



Conference on 'Improving nutrition in metropolitan areas' Symposium 4: Interventions to improve nutrition in urban areas

Improving nutrition to support healthy ageing: what are the opportunities for intervention?

Sian M. Robinson^{1,2}

¹MRC Lifecourse Epidemiology Unit, University of Southampton, Southampton, UK

²NIHR Southampton Biomedical Research Centre, Southampton, UK

Alongside declining activity levels, energy needs fall in older age and eating less is expected. However, as total food consumption declines, intakes of many nutrients are also likely to fall; while energy requirements may be met, other nutrient needs may not. Although this highlights the importance of nutrient-dense foods and overall diet quality in older age to ensure nutrient intakes are sufficient, maintaining or increasing diet quality may be difficult at a time when food access and preparation are becoming more challenging, and diets may be more monotonous. Poor nutrition, even in developed settings, is common. Older malnourished adults are more likely to have poorer health outcomes, longer hospital stays and increased mortality. Thus, apart from the evident personal costs, the economic burden of disease-related malnutrition is significant, and effective preventive strategies to promote good nutrition among older populations are needed. In particular, there is a need for wider recognition of malnutrition risk among older adults, including implementation of routine screening of nutritional status and early diagnosis. Design of future interventions to support older community-dwelling adults requires a clear understanding of the personal and contextual influences that affect patterns of food choice and consumption, including consideration of the importance of social and psychological factors. In addition, there are opportunities to intervene earlier in the lifecourse; the most effective preventive efforts to promote good nutrition in older age may need to start ahead of age-related changes in physiology and function, including younger adulthood and at the retirement transition.

Ageing: Nutrition: Prevention: Lifecourse

Increasing life expectancy is changing the age structure of populations across the world. For example, in the UK, adults aged 65 years and over represented 17.8 % of the population in 2015; current projections are that this figure will rise to 24.6 % by 2045⁽¹⁾. Set against expected population growth over this time, the numbers of older adults will grow significantly. However, to date, the changes in life expectancy have not been mirrored by comparable changes in healthy life expectancy, and in most countries, there have been increases in the number of healthy life years being lost to disability⁽²⁾. The need to address this gap in morbidity has focused attention on the role of lifestyle and health behaviours, including nutrition, and their links to the ageing process, with a

view to considering strategies to promote healthier ageing⁽³⁾. This review considers the importance of nutrition in older age and potential opportunities and approaches to support older adults to improve nutrition and health.

Age-related changes in food and nutrition

Alongside declining activity levels, age-related falls in food consumption are expected in later life, and are well documented. The differences in energy intake across adulthood are significant. In a recent analysis of energy intake data from healthy older (around 70 years) and younger (around 26 years) adults, a difference in energy



intake of approximately 16–20 % was shown between the groups, amounting to a reduction of about 0.5 % per year⁽⁴⁾; this compares with previous estimates of a fall in energy intake of about 25–30 % between young adulthood and older age^(4,5). There are a number of age-related physiological changes, which include more rapid and longer satiation, dental and chewing problems, being less hungry and thirsty, and impairments in smell and taste, that can act to change eating behaviour. Older adults may eat more slowly, consume smaller meals and snack less, leading to lower food consumption and ultimately, to weight loss^(3–5). These changes may be compounded by effects of comorbidities and medication that cause loss of appetite. Described as the ‘anorexia of ageing’, arising from the loss of appetite and/or falling food consumption, this is both common in older adults, and known to be an independent predictor of adverse health outcomes⁽⁶⁾. However, ahead of dietary changes that result in significant weight loss, declining food consumption can still affect the nutritional risk of older adults. Unless more nutrient-dense foods are selected at the same time as overall changes in the level of food consumption are occurring, falling food intake will result in lower nutrient intakes in parallel with energy intake, making it more challenging for older adults to meet their nutrient needs^(3,7). Importantly, although energy requirements are lower in older age, the requirements for many other nutrients may not change, or may even increase. Consistent with the possibility of an increasing nutritional risk, many studies of older adults describe insufficient intakes of a range of nutrients, which include protein, fibre and a number of micronutrients⁽³⁾. At a time of falling food consumption, and changing nutrient requirements, consumption of nutrient-dense foods and having a diet of adequate quality are key to ensuring older adults meet nutrient needs⁽³⁾.

