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The Role of **Nutrition** in **Active** and **Healthy Ageing**

For prevention and treatment of age-related diseases: evidence so far

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Preface

Demographic ageing is a key societal and economic challenge in Europe. Supporting active and healthy ageing is important to ensure individuals continue contributing to society as they grow older, improve the quality of life of older citizens and to reduce unsustainable pressure on health systems.[1] The European Commission has launched the European Innovation Partnership on Active and Healthy Ageing (the Partnership) to tackle the challenge of an ageing population (COM (2012) 83 final). It sets an important target of increasing the healthy lifespan of EU citizens by 2 years by 2020.

The Joint Research Centre (JRC), as the European Commission's in-house science service, has started activities in the areas of nutrition, ageing and public health. As a first step to support the aims of the Partnership, the JRC investigates the role of nutrition to promote active and healthy ageing and to raise awareness of its contribution. The present report highlights the challenges older people face including undernutrition and functional decline. It reviews the current evidence on key nutrient intakes and the prevention and treatment of age-related conditions, particularly the role of micronutrient supplements. During this report, a number of research gaps are identified and several areas for future research are highlighted. It is our hope that this report will raise awareness of nutrition as a key contributor to healthy ageing, and that more attention will be given to diet and nutrition in policymaking to protect our older citizens.

1. http://ec.europa.eu/health/ageing/docs/com_2012_83_en.pdf.

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Both authors Sandra Caldeira (SC) and Tsz Ning Mak (TNM) developed the content of the report. TNM carried out the evidence review and wrote the report; SC provided continual support and supervision throughout the project.

Executive summary

Europe is facing an ageing population. Life expectancy is at its highest and many European populations are experiencing major demographic changes and transition towards a much older population structure. However, despite living longer, many people suffer ill-health or disability in the last 15 to 20 years of life. To encourage active and healthy ageing and to help increase healthy life expectancy, the European Commission has launched the European Innovation Partnership on Active and Healthy Ageing (the Partnership), which aims to add an average of two healthy life years in Europe by 2020.

This report aims to support the Partnership and to review the contribution of diet and nutrition in increasing healthy life years and promoting active and healthy ageing (AHA). The report gives a description of the main determinants of AHA including economic, social and behavioural factors and how they may relate to diet. It focusses on the issue of undernutrition in older people – both a cause and consequence of functional decline. Given the importance of undernutrition and that micronutrient deficiency is a common problem in older adults, this report summarises the evidence regarding micronutrient supplementations in the prevention and treatment of age-related diseases and conditions. At this stage, the current evidence seems insufficient to support the use of vitamin and mineral supplementation to prevent or treat specific cognitive or functional impairments in older people, although it does not imply that supplements are not effective. As it stands, another approach to ensure proper nutrition in older people is to maximise their intake of essential vitamins and minerals from natural food sources. Indeed, evidence so far on the Mediterranean Diet as a whole diet approach to promote health, increase longevity and reduce the risks of various age-related diseases supports this in a number of observational studies.

A number of research gaps are also highlighted in this report, including:

1) Further research on the wider determinants of AHA, *e.g.* social, economic and environmental aspects and their interrelationships with dietary behaviours in older people.
2) To identify the most effective strategies to promote public health messages to the older population.
3) Further evidence on life-course approach to ageing.
4) To develop a set of validated, agreeable, cost-effective and non-invasive measures and tools to quantify AHA outcomes, including the quality of diet, fitness and well-being in older people.
5) Above all, there is a need to provide better guidance on diet and nutrition for older people and a set of age-specific, up-to-date dietary recommendations is essential to achieve AHA.

List of abbreviations

AD	Alzheimer's disease
AHA	active and healthy ageing
AMD	age-related macular degeneration
BMR	basal metabolic rate
CR	calorie restriction
CVD	cardiovascular disease
E%	percentage of daily energy
EAAs	essential amino acids
EC	European Commission
EFSA	European Food Safety Authority
EIP on AHA	European Innovation Partnership on Active and Healthy Ageing
EPIC	European Prospective Investigation into Cancer and Nutrition
EU	European Union
HALE	The Healthy Ageing: a Longitudinal study in Europe
GI	gastro-intestinal
LDL	low-density lipoprotein
MCI	mild cognitive impairment
MD	Mediterranean Diet
MUFA	monounsaturated fatty acids
n-3	omega-3 fatty acids
PAL	physical activity level
PUFA	polyunsaturated fatty acids
RCT	randomised controlled trial
TEE	total energy expenditure
TFA	trans fatty acids
WHO	World Health Organisation

