risk of malnutrition (Ballard et al., 2013; Benedict et al., 1999; Coulston et al., 1996; Ledikwe et al., 2003; Lokken et al., 2002; MacLellan and Van Til, 1998; Marshall et al., 1999; Marshall et al., 2001; Sharkey and Haines, 2001; Sharkey et al., 2000; Weatherspoon et al., 2004; Yap et al., 2007).

Higher malnutrition risks were reported among homebound elderly (Lee and Novielli, 1996), low income older adults (Lokken et al., 2002; Miller et al., 1996; Sharkey et al., 2000) and those living in rural areas (Ledikwe et al., 2003; Sharkey and Haines, 2001), compared to those living in urban areas (Weatherspoon et al., 2004). Poor self-perceived health (Lokken et al., 2002; Miller et al., 1996; Weatherspoon et al., 2004) and functional status (Lee and Novielli, 1996; Sharkey et al., 2000) were also higher in those individuals identified at nutritional risk.

3.2.2 Some of the studies have also focused on nutritional risk indicators from DETERMINE items with polypharmacy (Jensen et al., 1997; Ledikwe et al., 2003; MacLellan and Van Til, 1998; Marshall et al., 1999; Miller et al., 1996; Yap et al., 2007), inadequate dairy, fruit and vegetable intakes (Marshall et al., 1999; Miller et al., 1996; Yap et al., 2007), dietary modification due to illness (Benedict et al., 1999; MacLellan and Van Til, 1998; Marshall et al., 1999) and eating alone being identified as main contributors (Benedict et al., 1999; Ledikwe et al., 2003; MacLellan and Van Til, 1998; Marshall et al., 1999). Curl and Warren (1997) have identified malnutrition risks factors based on numbers of identified risk items (≥ 2 and ≥ 3 risks). Lokken et al (2002) reported that mean BMI in the high risk and at risk groups are 29 kg/m² and of 26 kg/m², respectively. Meanwhile, a self-reported BMI of >27 kg/m² is one of the most prevalent nutrition risk factors (Ledikwe et al., 2003) and nutritional risk score ≥ 12 is associated with poverty (Sharkey et al., 2000). SCREEN[©]

Adults younger than 65 years old were included in studies using SCREEN[©] for the purpose of early nutritional risk identification (Keller et al., 2007). Six Canadian studies had performed nutrition screening using this instrument targeting older adults aged 50 years and above; and had identified a range of 39 -57% for malnutrition risk in participants with a mean age of 65 years (Keller, 2004, 2006; Keller et al., 2007; Keller and Hedley, 2002; Keller and Østbye, 2003; Keller et al., 2004). Four of the studies were cohort studies, with the longest duration being 18 months (Keller, 2006; Keller et al., 2007; Keller and Østbye, 2003; Keller et al., 2004); while the remaining two were cross sectional in design (Keller, 2004; Keller and Hedley, 2002). At 18 months of follow up, 75% participants from various nutritional risk categories perceived that their quality of life had deteriorated since baseline, while whole-life satisfaction and good physical health days were lower in the high nutritional risk group in the follow up period compared to those in the other groups (Keller et al., 2004). In addition, mortality rate was 7.4% at follow up and was recorded to be higher in males, those of older age and those that were classified as malnourished (Keller and Østbye, 2003). Low nutritional risk was associated with better self-rated quality of life (Keller, 2004) and

common nutritional problems that were identified included self-reported significant weight change in 6 months, poor intake of fruits, vegetables and dairy products; and dietary restrictions (Keller and Hedley, 2002).

3.2.3 SCREEN[©] II

SCREEN[©] II, an improved version of SCREEN[©], identified 31-52% of individuals to be at high risk of malnutrition (Broeska et al., 2013; McElnay et al., 2012; Ramage-Morin and Garriguet, 2013; Wham et al., 2011a; Wham et al., 2011c). A combination of at risk and high risk categories resulted in a prevalence of up to 62% (Southgate et al., 2010; Watson et al., 2010; Wham et al., 2011c). Living alone (McElnay et al., 2012; Ramage-Morin and Garriguet, 2013; Wham et al., 2011c), less social support (Ramage-Morin and Garriguet, 2013), depression (Ramage-Morin and Garriguet, 2013), poor self rated health (Wham et al., 2011a), disability (Wham et al., 2011a) and eating alone (Watson et al., 2010; Wham et al., 2011a) were identified as factors associated with malnutrition risk. Meanwhile, a higher mortality rate within 5 years was documented in the high nutritional risk group, compared to those in other groups (Broeska et al., 2013). Low nutritional risk was associated with being physically more active, greater muscle mass and muscle strength, and a lower percentage of body fat (Wham et al., 2011c). The SCREEN[©] II may need to be modified when used in different populations from which it was developed. There is some evidence that interpretation of items included in the SCREEN[©] II differs according to population group being studied, and which makes cross-country comparisons difficult (Wham et al., 2011b).

3.2.4 Mini Nutritional Assessment-Short Form (MNA-SF[®])

Five studies used the MNA[®]-SF to screen for malnutrition and all of them were cross-sectional in design (Ji et al., 2012; Nykänen et al., 2013; Timpini et al., 2011; Ülger et al., 2010; Winter et al., 2013). Less than 8% of older adults were malnourished and at risk of malnutrition in a sub-urban area in Italy (Timpini et al., 2011). A study in Australian general practice demonstrated one malnourished and 16% at risk older adults aged 75 years and older (Winter et al., 2013). This study also reported that the at risk group had significantly lower mean body mass index (BMI) than their well-nourished peers and that 34% of the at-risk group had BMI ≥ 25 while 13% were identified as underweight. Twenty-eight percent of 2327 community living older adults in Turkey appeared to be at risk of malnutrition (score ≤ 11) in an outpatient geriatric clinic (Ülger et al., 2010). A higher prevalence of being at risk of malnutrition (70.4%) was documented in China (Ji et al., 2012), while a Finnish study reported 15% of older adults to be either malnourished or at risk (Nykänen et al., 2013). Poor self-rated health, receiving home care and meal services, polypharmacy, symptoms of depression, cognitive impairment, older age, and poor functional status were associated with an increased malnutrition risk (Nykänen et al., 2013).