Diet quality in older age

In common with younger age groups, there is huge variability in food choices and quality of diet among older adults^(8–10). Some of this variability is linked to differences in background characteristics such as education, gender and ethnicity^(8–10), but much is unexplained, and the influence of ageing on diet is not well understood. An important gap in current understanding is that much of the evidence is cross-sectional, and little is known about trajectories of change in diet quality in later life and how age-related factors impact on individual food choices⁽¹¹⁾. In two recent studies of older adults, followed over 3 years in Canada⁽¹²⁾ and over a decade in the UK⁽¹³⁾, average diet quality did not change substantially between baseline and follow-up assessments. However, these average figures mask sizeable decreases in diet quality for some participants in both studies, particularly among older women. Comparable messages about poorer diet quality have come from a number of studies of older adults, in which monotonous diets of lower diversity and quality have been reported^(14,15). Such patterns of diet, and changes in the balance of

nutrient-dense foods *v.* foods that are less dense, can contribute to lower intakes of protein and micronutrients^(14,16). As the need for a more nutrient-dense diet may coincide with a time when physical limitations are starting to impact on food access and availability, these changes are likely to affect nutritional risk. Additionally, alongside concerns regarding insufficient nutrient intakes, there is also a significant body of evidence that links lower diet quality in older age to an array of poorer health outcomes, which include increased risk of CVD and cancer^(17–19) and to declines in physical function⁽²⁰⁾. This has obvious implications for healthy life expectancy in older age, and raises further concerns about older adults who currently have poor diets.

Estimates of the prevalence of low diet quality in older age vary according to methods of assessment and definitions used, as well as to differences in study populations. In an analysis of data from four European countries (Finland, Sweden, Italy, UK), overall diet quality (defined using a diet quality index) was found to be relatively poor, with few participants achieving the maximum scores⁽¹⁵⁾. This is echoed in findings from the USA. For example, in a study of older independent adults living in New York City, 73 % of women and 78 % of men did not have diet scores that achieved the HEI-2005 (>80) that is defined as ‘good’⁽⁹⁾; among a study of rural older adults, the prevalence was even higher, with an equivalent figure of 98 % of older participants studied⁽¹⁰⁾. Although all of these studies highlighted considerable heterogeneity in diet quality in the study populations, and wide ranges in scores for the dietary indices used, the studies are consistent in their overall message that poor diets in contemporary older populations are common. Importantly, in each case, they identify sizeable groups of older adults, living independently, who are likely to be at nutritional risk.

Malnutrition

Low food intakes and poor diet quality maintained over a prolonged period can lead to lower nutrient status and weight loss. In recent years, the development of validated tools, which are now widely used to identify and define malnutrition^(21,22), have led to its clearer recognition as an issue in older populations, as well as to improved understanding of its health consequences and related economic costs. An important contribution to improving awareness has been the provision of data to enable estimates of prevalence in the population. In England, an estimated one in ten older adults are currently at risk of malnutrition, defined using the Malnutrition Universal Screening Tool⁽²³⁾, a figure that rises to one in three older adults on admission to hospital⁽²⁴⁾. The poorer health outcomes associated with malnutrition have been described in many studies, including greater risk of complications, longer hospital stays and increased mortality^(25–27). Thus, apart from the huge costs to the individual who is malnourished, there are significant incremental healthcare costs associated with malnutrition. For example, the most recent estimate of public expenditure on malnutrition in health and social care in

England amounted to £19.6 billion, with older adults accounting for 52 % of this figure⁽²⁴⁾. Given the changing age structure of populations in England and across the world, without effective strategies to prevent malnutrition in older age, future expenditure is likely to be unaffordable.

Progress has been made in nutrition screening of older populations to define malnutrition risk. Screening can improve nutritional status when it is timely and supported by appropriate care and continued monitoring⁽²²⁾. Although key components of many screening tools are thinness (low BMI) and unintended weight loss, individuals categorised as being at greater risk of malnutrition in this way have been shown also to be more likely to have lower micronutrient status⁽²⁸⁾. Similarly, in a recent review of data from five studies of community-dwelling and institutionalised older adults, malnutrition status, defined using the MNA (mini nutritional assessment), was found to be associated both with nutrient intake and with diet quality⁽²⁹⁾. However, an important finding from the latter study was that low energy and protein intakes, and insufficient micronutrient intakes, were common in older participants whose nutritional status was defined as normal using this tool. The authors conclude that the screening tool, which was not designed to describe low diet quality and suboptimal nutrient intakes, may not identify older adults who have poorer intakes, and that additional tools, such as dietary assessment, should also be used in order to recognise nutritional risk⁽²⁹⁾. As the vast majority of malnourished individuals are community-dwelling⁽²⁴⁾, this finding has important implications for screening approaches to identify falls in diet quality and food consumption in older age, occurring ahead of significant changes in nutrient status and weight loss. Recognising these early signs of declining nutrition among older independent adults may be key to effective preventive strategies in the future.

Identifying opportunities for prevention

The development of community-based interventions, to support older adults to ensure nutrient needs are met, requires a clear understanding of the influences that affect dietary choices and habits in older age, and the factors that determine diet quality and the amounts and types of food eaten. Although some influences on diet are common to younger and older age groups, including positive effects of education and female gender on diet quality^(8,12,15,30,31), there is also evidence to suggest that specific factors may be particularly important in older age. For example, in the study of diet quality among older adults in four European countries, living alone was consistently associated with poorer diets⁽¹⁵⁾. Other significant messages from this study were firstly that poor diet quality was not simply explained by insufficient resource in the older populations studied, and secondly that chronological age contributed little to explaining differences in diet quality. The lack of observed age effects on diet may be consistent with recognised differences between biological and chronological ages^(32,33), but it

emphasises the need to understand the roles and importance of age-related factors as determinants of food choice and diet quality to be able to inform the design of the interventions that are needed to support older adults⁽³⁴⁾.