1. Overview

1.1. Europe's ageing population

The European Union (EU) is facing an ageing population for reasons including continual rise of life expectancy and relatively low birth rates [1]. The current EU population structure is characterised by a large proportion of post-war baby-boomers, *i.e.* those born between mid-late 1940s and the late 1960s [2]. However, part of this generation have now entered retirement and the rest will soon follow, which means that Europe will go through major demographic changes and transition towards a much older population structure in the future (*Figure 1.1*). The population of Europeans aged 65 years and older is projected to increase from 17.4% to nearly 30% by 2060 (*Figure 1.2*) [2] while the population of those aged 80 years and older is predicted to triple during this period [3].

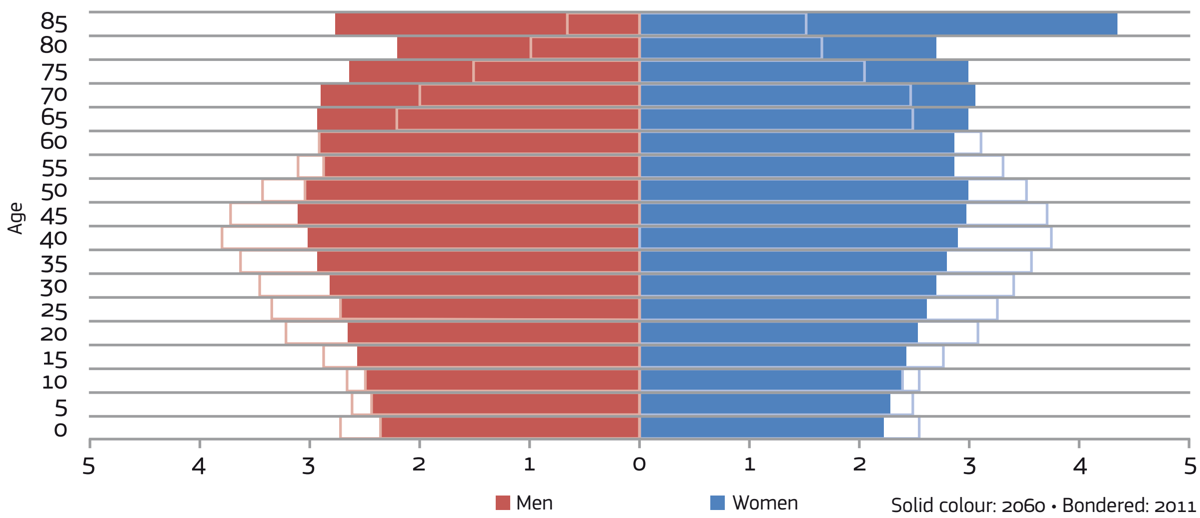

Figure 1.1. *Population pyramids in EU-27, comparison between 2011 data and projection in 2060. X-axis: percentage of the total population.* *Source:* Eurostat [3]

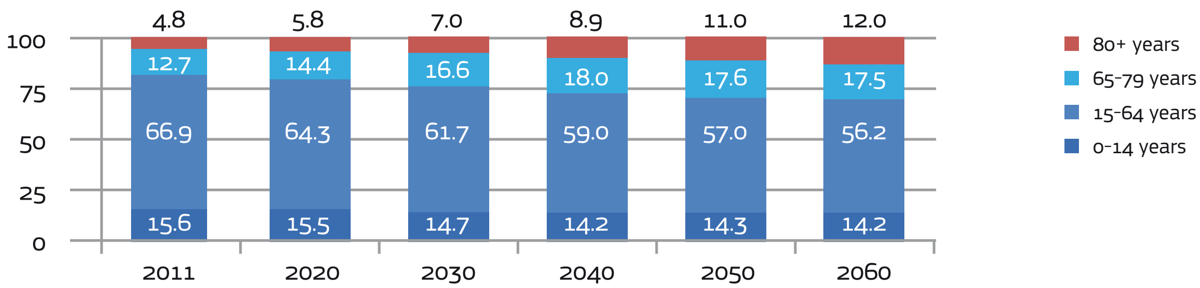

Figure 1.2. *Population structure by major age groups in EU-27, comparison between 2011 and projections in 2020-2060. Y-axis: percentage of the total population.* *Source:* Eurostat [3]