3.2.5 Nutritional Form For the Elderly (NUFFE)

Four cross sectional studies used the NUFFE. Three studies were conducted in Norway (Dale et al., 2012; Sundsli et al., 2012; Tomstad et al., 2012) and one in Sweden (Söderhamn et al., 2012). Approximately 80% of older adults were identified as well-nourished according to NUFFE classification (Söderhamn et al., 2012; Tomstad et al., 2012). Sundsli et al (2012) found a higher risk amongst adults aged ≥ 85 years with a mean NUFFE score of 6.6 ± 4.1 , which is in the at risk category; whilst the mean score of total participants aged ≥ 65 years was in the low risk category (4.0 ± 3.1). Poorer self-care ability was found in the at risk group

and associated with inability to prepare food (Dale et al., 2012). Identified contributors to nutrition risk were receiving assistance for daily living, being inactive, displaying a sense of helplessness and living alone (Tomstad et al., 2012).

3.2.6 Malnutrition Universal Screening Tool (MUST)

Two Norwegian cross sectional studies that used the MUST screening tool (Kvamme et al., 2011a; Kvamme et al., 2011b) reported that less than 10% of participants were at risk and/or malnourished (Kvamme et al., 2011a; Kvamme et al., 2011b). Health related quality of life reduced significantly in those considered to be at risk (Kvamme et al., 2011b) and mental health symptoms were significantly associated with nutritional risk (Kvamme et al., 2011a).

3.2.7 Elderly Nutrition Screening (ENS[®])

ENS was used in two studies. A prospective cohort study in Canada identified that 60% of free living older people were at moderate to high risk of malnutrition according to ENS classification. Poor self-rated health increased nutrition risk threefold (Roberts et al., 2007). Another Canadian study reported elevated risk in 46.1% men and 55.9% women; with older age being a significant factor contributing to nutrition risk (Ávila-Funes et al., 2008).

3.2.8 Australian Nutrition Screening Initiative (ANSI)

Brownie (2007), Burge and Gazibarich (1999), Patterson et al (2002); and Cobiac and Syrette (1995) used ANSI. Approximately 30% were identified at high nutritional risk, whilst the combination of high and moderate nutritional risk is up to 60%. (Brownie et al., 2007; Burge and Gazibarich, 1999; Cobiac and Syrette, 1995; Patterson et al., 2002). ANSI was used as an instrument to identify risk of malnutrition via a national postal survey (Brownie et

al., 2007; Patterson et al., 2002) as well as through self-completion (Cobiac and Syrette, 1995). However, Brownie et al (2007) warned that ANSI may overestimate risk of malnutrition as a screening tool and it has since been reported that the ANSI has poor reliability (Phillips et al., 2010).

3.2.9 Malnutrition Screening Tool (MST)

Only one study used MST to screen for malnutrition. The Australian study of clients of Home and Community Care (HACC) identified 15% of the sample to be considered to be at nutritional risk (Leggo et al., 2008).

3.2.10 Nutritional Risk Index (NRI)

Only one cross sectional study in the USA used the NRI tool. The study identified that 7.5% of older adults were at high risk (Nickols-Richardson et al., 1996). The authors found that older age was a predictor of nutritional risk; and suggested that the low identified risk may be due to frailer individuals having been institutionalised.

3.3 Structured pathways of care following screening

Structured pathways of care following nutrition screening are outlined by the MST, MNA[®]-SF and MUST tools according to categories of nutrition status. No structured pathways were identified from other screening tools. The DETERMINE checklist recommends that older adults who are classified as either being at moderate or high risk seek further nutritional advice from their health care professionals. Meanwhile, recommended intervals for repeat screening vary based on nutritional status categories and tools. From these three identified tools, the MNA[®]-SF is the only instrument that was specifically developed for older adults

3.4 Nutrition intervention and outcomes

Most international studies in community settings were cross sectional to determine the prevalence of malnutrition, but many did not include nutrition interventions (Yap et al., 2007). In this review, only eleven of the fifty-four nutrition screening studies were accompanied with nutrition interventions. Meanwhile, no nutrition interventions were available for older adults in nutrition screening studies that used the MNA[®]-SF, NUFFE, MUST, ENS[®] or NRI.

3.4.1 Dietetic referral and advice

Eight of the identified studies included dietetic intervention strategies to address malnutrition. Four studies demonstrated that dietetic advice improved older adults' nutritional status (Benedict et al., 1999; Keller et al., 2007; Klein et al., 1997; Leggo et al., 2008); whilst another four studies did not evaluate outcomes related to dietetic intervention (Burge and Gazibarich, 1999; Herndon, 1995; Watson et al., 2010; Weddle et al., 1997). A range of 7 to 64% of older adults refused to see a dietitian despite being identified as being at nutritional risk or malnourished (Benedict et al., 1999; Herndon, 1995; Keller et al., 2007; Klein et al., 1997; Leggo et al., 2008). More than half of older adults who attended dietetic consultations had no concerns about being at nutritional risk (Benedict et al., 1999). Keller et al (2007) have reported reasons for a decline in referral to dietetic services as being patient denial of risk status, lack of interest, cost of dietetic intervention and lack of intention to introduce changes to diet.

Only one study has highlighted dietetic referrals for nutrition intervention in Australia. Leggo et al. (2008) aimed to develop a dietetic referral system among Home and Community Care (HACC) clients through the implementation of nutrition screening using MST. A nutrition assessment tool, the Patient Generated- Subjective Global Assessment (PG-SGA)

was further employed to evaluate the extent of malnutrition risk in the study (Leggo et al., 2008). Other successful approaches to improve older adults' nutritional status include group nutrition education, which involved cooking demonstrations and group discussions, as well as telephone counselling (Wunderlich et al., 2011).

3.4.2 Nutrition information resources

This review identified that nutrition information resources were made available for older adults in five studies (Benedict et al., 1999; Burge and Gazibarich, 1999; Keller et al., 2007; Southgate et al., 2010; Wunderlich et al., 2011). Printed materials were most commonly used in order to deliver nutrition information; namely pamphlets, healthy eating booklets and flyers; and a one year subscription to a nutrition newsletter.