In their review of factors that affect the nutritional health of older adults, Shlisky *et al.* set out a model that brings together the diverse influences that have both positive and negative effects (Fig. 1)⁽³⁾. Alongside the negative effects of age-related physiological factors, such as loss of appetite, this model also highlights the positive role of social factors such as social support and social interaction, and effects of psychological factors such as resilience⁽³⁾.

The role of social and psychological factors as determinants of nutritional health have been described in a number of studies, and their importance within the complex range of influences that affect diet and health in older age has been described in other studies^(34–36). For example, in a recent systematic review of factors that influence food choice in older independent adults, qualitative analysis of twenty-four studies identified three broad domains: physiological changes associated with ageing, psychosocial aspects and personal resources⁽³⁴⁾. However, some of the evidence of effects of social and psychological factors is fragmented, and less is known about their mechanisms and how these factors interact to affect individual trajectories of nutritional health^(31,34,37). In a recent qualitative study of older (74–83 years) community-dwelling adults in the UK, the nature of these interactions was explored⁽³⁷⁾. Thematic analysis of focus group discussions showed that a number of age-related factors were linked to differences in patterns of food consumption and diet quality, which included bereavement and medical conditions. However, the variability described in individual responses to these influences suggested that psychological and social factors may act by mediating or conditioning ageing effects on diet⁽³⁷⁾. The proposed relationships that describe these interactions are shown in Fig. 2.

For example, discussion about ‘keeping going’ and other examples of coping strategies pointed to the importance of psychological factors in determining individual responses to age-related changes in physiology and context, and discussion about social activities highlighted the positive role of social engagement. Such differential effects of age-related factors suggest that they could act both as barriers or facilitators to maintaining diet quality in older age, and they may also contribute to some of the inconsistencies seen in the findings of intervention studies to improve nutrient intake in older populations^(38,39). To understand the implications of these findings for the design of future interventions, more needs to be known about their effects, and how they affect food consumption⁽³⁴⁾.

Social factors

Social factors, such as level of social engagement, size of social network and support, marital status and whether living alone, have been linked to differences in diet in a

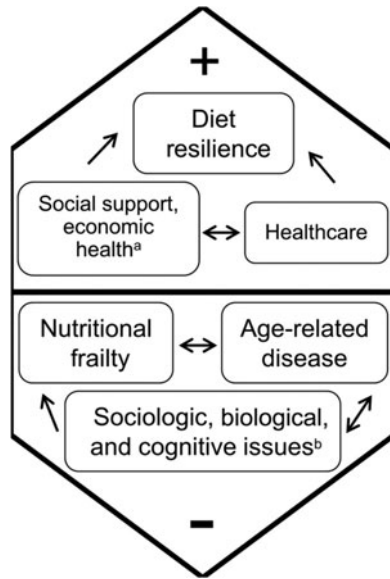


Fig. 1. Factors with positive and negative influences on nutritional health, including ^alack of social interaction, economic factors leading to food insecurity, as well as ^bage-related physiological changes, such as loss of appetite. From Shlisky *et al.*⁽³⁾.

number of studies of older adults^(40–43). In general, greater number and quality of social relationships and contacts are associated with better diet quality. This may be linked to positive psychological states that encourage healthier behaviours⁽¹³⁾, and consistent with positive effects of supportive social environments on health⁽⁴⁴⁾. In particular, living alone is identified as a risk factor for poor nutrition⁽³⁴⁾. However, there are differences in findings across studies, including lack of associations observed in some groups^(42,45). While some of these differences may be explained by the background characteristics and health of participants studied, sex differences appear to be particularly important^(40–42). For example, in a large study of older adults from the EPIC-Norfolk prospective cohort in the UK, the influence of marital status and living arrangement on fruit or vegetable variety were greater for men than for women⁽⁴⁰⁾. Some social factors, such as level of social engagement, are amenable to change and they may offer opportunity in terms of interventions to promote better diet quality. Social network interventions are already being used to support adults who have long-term conditions⁽⁴⁶⁾, and may be an effective approach for the promotion of health behaviours in the general population of older adults. The potential for social interventions to promote nutritional health is supported by recent data from a study of older community-dwelling adults who were participants in the Hertfordshire Cohort Study in the UK. Diet quality was defined by participants' 'prudent' diet scores at baseline (when aged 59–73 years), and in a subgroup who were followed up after 10 years. At baseline, a range of social factors predicted better diet quality score, which included better social support and greater social engagement (identified by greater participation in social and cognitive leisure

activities); these associations were seen both in men and women (Fig. 3)⁽¹³⁾.