1.2. Healthy life years

While it may seem that living longer is a good thing – and indeed the advances of modern technologies, medicine and healthcare have enabled us to do so, the not-so-good news is that there is a gap between *life expectancy*[2] and *healthy life years*[3] in the EU [1]. For example, in 2009, mean life expectancy at birth in the EU-27 was 76.7y for men and 82.6y for women, but healthy life years were 61.6y and 62.5y, respectively [1]. This means, although people who were born in the year 2009 are expected to live well into their seventies and eighties, they are likely to be in ill-health and/or with disability in the last 15 to 20 years of life. Furthermore, if life expectancy continues to rise as predicted and healthy life years do not increase at the same rate, the time spent in ill health will be even longer in the future.

Spending more years in ill health and disability not only affects the quality of life of individuals and their families, but also puts pressure on public health and care services, consequentially leading to substantial social and economic impact on the society. Therefore, it is crucial to identify appropriate strategies to help the population age healthier. Concerted, multi-level efforts will undoubtedly be needed, from the responsibility of self-care of the individuals, to coordinated care and health services at the community level and to reformed policies on healthcare, workforce and pension arrangements at the national level [1]. From the individual's standpoint, the utmost valuable investment one can make is in one's health. Appropriate lifestyle behaviours including good nutrition and physical activity throughout life are the first steps in preventing chronic diseases and disabilities in old age and to increase healthy life years. Subsequently with good health, older people can continue to be active in their community, thus having a positive knock-on effect on the society.

2. 'Life expectancy' at a certain age is the mean additional number of years that a person of that age can expect to live, if subjected throughout the rest of his or her life to the current mortality conditions. 'Life expectancy at birth' is the number of years a person is expected to live at birth. http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Life_expectancy.

3. 'Healthy life years' also known as disability-free life expectancy, is defined as the number of years that a person is expected to continue to live in a healthy condition. http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Healthy_life_years_(HLY).

1.3. EU response to ageing challenges

Recognising the importance of the above developments, the European Commission has identified active and healthy ageing as a major societal challenge common to all European countries, and an area which presents considerable potential for Europe to lead the world in providing innovative responses to this challenge. In 2011 the European Commission launched the pilot European Innovation Partnership on Active and Healthy Ageing (hereafter referred to as EIP on AHA or the Partnership), which aims to add an average of two healthy life years in Europe by 2020 [4] while pursuing a triple win[4] for Europe.

4. Triple win refers to 1) improving the health status and quality of life of European citizens, with particular focus on older people;

The Partnership aims to achieve this by bringing together key stakeholders from a variety of backgrounds, which share a common vision and commit to take priority actions to address the challenge of ageing through innovation. More specifically, a number of interventions undertaken by EIP on AHA stakeholders to improve prevention as well as care & cure include measures targeted at nutrition (and undernutrition). Further information on the EIP on AHA is attached in the *Annex*, which includes examples of nutrition activities within the Partnership.

1.4. Aim of report and chapters overview

The aim of this report is to critically examine the contribution of diet and nutrition in active and healthy ageing (AHA) and to highlight its importance in the ageing process. Although it is still an early stage in research to appropriately quantify the exact contribution diet has on increasing healthy life years, we believe it is time to set the ground for gathering evidence base in ageing and raise awareness for further research directions in this very important age group.

The current report gives a brief description of the key determinants of AHA including economic, social and behavioural contributions and their relationship to diet (*Chapter 2*). Secondly, it describes the issue of undernutrition in older people and the functional changes that lead to poor food and nutrient intake (*Chapter 3*). Based on current scientific evidence, the report summarises how specific nutrients and whole diet approach may promote various aspects of AHA, including reducing and delaying physical and cognitive declines commonly seen in older people (*Chapter 4*). The last part of the report (*Chapter 5*) concludes our findings and highlights future research opportunities in nutrition and AHA.

2) supporting the long-term sustainability and efficiency of health and social care systems; and 3) enhancing the competitiveness of EU industry.