3.4.3 Meals on Wheels (MOW) / home delivered meal service

Three studies have included MOW/ home delivered meals service as an approach for nutrition intervention (Keller, 2006; Keller et al., 2007; Watson et al., 2010). Meals on Wheels has been shown to be a successful intervention strategy in one of the studies through improvement in SCREEN[©] score at 18 months follow up (Keller, 2006). The other two studies did not highlight outcomes of the MOW intervention (Keller et al., 2007; Watson et al., 2010).

In this review, ten studies recruited MOW/home delivered meal service clients as study participants (Herndon, 1995; Keller, 2004, 2006; Keller et al., 2007; Keller and Østbye, 2003; Sharkey and Haines, 2001; Sharkey et al., 2000; Weatherspoon et al., 2004; Weddle et al., 1997; Wunderlich et al., 2011); whilst one study involved MOW applicants (Coulston et al.,

1996). In the USA, 68% of MOW clients were able to maintain their physical function and minimise adverse effects of malnutrition with the help of a MOW service (Herndon, 1995). It was reported that the increased use of a MOW service indicates deterioration in nutritional status (Keller, 2006).

3.4.4 Community services

The role of community services in nutrition intervention has been identified. Two studies have adopted this strategy. Referral to appropriate support services in the community such as assistance with shopping helped to improve nutritional status in a Canadian study (Keller et al., 2007); whilst the other study did not mention the specific community services offered to study participants (Klein et al., 1997).

3.4.5 Oral nutrition supplements (ONS)

The use of high energy and high protein ONS does not appear to be a frontline nutrition intervention approach in community settings as none of the identified studies adopted this strategy (Benedict et al., 1999; Wunderlich et al., 2011).

4 DISCUSSION

This review has identified fifty-four (n=54) nutrition screening studies using validated nutrition screening tools in community living older adults, types of nutrition interventions, pathways of care and patient outcomes following screening. The availability of various nutritional screening tools for malnutrition risk screening and the heterogeneity of study participants contribute to a wide range of reported risk of malnutrition (0- 83%) in

community-living older adults. The alarming figures warrant appropriate attention and care by health professionals.

The implementation of routine nutrition screening for community living older adults can help to identify malnutrition risk and improve patient outcomes if accompanied by appropriate and timely nutrition intervention and follow up. Only eleven (n=11) studies in this review went on to provide nutrition intervention for older adults who were identified to be either malnourished or at high nutritional risk. However, some of the studies reported that older adults refused to undergo nutrition intervention although it was offered to them (Herndon, 1995; Keller et al., 2007; Klein et al., 1997; Leggo et al., 2008). Further evaluation regarding reasons for refusing to see a dietitian and declining to avail themselves of the suggested interventions should be addressed accordingly.

Nevertheless, most screening tools being used in intervention studies do not provide guidelines on the structured intervention pathways following screening for further follow up. Only a study by Leggo and colleagues (2008) conducted nutrition screening in older Australians using the MST, a validated tool with a recommended intervention pathway. Although none of the studies in this review included high energy and high protein oral nutrition supplementation (ONS) as a nutrition intervention strategy, the recommendation of ONS intake is normally provided by dietitians during individualised dietetic consultations and is a strategy most often used in an inpatient setting. Another systematic literature review reported that dietary consultation, either with or without prescription of ONS, improved body weight in malnourished older adults which suggests that the dietetic consultation itself is key to improving nutritional status (Baldwin and Weekes, 2011). Furthermore, efficacy of

ONS for community living older adults remains unclear, as has been reported in a meta-analysis (Milne et al., 2009).

Only seven studies involved nutrition monitoring, whilst a total of eight studies reported outcomes of interventions. The duration of monitoring following an initial nutrition screen varied from 4 weeks (Southgate et al., 2010) to two years (Wunderlich et al., 2011). All studies reported improvements in older adults' nutritional status after they had received different approaches of nutrition intervention strategies, including printed nutrition education resources (Southgate et al., 2010), subscription to a nutrition newsletter and dietary consultation (Benedict et al., 1999), referral to MOW (Herndon, 1995; Keller, 2006); a combination of counselling, nutrition education resources and a home delivery meal program (Keller et al., 2007; Wunderlich et al., 2011), and individualised dietetic evaluation and consultation (Herndon, 1995; Klein et al., 1997; Leggo et al., 2008). Further evaluation of outcomes of nutrition interventions following nutrition screening for those in a compromised nutritional status living in the community is warranted (Vedantam et al., 2010; Visvanathan et al., 2003).

Most of the studies in this review are cross sectional studies to identify nutritional risk in community living older adults without nutrition intervention. A previous systematic literature review identified that a nutrition screening initiative alone is not enough to result in beneficial patient outcomes (Weekes et al., 2009). There is a need to conduct prospective longitudinal studies along with appropriate nutritional interventions as emphasized by Roberts et al (2007). Green and Watson (2006) also highlighted the need for a more detailed assessment and care plan following nutrition screening for those who are malnourished, or at risk of malnutrition. No randomised controlled trials using validated

nutritional screening tools followed up with appropriate nutrition intervention were identified in this review. A nutrition care process and model to further evaluate patients' nutritional status was established by the American Dietetic Association (ADA). This recommends a continuous cycle of nutrition assessment, diagnosis, intervention and monitoring (American Dietetic Association, 2008). There is ample evidence that nutrition intervention is essential and should be addressed accordingly before irreversible nutritional risk takes place (Keller et al., 2007; Ülger et al., 2010). However, there are challenges regarding patient review in the community setting following discharge from hospital (Beck et al., 2001). In order to prevent a disconnect between levels of care (tertiary vs primary), a systematic approach is required, as consistent with ADA's recommendation (de van der Schueren et al., 2014). Thus, a need for greater awareness from health care professionals is required for appropriate nutritional care delivery in the community as this is where the majority of the older population resides (Australian Institute of Health and Welfare, 2012).