In comparison, the study found fewer predictors of change in diet quality over the follow-up period. However, in men and women, greater social engagement at baseline was associated with smaller declines in prudent diet scores over the following decade, suggesting that it may have protective effects on diet quality⁽¹³⁾. These observational findings underline the importance of maintaining social relationships in older age and suggest that supporting older adults to achieve this could be a valuable part of strategies to promote health in later life. They may also point to subgroups in the population who might benefit from additional support, particularly with a view to targeting early preventive initiatives⁽⁴⁷⁾.

Psychological influences on diet in older age

A body of evidence from younger and older populations links psychological factors to differences in food choice and diet quality, which include psychological wellbeing, self-efficacy and depression^(34–36). For example, greater self-efficacy has been shown to predict adherence to healthier dietary patterns, and to affect ability to change dietary habits⁽⁴⁸⁾. Psychological influences may be key to mediating effects of age-related factors, such as medication and poor appetite, on the diet quality of older adults (Fig. 2)⁽³⁷⁾, with important implications for nutritional risk. One psychological characteristic is resilience. In a population-based cohort in Germany, Perna *et al.* showed that resilient older adults were more likely to have better health-related behaviours, which included high consumption of fruit and vegetables and moderate–high levels of physical activity, when compared with non-resilient participants⁽⁴⁹⁾. Importantly, these differences were independent of socioeconomic position and the findings provide strong support for interventions that focus on resilience to promote health in older age. More recently, cluster analysis of data from the Helsinki Birth Cohort, to define resilient and non-resilient older adults, has extended these findings to show differences in intakes of a range of foods among women studied (women with resilient personality profiles reported higher consumption of fruit, vegetables and fish, and lower consumption of processed meats and soft drinks when compared with non-resilient), although comparable differences were not found among men⁽⁵⁰⁾. One explanation for the differing findings in the German and Finnish cohorts may be differences in ages of the participants studied: the Finnish adults (average age 61.5 years) are likely to have been assessed before many age-related challenges had been encountered. Consistent with this suggestion, Vesnaver *et al.* have described the importance of dietary resilience in a group of older participants (73–87 years) from the Canadian NuAge cohort; analysis of semi-structured interviews with these men and women identified strategies used to deal with difficulties in shopping, meal preparation and eating⁽⁵¹⁾. Prioritising eating well and 'doing whatever it takes to keep eating well' were key themes identified. Consistent messages have also come from a recent study of older

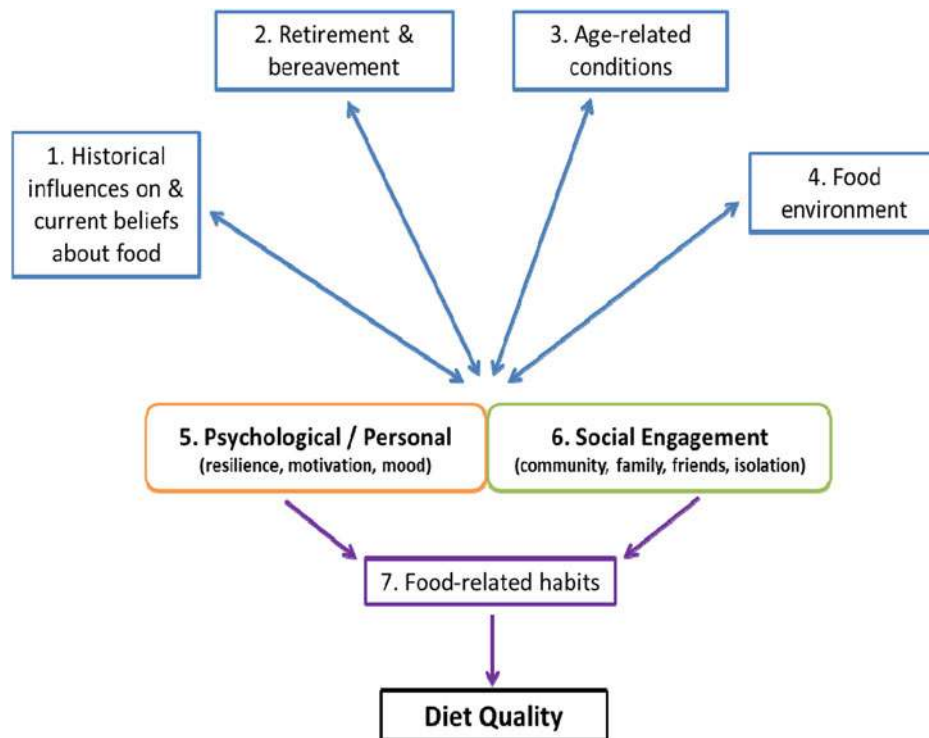


Fig. 2. (Colour online) Hypothetical model of the relationships between themes and potential routes to impact on diet quality in older age. From Bloom *et al.*⁽³⁷⁾.

community-dwelling adults in the USA (mean age 82.5 (SD 4.9) years) who were categorised according to their nutritional risk, using the dietary screening tool^(52,53). Participants who were classified as being at risk had lower resilience, and lower self-efficacy (fruit and vegetables) as well as higher geriatric depression scores⁽⁵²⁾. These data suggest a clustering of psychological factors among older adults who were at nutritional risk⁽⁵²⁾. Further research is needed, particularly to understand potential bi-directional effects of psychological factors on food choice and diet quality, to determine the focus of future interventions to support nutrition among older adults⁽⁴⁹⁾.