2. Determinants of active and healthy ageing

Active and healthy ageing is 'the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age. It applies to both individuals and population groups' ([4], p. 5). 'Health' refers to 'physical, mental and social well-being' ([4], p. 5). 'Active' refers to 'continuing participation in social, economic, cultural, spiritual and civic affairs, as well as the ability to be physically active or to participate in the labour force' ([4], p. 5). To embrace the notion of 'active and healthy ageing', it is important to adopt health-enhancing lifestyles that include healthy eating and adequate exercise [5].

Figure 2.1. *Determinants of active and healthy ageing.*
Source: European Commission [4]

In the *Strategic Implementation Plan* of the EIP on AHA [4], the European Commission summarised the six important determinants of AHA (*Figure 2.1*) based on the WHO's policy framework on active ageing [6]. Such key factors and the interplay between them will predict how well people age. The following sections describe these six determinants and where appropriate, their relationships with food and dietary behaviour are mentioned.

2.1. Economic determinants

The WHO active ageing policy framework identified three important economic factors that have particular importance for ageing: income, work and social protection [6]. People with low income are at higher risk of ill health and disabilities, as healthy foods, health care and housing are less affordable and accessible to them than to their wealthier counterparts. The type of work people engage in not only affects their level of income but also their overall well-being. Being active and productive in work and voluntary activities, and to be recognised for such valuable contributions will have beneficial effects on the individual psychosocial well-being. In many countries, social protection and insurance programmes exist to provide financial aid to older people who are no longer able to work. In recent years, policy reforms have favoured the combination of state and private support for old age security that encourages people to work for longer and adopt gradual retirement [6].

2.2. Health and social service systems

Having access to quality health and social services is crucial for AHA. Good health systems should 'take a life course perspective that focuses on health promotion, disease prevention and equitable access to quality primary health care and long-term care' ([6], p. 21). Health promotion and disease prevention are particularly important, as the potential cost savings from avoiding treatment on diseases (especially chronic, non-communicable diseases) and injuries can be high. Vaccination against influenza and pneumococcal infections as well as regular screening for malnutrition and frailty are effective strategies to prevent certain diseases and reduce mortality among older people, particularly those with underlying medical conditions. It has been estimated that influenza vaccination can reduce severe illnesses by up to 60 % and influenza-related deaths by up to 80 % [7]. Given the increasing incidence of chronic diseases, primary care and long-term care systems (including home care, rehabilitation, and palliative care) must be equipped to meet the needs from the rapidly expanding ageing populations [6].

2.3. Physical environment

To ensure older adults can remain active, independent and engaged with their communities, their physical environment (*i.e.* neighbourhood and surroundings) needs to be in good and safe condition for them to carry out their day-to-day activities. The WHO introduced the concept of the *age-friendly city*, to encourage cities, communities and neighbourhoods to adapt their structures and services to be accessible to older people with varying needs and capacities [8]. Accessible and affordable public transportation systems are important to allow older people to stay mobile in their communities for activities such as food shopping, dining-out or other social engagements. After retirement, people may have more time to enjoy outdoor activities as well as various community facilities [9]. Features such as a pleasant and clean environment; ample green spaces and walkways; the availability of outdoor seating to rest; and the adequacy of smooth, level, non-slip surfaces and well-lit pavements are important to motivate people to stay physically active and independent into old age [8]. Safe and affordable housing and care homes, as well as households free of hazards are also critical to the physical health and well-being of older adults [6].

2.4. Social environment

The level of social support and degree of social interaction older people have can greatly affect their health and well-being. Studies have shown that social isolation can influence older people's eating habits and behaviour. Those who live alone eat fewer meals per day, have lower daily intake of protein, fruits and vegetables, experience a loss of appetite and tend to be thinner than those living with family [10]. Isolation and the lack of social support are also associated with increased risk of chronic diseases and mortality [11].

Low education and literacy level are believed to indirectly relate to disability and early death. It has been suggested that education in early life and lifelong learning can help people to stay independent, confident and skilled as they age [6]. Keeping up with modern technologies such as electronic communications can also help to promote social support and social interactions with younger people, and to bridge the gaps between generations [6].