Implementation of routine nutrition screening in general practice is an ideal strategy for timely malnutrition risk identification and provision of appropriate nutrition interventions and follow up (Flanagan et al., 2012; Hamirudin et al., 2014). However, reports of nutrition screening initiatives conducted in general practice are uncommon, as confirmed in this review. It is more beneficial to screen patients early in order to prevent and identify this issue rather than detecting severe malnutrition problems later on (BAPEN Malnutrition Advisory Group, 2003b). Adequate community resources are essential for implementation of nutrition screening and intervention (Keller et al., 2007). The use of a nutrition screening tool can help in increasing nutrition awareness (Southgate et al., 2010). Meanwhile, older adults have identified general practice as the most preferred place to obtain nutrition information (Benedict et al., 1999). Thus, the nutrition screening process presents a window

of opportunity for further discussion on nutrition; and identification of malnutrition and related adverse effects (Healy et al., 2014). A real challenge is to deliver a seamless nutritional care process in general practice settings; between general practitioners and other healthcare providers (Ball et al., 2012). As nutrition screening is not usually performed by dietetic and nutrition specialists (ADA, 2008), nurses have been recognised to play this key role in conducting nutrition screening in the community and across other care settings (Skates and Anthony, 2012).

Healthy ageing and independent living at home are essential targets for older adults (Department of Health and Ageing, 2012). Malnutrition identification through nutrition screening in the community and nutrition intervention and monitoring are vital as reversing the negative outcomes of malnutrition are far more difficult (Flanagan et al., 2012). Further collaborative work amongst healthcare professionals is important to assist older adults to live independently at home in their best nutritional status (Australian and New Zealand Society for Geriatric Medicine, 2009).

Limitations of this review include exclusion of non-English journal articles and that it covered for the time period of January 1994 until December 2013 only. However, this review is at the forefront in reporting outcomes following nutrition screening in community living older adults. Further high quality studies are warranted to further confirm beneficial outcomes of nutrition screening accompanied with nutrition intervention, monitoring and evaluation. Appropriate nutrition intervention using structured pathways of care and multi-disciplinary approaches to nutritional care are recommended.

5 CONCLUSIONS

Timely identification of malnutrition risk using validated nutrition screening instruments, along with appropriate nutrition interventions and ongoing monitoring, improves the nutritional status of community living older adults. Nutrition interventions should also be considered a priority following nutrition screening for malnourished and at risk older adults. Further evaluation of outcomes related to nutrition screening and appropriate intervention, according to structured pathways of care is warranted.

6 ACKNOWLEDGEMENT

We would like to thank Cecile Perrin, a librarian from the University of Wollongong for advice on the literature searches.

7 CONFLICTS OF INTEREST

None.

Table 2 Nutrition screening studies in community living older adults without nutrition intervention (presented in alphabetical order of tools and most recent year of studies)

Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/mean age in years	Nutrition Screening tool, score indicators	Key Findings	NHMRC ¹ Level of Evidence
Australian Nutrition Screening Initiative (ANSI)¹						
Brownie et al. (2007) Australia	Community-living	Cross-sectional	1263 (50.8%male, 49.2%female) Age: 65- 98	ANSI	-High risk: 36% -Moderate risk: 23%	IV
Patterson et al. (2002) Australia	Community-living (Older cohort of the Australian Longitudinal study on Women's Health 1996)	Cross sectional postal survey	12 939 (all female) Age:70-75	ANSI	-High-risk: 30% -Moderate risk: 23%	IV

¹ ANSI score indicator: High nutritional risk ≥ 6 , Moderate nutritional risk 4-5, Good 0-3

Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/mean age in years	Nutrition Screening tool, score indicators	Key Findings	NHMRC ¹ Level of Evidence
Cobiac and Syrette (1995) Australia	Community-living (Australian Longitudinal Study of Ageing)	Cross sectional (Self-completed questionnaire)	1098 (male and female) Age: ≥70	ANSI	-High risk: 30% -Moderate risk: 20.6%	IV
Elderly Nutrition Screening[®] (ENS[®])²						
Ávila-Funes et al. (2008) Canada	Community-living	Cross-sectional	1,755 (48% male, 52% female) Age: 67-84 Mean age: 70 ± 2	ENS [®]	Elevated risk: - 46.1 % (male) - 55.9% (female)	IV
Roberts et al. (2007) Canada	Community-living	Prospective cohort (baseline & at 12 months)	839 (31.3% male, 68.7% female) Mean age: 79.6 years	ENS [®]	- Elevated risk: 60% (baseline)	III-2
Author, Year, Country	Setting	Study design	Total participants (gender), age	Nutrition Screening tool, score indicators	Key Findings	NHMRC ¹ Level of Evidence

² ENS[®] score indicator: Score ≥3 shows elevated risk.

			range in years/mean age in years			
MNA[®]-SF						
Winter et al. (2013) Australia	General practice	Cross-sectional	225 (48% male, 52% female) Age: ≥75 Mean age: 81.3 ±4.3	MNA [®] -SF (revised) ³	-Malnourished : One patient -At risk: 16%	IV
Nykänen et al. (2013) Finland	Community-living	Cross-sectional	696 (30.6% male, 69.4% female) Mean age: 81 ± 4.6	MNA [®] -SF (revised)	- At risk and malnourished (score ≤11): 15% -	IV
Ji et al. (2012) China	Community-living	Cross-sectional	632 (33% male, 67% female) Age: ≥90 Mean age: 94 ± 3	MNA [®] -SF (revised)	- Mean score: 10.3 ± 1.8 - Malnourished: 5.7% - At risk: 70.4%	IV
Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/mean age in years	Nutrition Screening tool, score indicators	Key Findings	NHMRC¹ Level of Evidence

³MNA[®]-SF (revised) score indicator: Malnourished 0 -7, At risk 8-11, Well-nourished 12-14

Timpini et al (2011) Italy	Community-living (sub-urban)	Cross-sectional	698 (41.5% male, 58.5% female) Age: ≥ 65 Mean age: 75.6 ± 6.4	MNA [®] -SF (original) ⁴	- At risk: 8%)	IV
Ülger et al. (2010) Turkey	Community living (outpatient clinic)	Cross sectional	2327 (36.4% male, 63.6% female) Age: ≥ 65 Mean age: 72.14 ± 2.18	MNA [®] -SF (original)	At risk: 28%	IV
Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/mean age in years	Nutrition Screening tool, score indicators	Key Findings	NHMRC¹ Level of Evidence