Lifecourse perspectives

Much of the evidence reviewed here is cross-sectional and based on studies of older populations. As early identification of the declines in food consumption and falls in diet quality, which lead to increased risk of undernutrition, will be key to effective strategies to promote nutritional health in older age, data from longitudinal studies are needed that can inform the timing and nature of interventions to achieve this. There are few studies that have addressed the early determinants of developing nutritional risk among older adults. An important example is the study reported by Schilp *et al.*⁽⁴⁷⁾. Using baseline and follow-up data, over 9 years, from the Longitudinal Aging Study Amsterdam (participants aged 65–85

years), the predictors of incident undernutrition (defined by low BMI or self-reported unintentional weight loss) were examined. A number of factors were linked to incidence of undernutrition, but in a multivariate model, poor appetite and reported difficulties in climbing stairs (<75 years) remained the only independent predictors⁽⁴⁷⁾. The authors concluded that simple measures could be used to identify subgroups of older adults in the population who are at greater risk of undernutrition, who could benefit from additional support, enabling the targeting of interventions to those at highest risk.

Future longitudinal studies are needed to inform our understanding of the determinants of nutritional risk in older age. However, progress may also come from better recognition of opportunities for preventive strategies that start even earlier in the lifecourse. Partly this is due to the tracking of health behaviours, including diet^(54,55), such that health promotion efforts at much younger ages have potential to be effective in improving nutrition and health in older age. But alongside such behavioural considerations, the lifecourse approach to understanding health and disease in older age underlines the benefit of slowing age-related falls in function, starting much earlier in adulthood, to preserve functional capacity⁽⁵⁶⁾. For example, diets of higher quality in middle age are associated with better measured physical function in older age^(54–57) and dietary pattern trajectory analyses from the China Health and Nutrition Survey showed cumulative benefits of longer exposure to healthier diets in adulthood in relation to glycaemic control (assessed by glycated Hb)⁽⁵⁸⁾.

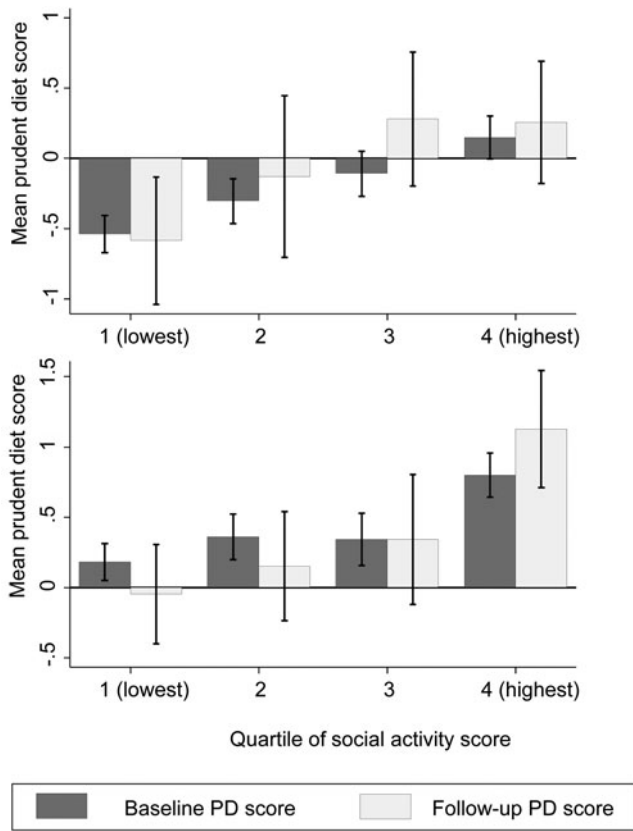


Fig. 3. Diet quality scores (prudent dietary pattern (PD)⁽⁸⁾) at baseline and 10-year follow-up, according to participation in leisure activities (social and cognitive) at baseline, among older men and women in the Hertfordshire Cohort Study⁽¹³⁾. Values are mean with 95 % CI indicated by vertical bars.