2.5. Cultural and personal determinants

Cultural values, norms and traditions shape the way people age as they affect other ageing determinants [6]. For instance, in some cultures it may be the norm to have extended families or different generations living in one household, where the grandparents are cared for by family members [6]. In other societies, older people may have to rely on community care services to sustain daily life.

Personal[5] factors are also key determinants of how well a person ages over the lifetime. Gender differences in life expectancy are well known across both developed and developing countries (*e.g.* women tend to live longer). The underlying cause for this difference is not clear but is likely due to a combination of genetic variation, immune system responses, hormones, disease patterns and risk behaviours between men and women [12]. In terms of the genetic influence on human lifespan, family studies on twins have demonstrated very moderate effects (20-30% variation) on longevity accounted for by hereditary factors [13] [14] [15]. Interestingly, studies on older twins (aged 60y+) have shown that genetic influences on lifespan tend to be minimal prior to age 60y but will increase thereafter [13]. For adults below age 60y, it appears that other external and environmental influences such as lifestyle behaviours will have a greater impact on how well they age rather than heredity [6]. Furthermore, recent research has suggested epigenetic factors such as DNA methylation [16], may influence the ageing process.

The rate of telomere[6] shortening is one of the biomarkers of biological ageing [17]. Studies in recent decades have found that telomeres shorten with advancing age and shorter telomeres are associated with various disease states including cancer and cardiovascular disease (CVD) [18]. Furthermore, recent studies have shown associations between shorter telomere length and other acquired states such as smoking, obesity and emotional stress; while conversely, longer relative telomeres are seen in people who eat a healthier diet and exercise frequently [19].

2.6. Behavioural determinants

As mentioned, adopting positive lifestyle behaviours throughout the life course is one of the major determinants to achieve active and healthy ageing. Eating a well-balanced diet, engaging in physical activity, not smok-

5. Personal factors in this context refer to biological and genetic factors.

6. Telomeres are found at the ends of chromosomes to protect them from damage, and they shorten during cell division [19].

ing, moderate alcohol consumption and appropriate use of medications are behaviours that can prevent or delay the onset of chronic disease, functional and mental decline as well as increase quality of life [6].

Smoking is a major cause of premature death and disability in Europe [1]. It increases the risk of lung cancer and reduces lung function, bone density and muscle strength in older people [6]. Studies have shown that being a current non-smoker (*e.g.* never smoked or have quit for a minimum of 15 years) was associated with healthier ageing [20].

Excessive alcohol consumption (*e.g.* repeated heavy drinking, more than five alcohol units[7] at a time, with the purpose of getting drunk [21]) is another problem in some older people [22]. It is directly linked to disorders such as malnutrition, causes damage to the liver, stomach and pancreas as well interacting with prescription drugs. Furthermore, it increases the chances of falls and injuries [1] [6]. The evidence on the benefits of moderate drinking on healthy ageing is currently not clear. In a review, one study demonstrated that light or moderate alcohol consumers were twice as likely to age healthily compared to those who did not drink at all, but other studies did not find similar results [20]. Another review on alcohol and Alzheimer's disease found no consensus regarding its impact, where seven studies suggested drinking alcohol decreased the risk of the disease, three studies found increased risk and nine others reported no effects between alcohol and Alzheimer's disease [23].

Physical activity and healthy eating are known behaviours to add extensive health benefits to the ageing process. For physical activity, the WHO recommends older adults engage in at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic exercise per week [24]. Older adults who engage in regular exercise and activity have lower rates of all-cause mortality, chronic diseases (*e.g.* coronary heart disease, high blood pressure, stroke, type 2 diabetes, colon cancer and breast cancer), a higher level of cardiorespiratory and muscular fitness, healthier body mass and composition, higher levels of functional health, better bone health, a lower risk of falling, as well as better cognitive function [24] [25]. The importance of specific nutrients on AHA will be discussed in greater detail in *Chapter 4*.

7. One unit of alcohol is 10 ml of pure alcohol.

3. Undernutrition and functional decline in ageing

In the EU, over 20 million older people are at risk of undernutrition.[8] This condition, along with associated health complications, are costing European health and social care systems around EUR 120 billion per year [4]. Undernutrition is a common disorder in older people as a result of reduced nutrient intake and/or impaired metabolism [26], and it is associated with a number of age-related complications, diseases and mortality in developed countries [4] [26]. Functional changes with ageing can greatly impact food intake and the degree of undernutrition in older people. Gradual decline of physical capabilities, such as movement and mobility; changes in physiological (particularly neurological) functions in the ageing body; chronic diseases and other age-related illnesses can lead to changes in food choice, eating habits and dietary intake, subsequently increasing the risk of malnutrition. As well as being a cause of undernutrition, it is clear that functional decline and comorbidity are also the consequence of chronic undernutrition, whereby long-term nutrient deficiencies can further aggravate these age-related conditions.