⁴ MNA[®]-SF (original) score indicator: At risk ≤ 11 , Well-nourished 12-14

Malnutrition Universal Screening Tool (MUST)⁵						
Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/mean age in years	Nutrition Screening tool, score indicators	Key Findings	NHMRC¹ Level of Evidence
Kvamme et al. (2011a) Norway	Community-living	Cross-sectional	3111 (50.1% male, 49.9% female) Age: 65 -87 Mean age: 71.2(male), 72.0 (female)	Malnutrition Universal Screening Tool (MUST)	- At risk of malnutrition (medium and high risk): 7.1% (5.6% male and 8.6% female).	IV
Kvamme et al. (2011b) Norway	Community-living	Cross-sectional	3,286 (49.7% male, 50.3% female) Age: 65 -87 Mean age: 71.7 ± 5.5	Malnutrition Universal Screening Tool (MUST)	- At risk of malnutrition (medium and high risk): 5.6% male and 9.6% female	IV

⁵ MUST score indicator: Low risk (score=0), medium risk (score =1), high risk (score ≥2)

Nutritional Risk Index ⁶						
Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/mean age in years	Nutrition Screening tool, score indicators	Key Findings	NHMRC ¹ Level of Evidence
Nickols-Richardson et al (1996) USA	Community-living (good cognition)	Cross sectional	240 Three age groups: 60-69: n= 79 (32.9%), 41.8% male, 58.2% female 80-89: n=86 (35.8%), 31.4% male, 68.6% female 100+: n=75 (31.3%), 22.7% male, 77.3% female	Nutritional Risk Index	-Mean score: 4.06 ± 2.27 -High risk: 7.5% -Low to moderate risk: 92.5%	IV

⁶ Nutritional Risk Index score indicator: High risk 8-16, Low to moderate risk 0-7

Nutrition Screening Initiative (NSI) ⁷						
Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/mean age in years	Nutrition Screening tool, score indicators	Key Findings	NHMRC ¹ Level of Evidence
Ballard et al. (2013) Ireland	Community health centres (urban)	Retrospective cross-sectional	120 (30.8% male, 69.2% Female) Age: 65-97 Mean age: 79.8	Nutrition Screening Initiative (DETERMINE Checklist)	- Mean score: 3.55 ± 2.62 - High risk: 20.2% - Moderate risk: Not reported	IV
Yap et al. (2007) Singapore	Community -living	Cross-sectional	2605 Age: 55 -98 Mean age: 66.0±7.7	Nutrition Screening Initiative (DETERMINE Checklist)	- High risk: 4.6% - Moderate risk: 25.5%	IV
Weatherspoon et al. (2004) USA	Congregate meal sites (urban & rural)	Cross-sectional	324 (25% male, 75% female) Age: >60 (93% aged ≥65)	Nutrition Screening Initiative (Modified DETERMINE Checklist)	-Mean score: 4.45 ± 2.76 -High risk: 31% -Moderate: 46%	IV

⁷ NSI score indicator: High risk ≥6, Moderately at risk 3-5, Good 0- 2

Ledikwe et al. (2003) USA	Community-living (rural)	Cross-sectional	179 (45.3% male, 54.7% female) Age: ≥65 Mean age: Male 73.3±5.0 Female 73.5 ± 5.0	Nutrition Screening Initiative (modified Level II ⁸) (Telephone administered)	-Mean score : 6.3 ± 3 .0 (male) 6.3 ± 3 .0 (female) -	IV
Sharkey and Haines (2002) USA	Community-living	Cross-sectional	152 (40% male, 60% female) Age: 60-95 Mean age: 72.2 ± 7.9	Nutrition Screening Initiative (modified Level I ⁹ and Level II based on DETERMINE checklist). (Telephone administered)	-High risk: 12.6% -Moderate risk: 34.4%	IV
Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/mean age in years	Nutrition Screening tool, score indicators	Key Findings	NHMRC¹ Level of Evidence

⁸ Level II: No standardized scoring algorithm for original Level II screen

⁹ Level I: No standardized scoring algorithm for original Level I screen

Lokken et al. (2002) USA	Community-living (low income)	Cross-sectional	212 (22.6% male, 77.4% female) Age: ≥55	Nutrition Screening Initiative (DETERMINE Checklist)	-High risk: 74% -Moderate risk: 17%	IV
Sharkey and Haines (2001) USA	Community-living (rural home delivered meals)	Cross-sectional	245 (27% male, 73% female) Age: >60 Mean age: 78.9 ± 8.2	Nutrition Screening Initiative (DETERMINE Checklist)	-High risk: 69.4% - Moderate risk: Not reported	IV
Marshall et al (2001) USA	Community-living	Cross-sectional	220 (33% male, 67% female) Age:>79 Mean age: 84.7± 3.9	Nutrition Screening Initiative (DETERMINE Checklist)	High risk:14% Moderate risk: 52%	IV
Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/mean age in years	Nutrition Screening tool, score indicators	Key Findings	NHMRC¹ Level of Evidence
Sharkey et al.	Community-living	Cross-sectional	245 (27% male,	Nutrition Screening	-High risk: 69.4% - Moderate risk: 27.3%	IV

(2000) USA	(rural home delivered meals)		73% female) Mean age: 79 ± 8.2	Initiative (DETERMINE Checklist)		
Marshall et al (1999) USA	Community -living (rural) Hispanic & non-Hispanic	Cross sectional	1006 (44% male, 56% female) Age: ≥65 Mean age: 74.5	Nutrition Screening Initiative (DETERMINE Checklist)	-Hispanic (male: M, female: F) High risk: 24.3% (19% M, 30% F) Moderate risk: 39% (40% M, 39.5% F) -Non-Hispanic (male: M, female: F) High risk: 16% (14% M, 17% F) Moderate risk: 41.3% (46% M, 37.5% F)	IV
MacLellan and Van Til (1998) Canada	Community -living	Cross sectional	215 (32% male, 68% female) Age: ≥70 Mean age: 74.3 ± 7.7	Nutrition Screening Initiative (DETERMINE Checklist)	-High risk: 10% -Moderate risk: 27%	IV
Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/mean age in years	Nutrition Screening tool, score indicators	Key Findings	NHMRC¹ Level of Evidence
Jensen et al. (1997) USA	Clinic sites (rural)	Cross sectional	5373 (47% male, 53% female)	Nutrition Screening Initiative (Modified Level I	-Most commonly reported screening items: intake of ≥ 3 medications (41%) and inadequate food group intakes than recommended (> 50%).	IV

Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/mean age in years	Nutrition Screening tool, score indicators	Key Findings	NHMRC ¹ Level of Evidence
Curl and Warren (1997) USA	Clinic sites (rural)	Retrospective cross sectional	Mean age: 71 228 (35% male, 65% female) Median age: 77	Nutrition Screening Initiative (NSI) (DETERMINE Checklist)	- ≥ 2 Nutritional risk factors: 82% - ≥ 3 nutritional risk factors: 59%	IV
Lee and Novielli (1996) USA	Community-living (home visit program for home bound elderly)	Cross sectional	23 (13% male, 87% female) Age: 58 -93 Mean age: 76 \pm 11	Nutrition Screening Initiative (DETERMINE Checklist)	- Mean score: 7 \pm 2- High risk: 78.3% - Moderate risk: 21.7%	IV
Miller (1996) USA	Community-living (inner- city) North St. Louis (NSL) & East St. Louis	Cross sectional	416 (NSL: 31% male, 69% female) (ESL: 18% male, 82% female)	Nutrition Screening Initiative (DETERMINE Checklist)	-High risk: 48% (NSL), 66 % (ESL) -Moderate risk: 34% (NSL), 24% (ESL) -	IV

	(ESL)		Mean age: 81.5 ± 6.3 (NSL) 69.4 ± 9.1 (ESL)			
Coulston et al (1996) USA	Community-living (MOW applicants)	Cross-sectional	230 (32.2% male, 67.8% female) Mean age: 77.4± 7	Nutrition Screening Initiative (DETERMINE Checklist)	-High risk: 83% -Moderate: 15%	IV
Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/mean age in years	Nutrition Screening tool, score indicators	Key Findings	NHMRC¹ Level of Evidence
Nutritional Form For the Elderly (NUFFE)¹⁰						
Tomstad et al. (2012)	Community-living	Cross-sectional	158 (41.8% male, 58.2%	Nutritional Form For the Elderly (NUFFE)	- Mean score: 3.7 ± 2.6 - High risk: 1.3% - Medium risk: 19%	IV

¹⁰ NUFFE score indicator: High risk ≥13, medium risk 6-12, low risk <6

Norway			female) Age: ≥ 65 Mean age: 73.2 ± 6.9 years			
Sundsli et al (2012) Norway	Community-living (urban)	Cross-sectional	1044 (49.3% male, 50.7% female) Age: ≥ 65 Mean age: 74.8 ± 7.1	Nutritional Form For the Elderly (NUFFE)	- Mean score: 4.0 ± 3.1 -Mean score according to age groups: 3.2 ± 2.3 (age 65-74) 4.3 ± 3.3 (age 74- 84) 6.6 ± 4.1 (age 85+)	IV
Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/mean age in years	Nutrition Screening tool, score indicators	Key Findings	NHMRC¹ Level of Evidence
Söderhamn et al. (2012) Sweden	Community-living	Cross-sectional	1461 (45.2% Male, 54.4% Female) Age: ≥ 75	Nutritional Form For the Elderly (NUFFE)	- High risk: 1% - Medium risk: 21.3%	IV
Dale et al. (2012) Norway	Community-living (rural)	Cross-sectional	1050 (50.1% male, 49.9% female) Age: ≥ 65	Nutritional Form For the Elderly (NUFFE)	- Meanscore: 3.3 ± 2.3 (higher self-care ability group) - Mean score: 7.1 ± 4.6 (lower self-care ability group)	IV

			Mean age: 74.3 ± 6.8			
SCREEN^{®11}						
Keller et al. (2004) Canada	Community-living (23 community service providers)	Cohort (18 months)	367 (26.4% male, 73.6% female) Mean age: 79.3 ± 7.9	SCREEN [®]	-Baseline: High risk: 44.4% Moderate risk: 24.3%	III-2
Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/mean age in years	Nutrition Screening tool, score indicators	Key Findings	NHMRC¹ Level of Evidence
Keller (2004) Canada	Community-living (frail)	Cross-sectional	367 (26.4% male, 73.6% female) Mean age: 79.3 ± 7.9	SCREEN [®]	- Mean score: 45.8 ± 6.6 (range: 24-59) - High risk: 44.4% - Moderate risk: 24.3%	IV
Keller and Østbye (2003) Canada	Community-living (23 community service providers)	Cohort (18 months)	367 (baseline) (26.4% male,	SCREEN [®] (abbreviated) Total score: 48	-At 18 months follow up: Mean score: 37.2 ± 6.9 (Alive) Mean score: 35.2 ± 7.6 (Deceased)	III-2

¹¹ SCREEN[®] score indicator: High risk (score ≤ 45), moderate risk (score= 46-49), low risk (score= 50 - 60).

			73.6% female) Mean age: 79.3 ± 7.9			
Keller and Hedley (2002) Canada	Community-dwelling (seniors recreation centre)	Cross-sectional (mail survey)	263 (40.7% male, 59.3% female) Mean age: 71.7 ± 8.3	SCREEN [®]	- Mean score: 49.6 ± 5.7 (all participants) 50.36 (4.95) (male) 49.24 (6.39) (female) - High risk: 23.5% - Moderate and high risk: 56.7% -	IV
Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/mean age in years	Nutrition Screening tool, score indicators	Key Findings	NHMRC¹ Level of Evidence
SCREEN[®] II¹²						
Ramage-Morin and Garriguet (2013) Canada	Community-living	Cross-sectional	15,669 (40.4% male, 59.6% female) Age: ≥65 Mean age: 77	SCREEN [®] II (abbreviated version, high risk score <38)	-High risk: 34%	IV

¹² SCREEN[®] II score indicator: High risk (score= 15 -49), moderate risk (score= 50 -53), low risk (score ≥ 54 and 64).

Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/mean age in years	Nutrition Screening tool, score indicators	Key Findings	NHMRC ¹ Level of Evidence
Broeska et al (2013) Canada	Community-living	Cohort (The Manitoba Follow-Up Study)	522 (All male) Age: >78 Mean age: 86.8	SCREEN [®] II	-Mean score; 49.9 ± 6.7 -High risk: 44% -Moderate risk: 24%	III-2
McElnay et al. (2012) New Zealand	Community-living (Maori and non-Maori)	Cross-sectional	473 (43. 8% male, 49.9% female, 6. 3% unspecified) Age: ≥65 Mean age: 74	SCREEN [®] II	- High risk: 32.8% - Moderate risk: 23.7 %	IV

Wham et al. (2011a) New Zealand	Community-living	Cross-sectional	51 (29% male, 71% female) Age: 80-85 Mean age: 82.4 ± 1.7	SCREEN [®] II (modified version: High risk score <50, moderate/low risk score 51-64)	- Mean score : 52.2 ± 6.7 - High risk: 31% - Moderate/low risk: 69%	IV
Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/mean age in years	Nutrition Screening tool, score indicators	Key Findings	NHMRC¹ Level of Evidence
Wham et al. (2011b) New Zealand	Community-living (Maori and non-Maori)	Cross-sectional	108 (44% male, 56% female) Mean age: 76.6 ± 1.8 (Maori) 85.2 ± 0.6 (Non-Maori)	SCREEN [®] II (modified version: High risk score <50, moderate/low risk score 51-64)	-High risk: 52% - Moderate/low risk: 48%	IV
Wham et al. (2011c) New Zealand	Community-living	Cross-sectional	108 (44% male, 56% female) Age: 75 -85 Mean age:	SCREEN [®] II (modified version: High risk score <50, moderate/low risk score 51-64)	- Mean score: 46.4 ±5.8 (living alone) - Mean score: 50.3 ±5.1(living with others) - High risk: 52% - Moderate/low risk: 48% -	IV

			76.6 ± 1.8 (Maori) 85.2 ± 0.6 (Non-Maori)			
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¹NHMRC level of evidence; I: A systematic review of level II studies, II: A randomised controlled trial, III-1: A pseudorandomised controlled trial(i.e. alternate allocation or some other method), III-2 A comparative study with concurrent controls (Non-randomised, experimental trial, Cohort study, Case-control study, Interrupted time series with a control group), III-3: A comparative study without concurrent controls (Historical control study, Two or more single arm study, Interrupted time series without a parallel control group), IV: Case series with either post-test or pre-test/post-test outcomes.

Table 3 Nutrition screening studies in community living older adults accompanied by nutrition intervention (presented in alphabetical order of tools and most recent year of studies)

Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/ mean age in years	Nutrition Screening Tool	Nutrition Intervention	Key Findings	NHMRC Level of Evidence
Australian Nutrition Screening Initiative (ANSI)							
Burge and Gazibarich (1999) Australia	Community-living (Senior citizen's centres and groups)	Cross-sectional	92 (24%, male, 76% female) Age: ≥65 Mean age: 75.2 ±5.8	Australian Nutrition screening Initiative (ANSI)	Availability of healthy eating flyer with a local dietitian's contact number	-High risk: 27% (score of 6 or more) -Moderate risk: 30% (score of 4-5) -Low risk: 43% (score of 0-3) -Most common nutrition risk factors: polypharmacy (47%), eating alone most of the time (45%) and dietary modification due to illness (35%). -Significant positive association between self-rated health and nutritional risk was identified. -Home help was significantly associated with nutrition risk. -Inability to shop, cook, or self-feed were more	IV

						prevalent among those aged >80. -Emphasising multi-disciplinary team approach to address nutrition risk.	
Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/ mean age in years	Nutrition Screening Tool	Nutrition Intervention	Key Findings	NHMRC Level of Evidence
Malnutrition Screening Tool (MST)							
Leggo et al. (2008) Australia	Community (HACC eligible clients)	Cross-sectional	1145 Mean age: 76.5 ± 7.2 years	Modified version of Malnutrition Screening Tool (MST) for nutrition screening, PG-SGA for nutrition assessment	Individualized nutrition counselling for at risk subjects who consented to treatment.	-At risk: 15% -Further research: to inquire clients' refusal to free dietetics' service and finding ways to increase the referral uptake. -82% of clients who received dietetics intervention have improved nutritional status.	IV
Nutrition Screening Initiative (NSI)							
Wunderlich et al. (2011)	Home delivered meals (HDM) and	Longitudinal cohort (2 years)	355 participants (n=259 CGM,	Nutrition Screening initiative (Modified	CGM: regular topical nutrition education and counselling (cooking demo,	- Nutrition risk scores improved through provided intervention(nutrition education and counselling): Home-delivered meals from 8.1 to 6.1(p<0.01)	III-2

USA	congregate meals (CGM) participants		n=96 HDM). Mean age: 74.5 ± 9.5	DETERMINE checklist-Nutrition Survey Risk Screening)	discussion, and handouts). HDM: Only received the similar handouts and phone counselling.	Congregate meals from 5.76 to 5.32 (p=0.14)	
Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/ mean age in years	Nutrition Screening Tool	Nutrition Intervention	Key Findings	NHMRC Level of Evidence
Benedict et al. (1999) USA	Community-living (senior nutrition programs)	Cohort (6 months)	2037 (36% male, 64% female) Mean age: 74.3 ± 7.7	Nutrition Screening Initiative (DETERMINE Checklist)	-Screening results and one year subscription of nutrition newsletter (to reduce nutrition risk) were provided to participants. -Screening results were sent to physician if participants' consented. -Dietitian contacted high risk participants in rural area through phone call to arrange for a nutrition counselling.	-High risk: 24% (n = 494) (score of 6 or greater) -Moderate risk: 30% (n = 620) (score of 3 to 5) -Most common nutrition risk factors: polypharmacy eating alone most of the time and dietary modification due to illness. -Only 22% of participants consented their result to be sent to physician. -68 (36%) eligible participants agreed to participate in nutrition counselling. -56% participants attended the nutrition counselling had no concern of malnutrition. -89% rated strongly agree or agree that dietetic intervention improved their nutritional status. -Rural participants at high risk with limited medical support received intensive nutrition intervention. -Multidisciplinary approach should be targeted for this at risk group to educate and improve nutrition awareness.	III-2

Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/ mean age in years	Nutrition Screening Tool	Nutrition Intervention	Key Findings	NHMRC Level of Evidence
Weddle et al. (1997) USA	Community-living (Congregate (C) and home delivered (HD) meals participants)	Cross sectional	288 congregate meal and 36 home delivered meal participants (22 % male, 78% female) Age: ≥ 70 Mean age: 75.9 ± 8.3	Nutrition Screening Initiative (Modified Level 1)	-At risk participants were referred to project dietitians.	-Moderate or high malnutrition risk: 68% of 288 congregate and 89% of 36 home delivered meals participants. -150 congregate and 27 home delivered meals participants consented for an in-depth assessment with dietitian to clarify specific needs. -The most frequent needs: nutrition counselling (87% C, 100% HD), drug/nutrient counselling (44% C, 52% HD) and dental issues (24% C, 30% HD). -Nutrition screening and assessment should be coordinated in older adult's nutrition in the community program.	IV
Klein et al. (1997) USA	Clinic sites (rural)	Cohort (6 months)	417 Age: ≥ 65	Nutrition Screening Initiative (modified Level I and II)	-Dietetic evaluation and intervention, diet counselling; medical evaluation; social and community services -Repeat screening was performed 6 months after	-38% had BMI < 22. -Interventions were offered to 68 malnourished patients (male n= 28, mean age: 71; female n=40 mean age: 73). -7% had cancelled/refused intervention. -Follow up was still in progress at the time the article was published. 26% had completed repeat screening.	III-2

Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/ mean age in years	Nutrition Screening Tool	Nutrition Intervention	Key Findings	NHMRC Level of Evidence
					intervention. (screening form were mailed to patients to be completed and returned)		
Herndon (1995) USA	Community -living (MOW recipients)	Cohort	245 (29% male, 71% female) Mean age: 79.3	Nutrition Screening Initiative (DETERMINE Checklist)	130 clients that scored ≥ 3 agreed for further screening using the NSI Level I Screen. by a dietitian at home (46 declined)	-High risk:33 % (n = 81) -Moderate: 39% (n = 95) -Low: 28% (n = 68) -77% reported of having functional issues, which required help for shopping. -Inadequate food intake was the reason of poor nutritional status, but not choices. -Nutrition screening and intervention can prevent further deterioration and risk of institutionalisation.	III-2
SCREEN[®]							
Keller et al. (2007) Canada	Community -living	Cohort (Phase 1, 2 and 3)	1196 Mean age: 74.4 \pm 10 years	SCREEN [®]	-All participants were provided with nutrition resources during screening (Phase 1). -Counselling & referral to community services, MOW was offered to at risk participants (score less than 50).	-At risk: 38.9% (n=465) -39% of at risk participants accepted further referrals services (109 referred to dietitian & others to other services). -Reasons for referral decline: denial of at risk status, not interested, believed that they can manage by themselves. -From 59% accepting referral to dietitian, only 44 (40%) turned up during the follow up. -Phase 3: 55% reported improve nutritional status due to screening and intervention; whilst	III-2

Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/ mean age in years	Nutrition Screening Tool	Nutrition Intervention	Key Findings	NHMRC Level of Evidence
					-Phase 2: follow up telephone call for at risk participants (2-4 months after screening) -Phase 3: in-depth interview	21% made no modification since screening. -Implementation of screening program requires targeted and adequate resources.	
Keller (2006) Canada	Community-living (community service agencies e.g MOW)	Cohort (18 months)	367 (baseline), 263 (completed at follow up) Mean age: 78.7 ± 8.0	SCREEN [®]	Participation in community meal program	- At follow-up: Mean score: 46.9 ± 5.7 High risk: 41% (Score ≤45) - Scores improved at follow up for the high risk group. - Use of community meal program help in maintaining and improving older adults' nutritional status. -Increased use of community meal program indicates deterioration in nutritional status.	III-2
SCREEN[®] II							
Watson et al. (2010) New Zealand	Medical centres and a fall prevention service	Cross-sectional	152 (37.5% male, 62.5% female) Mean age: 79.5	SCREEN [®] II	Dietary advice during interview or referral to nutrition-related intervention e.g. HDM	-High nutrition risk: 31% -At risk: 23% -At risk and high risk groups were more likely to live alone and female -Four most frequent risk factors for being 'high risk': unintentional weight change, eating alone, perception of own weight (more or less than actual), and low dairy intake.	IV

Author, Year, Country	Setting	Study design	Total participants (gender), age range in years/ mean age in years	Nutrition Screening Tool	Nutrition Intervention	Key Findings	NHMRC Level of Evidence
						-Eating alone has poor effect to diet quality.	
Southgate et al. (2010) Canada	Non-institutionalized older adults at local senior's centre	Cohort (4 weeks)	61 (36.4% male, 63.6% female) 50% aged >75	SCREEN [®] II	Group A: Personalized letters and healthy eating booklet Group B: Personalized letters only	-At risk: 62.3% -Group A demonstrated better nutrition knowledge than Group B. -Screening and printed education materials have the potential positive effect to modify risk behaviour and nutrition knowledge.	III-2

NHMRC level of evidence; I: A systematic review of level II studies, II: A randomised controlled trial, III-1: A pseudorandomised controlled trial(i.e. alternate allocation or some other method), III-2 A comparative study with concurrent controls (Non-randomised, experimental trial, Cohort study, Case-control study, Interrupted time series with a control group), III-3: A comparative study without concurrent controls (Historical control study, Two or more single arm study, Interrupted time series without a parallel control group), IV: Case series with either post-test or pre-test/post-test outcomes.

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