Earlier health promotion, with the aim of achieving better nutritional health in older age, could easily build on existing strategies, even though messages regarding potential longer term benefits of healthier diets may be more novel. In addition, there may be particular opportunities for behavioural interventions, including the promotion of healthier lifestyles, around the time of transition to retirement^(59,60). Present studies point to the importance, as well as the feasibility and acceptability of participatory approaches to intervention design for community-based research, which involve older people from the concept-planning stages onwards^(61,62). Existing prevalence figures for poor nutrition among older adults in developed settings, together with current population projections, underline the need for further longitudinal data to inform the design of such preventive interventions to address nutritional risk in older populations.

Conclusions

Falling food consumption may put older adults at nutritional risk. Although this highlights the importance of nutrient-dense foods and overall diet quality in older

age to ensure nutrient intakes are sufficient, maintaining or increasing diet quality may be difficult at a time when food access and preparation are becoming more challenging and diets may be more monotonous. Poor nutrition, even in developed settings, is common, and malnutrition rates are very high⁽²⁴⁾. Effective preventive strategies to promote good nutrition among older populations are needed. Design of future interventions to support older community-dwelling adults requires a clear understanding of the personal and contextual influences that affect patterns of food choice and consumption, including consideration of the importance of social and psychological factors. In addition, there are opportunities to intervene earlier in the lifecourse; the most effective preventive efforts to promote good nutrition for healthier ageing may need to start ahead of age-related changes in physiology and function, including younger adulthood and at the retirement transition.

Financial support

None.

Conflicts of interest

None.

Authorship

The author was solely responsible for all aspects of preparation of the present paper.

References

- Office for National Statistics (2017) Overview of the UK population: March 2017. <https://www.ons.gov.uk/people-populationandcommunity/populationandmigration/populationestimates/articles/overviewoftheukpopulation/mar2017>. Accessed August 2017.
- Salomon JA, Wang H, Freeman MK *et al.* (2012) Healthy life expectancy for 187 countries, 1990–2010: a systematic analysis for the Global Burden Disease Study 2010. *Lancet* **380**, 2144–2162.
- Shlisky J, Bloom DE, Beaudreault AR *et al.* (2017) Nutritional considerations for healthy aging and reduction in age-related chronic disease. *Adv Nutr* **8**, 17–26.
- Giezenaar C, Chapman I, Luscombe-Marsh N *et al.* (2016) Ageing is associated with decreases in appetite and energy intake – a meta-analysis in healthy adults. *Nutrients* **8**, 28.
- Nieuwenhuizen WF, Weenen H, Rigby P *et al.* (2010) Older adults and patients in need of nutritional support: review of current treatment options and factors influencing nutritional intake. *Clin Nutr* **29**, 160–169.
- Landi F, Calvani R, Tosato M *et al.* (2016) Anorexia of aging: risk factors, consequences, and potential treatments. *Nutrients* **8**, 69.
- Wakimoto P, Block G (2001) Dietary intake, dietary patterns, and changes with age: an epidemiological perspective. *J Gerontol A Biol Sci Med Sci* **56**, 65–80.