The following sections explore how functional changes in areas including mobility, sensory, eye health, oral and gastro-intestinal health, cognitive function, as well as disease status are associated with dietary intake in older people that determine their risk of undernutrition.

8. Undernutrition is one of the two types of malnutrition. The other type being overnutrition – which is the overconsumption of nutrients (in particular energy), that can lead to adverse health outcomes.

3.1. Mobility

Reduced mobility is a common concern in older people. Mobility refers to a person's ability to move oneself independently and safely from one place to another [27]. It can be affected by the progression of chronic conditions such as obesity, physical injuries such as fractures from falling, as well as physiological changes over time – predominantly in the musculoskeletal, neurological and cardiorespiratory systems, leading to limited movement [27]. Sarcopenia is a complex multifactorial condition common in older adults that features the loss of muscle mass and strength, and it plays a major role in the pathogenesis of frailty and functional impairment [28]. After its peak in early-mid adulthood, skeletal muscle mass declines at the rate of 0.5 to 1.0 % per year [29]. It affects 30 % of adults over aged 60y and more than 50 % of those aged 80y and older [29]. Other musculoskeletal disorders including osteoarthritis, rheumatoid arthritis and osteoporosis are major causes of pain and functional limitations in the bones and joints in older people, particularly among women [30]. Limitations in movement and mobility are likely to affect accessibility of food, *e.g.* food shopping, meal preparation and subsequently food consumption.

3.2. Sensory changes

Sense of smell and taste decline with age. Olfactory functions (sense of smell) deteriorate due to the progressive reduction of olfactory receptors and fibres in the olfactory bulbs, as well as increased occurrences of receptor cell death [31]. Over time, the physiology of the taste cell membranes also changes and the functions of receptors and ion channels are affected [31]. The use of medications can also impact taste sensitivity [32] and it is known that zinc deficiency can affect taste acuity [33]. When senses are hampered, it may be harder to detect and recognise particular tastes and flavours, *e.g.* salt and sugar [31]; the eating experience becomes less enjoyable and the sense of thirst is less acute. The motivation to eat and the interest in food also decline. Subsequently, these sensory changes can affect older people's dietary habits such as adding extra salt and sugar to food and beverages to enhance flavour, as well as altering the quantity, quality and variety of food they consume [34], thus increasing their risk of undernutrition and the development of chronic conditions such as type 2 diabetes and hypertension.

3.3. Eyesight

The prevalence of eye diseases such as cataract, diabetic retinopathy, glaucoma and age-related macular degeneration (AMD) are higher in old age [35]. In the United Kingdom, AMD causes blindness in 42% of people aged 65y to 74y, almost two-thirds of those aged 75y to 84y, and almost 75% of people aged 85y or older [36]. Poor vision in old people impacts their overall quality of life, as they are less independent to take care of their daily needs such as food shopping and meal preparation.

3.4. Oral health

Oral health is an important determinant of food consumption. With ageing, the physiology of the oral cavity changes and older adults often experience issues such as the loss of teeth, reduced saliva secretion and flow (dry mouth) and a reduction in muscle and connective tissue elasticity in the oral cavity. These problems affect one's ability and efficacy to chew and swallow [37] [38]. Subsequently, older people avoid certain foods that are hard to chew such as fruit and vegetables, or alter the ways they prepare foods such as overcooking vegetables to compensate for the difficulty in chewing and swallowing, hence compromising their intake of key nutrients, *e.g.* dietary fibre and vitamin C [39].

3.5. Gastro-intestinal functions and health

The physiology of the gastro-intestinal (GI) tract changes with age, which has a direct effect on gut functions such as the regulation of appetite and satiety. 'Anorexia of ageing' is a term used to describe reduced appetite and food intake in older people, where they often eat smaller meals and fewer snacks and eat more slowly than younger people [40].