8. Robinson S, Syddall H, Jameson K *et al.* (2009) Current patterns of diet in community-dwelling older men and women: results from the Hertfordshire Cohort Study. *Age Ageing* **38**, 594–599.
9. Deierlein AL, Morland KB, Scanlin K *et al.* (2014) Diet quality of urban older adults age 60 to 99 years: the Cardiovascular Health of Seniors and Built Environment Study. *J Acad Nutr Diet* **114**, 279–287.
10. Savoca MR, Arcury TA, Leng X *et al.* (2009) The diet quality of rural older adults in the South as measured by healthy eating index-2005 varies by ethnicity. *J Am Diet Assoc* **109**, 2063–2067.
11. Lengyel CO, Jiang D, Tate RB (2017) Trajectories of nutritional risk: the Manitoba Follow-Up Study. *J Nutr Health Aging* **21**, 604–609.
12. Shatenstein B, Gauvin L, Keller H *et al.* (2016) Individual and collective factors predicting change in diet quality over 3 years in a subset of older men and women from the NuAge cohort. *Eur J Nutr* **55**, 1671–1681.
13. Bloom I, Edwards M, Jameson KA *et al.* (2017) Influences on diet quality in older age: the importance of social factors. *Age Ageing* **46**, 277–283.
14. Bartali B, Salvini S, Turrini A *et al.* (2003) Age and disability affect dietary intake. *J Nutr* **133**, 2868–2873.
15. Irz X, Fratiglioni L, Kuosmanen N *et al.* (2014) Sociodemographic determinants of diet quality of the EU elderly: a comparative analysis in four countries. *Public Health Nutr* **17**, 1177–1189.
16. Roberts SB, Hajduk CL, Howarth NC *et al.* (2005) Dietary variety predicts low body mass index and inadequate macronutrient and micronutrient intakes in community-dwelling older adults. *J Gerontol A Biol Sci Med Sci* **60**, 613–621.
17. Hlebowicz J, Drake I, Gullberg B *et al.* (2013) A high diet quality is associated with lower incidence of cardiovascular events in the Malmö diet and cancer cohort. *PLoS ONE* **8**, e71095.
18. Reedy J, Krebs-Smith SM, Miller PE *et al.* (2014) Higher diet quality is associated with decreased risk of all-cause, cardiovascular disease, and cancer mortality among older adults. *J Nutr* **44**, 881–889.
19. Schwingshackl L, Hoffmann G (2015) Diet quality as assessed by the healthy eating index, the alternate healthy eating index, the dietary approaches to stop hypertension score, and health outcomes: a systematic review and meta-analysis of cohort studies. *J Acad Nutr Diet* **115**, 780–800.
20. León-Muñoz LM, García-Esquinas E, López-García E *et al.* (2015) Major dietary patterns and risk of frailty in older adults: a prospective cohort study. *BMC Med* **13**, 11.
21. Elelemaat F, Meijers J, Kruizenga H *et al.* (2011) Comparison of five malnutrition screening tools in one hospital inpatient sample. *J Clin Nurs* **20**, 2144–2152.
22. Hamirudin AH, Charlton K, Walton K (2016) Outcomes related to nutrition screening in community living older adults: a systematic literature review. *Arch Gerontol Geriatr* **62**, 9–25.
23. Stratton RJ, Hackston A, Longmore D *et al.* (2004) Malnutrition in hospital outpatients and inpatients: prevalence, concurrent validity and ease of use of the 'malnutrition universal screening tool' ('MUST') for adults. *Br J Nutr* **92**, 799–808.
24. Elia M (2015) The cost of malnutrition in England and potential cost savings from nutritional interventions. Redditch: British Association for Parenteral and Enteral Nutrition.
25. Naseer M, Forssell H, Fagerström C (2016) Malnutrition, functional ability and mortality among older people aged ≥ 60 years: a 7-year longitudinal study. *Eur J Clin Nutr* **70**, 399–404.
26. Kruizenga H, van Keeken S, Weijs P *et al.* (2016) Undernutrition screening survey in 564,063 patients: patients with a positive undernutrition screening score stay in hospital 1.4 d longer. *Am J Clin Nutr* **103**, 1026–1032.
27. de van der Schueren M, Elia M, Gramlich L *et al.* (2014) Clinical and economic outcomes of nutrition interventions across the continuum of care. *Ann N Y Acad Sci* **1321**, 20–40.
28. Margetts BM, Thompson RL, Elia M *et al.* (2003) Prevalence of risk of undernutrition is associated with poor health status in older people in the UK. *Eur J Clin Nutr* **57**, 69–74.
29. Jyväkorpi SK, Pitkälä KH, Puranen TM *et al.* (2016) High proportions of older people with normal nutritional status have poor protein intake and low diet quality. *Arch Gerontol Geriatr* **67**, 40–45.
30. Atkins JL, Ramsay SE, Whincup PH *et al.* (2015) Diet quality in older age: the influence of childhood and adult socio-economic circumstances. *Br J Nutr* **113**, 1441–1452.
31. Shatenstein B, Gauvin L, Keller H *et al.* (2013) Baseline determinants of global diet quality in older men and women from the NuAge cohort. *J Nutr Health Aging* **17**, 419–425.
32. Lowsky DJ, Olshansky SJ, Bhattacharya J *et al.* (2014) Heterogeneity in healthy aging. *J Gerontol A Biol Sci Med Sci* **69**, 640–649.
33. Martin-Ruiz C, von Zglinicki T (2014) Biomarkers of healthy ageing: expectations and validation. *Proc Nutr Soc* **73**, 422–429.
34. Host A, McMahan AT, Walton K *et al.* (2016) Factors influencing food choice for independently living older people – a systematic literature review. *J Nutr Gerontol Geriatr* **35**, 67–94.
35. Clarke DM, Wahlqvist ML, Strauss BJ (1998) Undereating and undernutrition in old age: integrating bio-psychosocial aspects. *Age Ageing* **27**, 527–534.
36. Tyrovolas S, Haro JM, Mariolis A *et al.* (2014) Successful aging, dietary habits and health status of elderly individuals: a k-dimensional approach within the multi-national MEDIS study. *Exp Gerontol* **60**, 57–63.
37. Bloom I, Lawrence W, Barker M *et al.* (2017) What influences diet quality in older people? A qualitative study. *Public Health Nutr* **20**, 2685–2693.
38. Bandayrel K, Wong S (2011) Systematic literature review of randomized control trials assessing the effectiveness of nutrition interventions in community-dwelling older adults. *J Nutr Educ Behav* **43**, 251–262.
39. de van der Schueren MA, Wijnhoven HA, Kruizenga HM *et al.* (2016) A critical appraisal of nutritional intervention studies in malnourished, community dwelling older persons. *Clin Nutr* **35**, 1008–1014.
40. Conklin AI, Forouhi NG, Surtees P *et al.* (2014) Social relationships and healthful dietary behaviour: evidence from over-50s in the EPIC cohort, UK. *Soc Sci Med* **100**, 167–175.
41. Locher JL, Ritchie CS, Robinson CO *et al.* (2008) A multi-dimensional approach to understanding under-eating in homebound older adults: the importance of social factors. *Gerontologist* **48**, 223–234.
42. Pieroth R, Rigassio Radler D, Guenther PM *et al.* (2017) The relationship between social support and diet quality in middle-aged and older adults in the United States. *J Acad Nutr Diet* **117**, 1272–1278.
43. Sahyoun NR, Zhang XL (2005) Dietary quality and social contact among a nationally representative sample of the



- older adult population in the United States. *J Nutr Health Aging* **9**, 177–183.
44. Holt-Lunstad J, Smith TB, Layton JB (2010) Social relationships and mortality risk: a meta-analytic review. *PLoS Med* **7**, e1000316.
 45. Holmes BA, Roberts CL (2011) Diet quality and the influence of social and physical factors on food consumption and nutrient intake in materially deprived older people. *Eur J Clin Nutr* **65**, 538–545.
 46. Kennedy A, Vassilev I, James E *et al.* (2016) Implementing a social network intervention designed to enhance and diversify support for people with long-term conditions. A qualitative study. *Implement Sci* **11**, 27.
 47. Schilp J, Wijnhoven HA, Deeg DJ *et al.* (2011) Early determinants for the development of undernutrition in an older general population: Longitudinal Aging Study Amsterdam. *Br J Nutr* **106**, 708–717.
 48. Cuadrado E, Tabernero C, Gutiérrez-Domingo T *et al.* (2018) The self-efficacy scale for adherence to the Mediterranean diet (SESAMEd): a scale construction and validation. *Appetite* **120**, 6–15.
 49. Perna L, Mielck A, Lacruz ME *et al.* (2012) Socioeconomic position, resilience, and health behaviour among elderly people. *Int J Public Health* **57**, 341–349.
 50. Tiainen AM, Männistö S, Lahti M *et al.* (2013) Personality and dietary intake – findings in the Helsinki birth cohort study. *PLoS ONE* **8**, e68284.
 51. Vesnaver E, Keller HH, Payette H *et al.* (2012) Dietary resilience as described by older community-dwelling adults from the NuAge study ‘if there is a will, there is a way!’. *Appetite* **58**, 730–738.
 52. Greene GW, Lofgren I, Paulin C *et al.* (2017) Differences in psychosocial and behavioral variables by dietary screening tool risk category in older adults. *J Acad Nutr Diet* [Epublication ahead of print version].
 53. Bailey RL, Miller PE, Mitchell DC *et al.* (2009) Dietary screening tool identifies nutritional risk in older adults. *Am J Clin Nutr* **90**, 177–183.
 54. Artaud F, Sabia S, Dugravot A *et al.* (2016) Trajectories of unhealthy behaviors in midlife and risk of disability at older ages in the Whitehall II Cohort Study. *J Gerontol A Biol Sci Med Sci* **71**, 1500–1506.
 55. Robinson SM, Westbury LD, Cooper R *et al.* (2017) Adult lifetime diet quality and physical performance in older age: findings from a British birth cohort. *J Gerontol A Biol Sci Med Sci* [Epublication ahead of print version].
 56. World Health Organisation (2015) *World Report on Ageing and Health*. Geneva, Switzerland.
 57. Hagan KA, Chiuve SE, Stampfer MJ *et al.* (2016) Greater adherence to the alternative healthy eating index is associated with lower incidence of physical function impairment in the Nurses’ Health Study. *J Nutr* **146**, 1341–1347.
 58. Batis C, Mendez MA, Sotres-Alvarez D *et al.* (2014) Dietary pattern trajectories during 15 years of follow-up and HbA1c, insulin resistance and diabetes prevalence among Chinese adults. *J Epidemiol Community Health* **68**, 773–779.
 59. O’Brien N, McDonald S, Araújo-Soares V *et al.* (2015) The features of interventions associated with long-term effectiveness of physical activity interventions in adults aged 55–70 years: a systematic review and meta-analysis. *Health Psychol Rev* **9**, 417–433.
 60. Lara J, Hobbs N, Moynihan PJ *et al.* (2014) Effectiveness of dietary interventions among adults of retirement age: a systematic review and meta-analysis of randomized controlled trials. *BMC Med*, **12**, 60.
 61. Evans JM, Ryde G, Jepson R *et al.* (2016) Accessing and engaging women from socio-economically disadvantaged areas: a participatory approach to the design of a public health intervention for delivery in a Bingo club. *BMC Public Health* **16**, 345.
 62. Patzelt C, Heim S, Deitermann B *et al.* (2016) Reaching the Elderly: understanding of health and preventive experiences for a tailored approach – results of a qualitative study. *BMC Geriatr* **16**, 210.