Appetite is largely controlled by the regulation of gut hormones, which are released in response to nutritional stimuli. Evidence suggests that with age, the release of specific gut hormones is altered, leading to the feeling of satiety as well as suppressing hunger [40].

Furthermore, there are physiological changes in the stomach during ageing. Delay in gastric emptying accentuates the feeling of fullness during meals (satiation) and early satiety in older people [41]. Changes in the colon also affect the desire to eat, *e.g.* decline in colonic neurons leads to the reduction of neural transmitters in the colon, affecting its peristaltic and propulsive activities and increasing bowel transit time [41]. Subsequently, these lead to constipation – a common complaint observed in old people where the abdominal discomfort alters their appetite [42].

These physiological changes, together with lifestyle factors such as smoking, diet (*e.g.* large meals, fatty foods, caffeine) and medications (*e.g.* non-steroidal anti-inflammatory drugs), can lead to pathological consequences in the upper GI tract, including gastro-oesophageal reflux disease, peptic ulcer and gastric cancer in older people [43]. These diseases affect food consumption and lead to clinical symptoms including anorexia, weight loss, anaemia, vomiting and dysphagia (difficulty in swallowing), which increase in severity with advancing age [43].

There are suggestions in the literature that ageing leads to distinct changes in the composition of the gut microflora, such as reducing the number and species of many beneficial or protective anaerobes (*e.g.* bacteroides and bifidobacteria) in older gut [44]. The downstream effects of changes in the gut microflora composition may be increased transit time and increased susceptibility to disease such as gastroenteritis, or infections following antibiotic treatment [44].

3.6. Cognitive functions

Dementia is a disease of the brain that is caused by ageing, characterised by a progressive global deterioration in intellect which affects memory, thinking, learning, orientation, language, comprehension, judgement, as well as behaviour and the ability to perform everyday activities such as shopping and cooking [45] [46]. After the age of 65y, the risk of developing dementia doubles every five years [45]. Alzheimer's disease (AD) is the most common type of dementia, affecting one in four people aged 85y+ [47]. Furthermore, cerebrovascular disease and diet-related diseases and conditions, *e.g.* diabetes, hypertension, obesity and elevated lipid levels, as well as smoking have been shown to increase the risk of AD [47]. It is known that people with dementia or AD may forget to eat or drink, or forget that they have already eaten [48]; such behaviours are different according to the various stages of dementia [49]. For example, at the middle stage of dementia, patients appear to have excessive hunger or increased appetite; whereas in late-stage patients – where one is near total dependence and inactivity – often have difficulty eating and drinking [46] [49], hence are most likely to become undernourished.

3.7. Chronic disease and age-related illnesses

Older people with chronic diseases, infections or other disabilities that require long-term medical treatments are at risk of undernutrition. In addition to disease status, hospitalisation, medications and their side effects (*e.g.* malabsorption of nutrients, loss of appetite, nausea, vomiting, delayed gastric emptying, anorexia and diarrhoea) are the major causes of undernutrition in old people [50].

4. The role of diet in active and healthy ageing

This chapter reviews the contribution of nutrition on AHA. The rationale of evidence selection and explanations on the different study designs are provided in *Table 4.1* to aid the interpretation of the evidence presented. The review begins with the discussions on water and macronutrients (carbohydrate, protein and fat) and their health benefits for older people and where available, health authorities' recommendations on intake levels are provided. Secondly, the review pays special attention to a number of key micronutrients that are related to age-related diseases. As one of the widely-used strategies to reduce micronutrient deficiency in older people is to take vitamin and mineral supplements to increase nutritional status, therefore the effectiveness of micronutrient supplementation on age-related disease prevention and treatment from clinical trials is reviewed. Furthermore, phytochemicals and functional foods with possible health enhancing properties such as probiotics and prebiotics are mentioned. Lastly, the evidence on the *Mediterranean Diet* as a whole diet approach in reducing mortality rates and chronic disease risks are also presented.

Table 4.1. *Summary on evidence selection, its limitations and explanation of study designs.*

I. Selection of evidence
The key nutrients (both macro- and micronutrients) presented in the report have been selected based on an existing knowledge on ageing including review papers and reports (*e.g.* the WHO's *Keep Fit for Life* published in 2002 [5]).
For macronutrients, if available, recommendations for daily intake for older adults were provided based on published European Food Safety Authority (EFSA) scientific opinions.
For the review of micronutrients, the evidence was mainly derived from Cochrane reviews (see *Section III* of this table). In some instances where the Cochrane reviews were dated (*e.g.* Section 4.6.1.2 vitamin B6 and Section 4.6.1.3 vitamin B12), evidence from more recent systematic reviews were also provided.
On some rare occasions where Cochrane reviews were not available, evidence was sought from systematic reviews first. If those were also unavailable, results from individual clinical trials were mentioned.
For the review on the *Mediterranean Diet*, only one Cochrane review (2013) was available. Evidence from observational studies such as prospective cohorts were included mainly because this study design is better suited for studying habitual dietary intake and following up free-living individuals to assess mortality rates and disease risks.
Readers should bear in mind the methodological limitations of different research approaches (*e.g.* clinical trials *vs* observational studies) where different study design often lead to different findings and conclusions on the same topic. For example, observational studies are prone to selection bias of participants especially in hard-to-reach populations like the older population. On the other hand, clinical trials usually have much smaller sample sizes and apply strict inclusion and exclusion criteria when selecting subjects [51]. Further description on each type of research methodology is illustrated below in *Section III* of this table.

Table 4.1. *(cont.)*

II. Limitations of methodology used in this report

1. Choice of studies presented

The evidence presented in this report was mainly limited to findings from Cochrane reviews, although other systematic reviews, meta-analyses, and individual observational and clinical human studies were occasionally considered. Evidence from non-human studies, *e.g.* studies on a range of different organisms, investigating the effects of nutrients and bioactive compounds as well as caloric restriction on animal health and lifespan has not been considered. In addition, there are an immense number of *in vitro*, cellular or animal studies that investigate the underlying molecular or cellular mechanisms on how nutrients work to promote healthy ageing. While acknowledging their importance in complementing human studies and increasing the plausibility of some of their results, these types of studies have also not been considered, as the aim of this report was limited to reviewing measurable effects of particular food components on human health in ageing.

2. Recruitment of sample populations

There were no strict definitions imposed on the terms 'older people' in many of the studies reviewed, where some studies recruited older people from the age of 50 years, 60 years, or some 65 years and older. However, this report has not covered the 'very old' population, *e.g.* 85y+, because currently little is known about such populations since few on-going studies are focussing on the very old. Furthermore, some studies recruited subjects from institutionalised settings and some were free-living individuals, some were healthy and some suffered from existing chronic conditions. These differences between sample populations make comparisons of study results difficult.

3. Nutrients included in this report

Not all nutrients from food were reviewed in this report; only key nutrients that are actively researched in the field and have been suggested to play important roles in preventing or delaying the development of age-related diseases were selected. For example, alcohol, by definition a nutrient, may have an impact on ageing depending on the level of consumption. However, research on alcohol use (or misuse) and its benefits or harm in older people is limited and cannot be reported at this stage. Equally, there may be other dietary derived compounds with potential health benefits, but it is still too early to establish their efficacy. Furthermore, this report has emphasised the evidence from supplementation of nutrients (prone to deficiency) on reducing disease risks and has not explored other areas such as food fortification or other non-nutritive supplements for older people, where there are few completed scientific research studies to evaluate their efficacy.

4. Lifecycle approach to ageing

The evidence reviewed was based on older people at present. In some cases where longitudinal data were discussed, earlier years of adulthood might have been accounted for. However, the life course approach to ageing was not addressed in this report. Ageing is a life-long process that begins in the womb and how well one will age can be modified by a vast number of external influences (nutrition included) throughout life. Pregnancy and birth cohort studies can help to unravel such relationships. Currently, there are very few existing birth cohorts that have followed participants into adulthood. The oldest British birth cohort – *MRC National Survey of Health and Development (NSHD)* began in 1946 and has to date followed participants up to age 67 years. Birth cohorts of such as NSHD are extremely important to further our understanding of ageing, particularly to identify key healthy ageing markers at different stages of life.

III. Types of study designs

In clinical research including nutritional sciences, there are two main domains of study design: experimental (*e.g.* randomised controlled trials (RCT)) and observational studies (*e.g.* prospective cohorts). *Figure 4.1* illustrates the classification of different types of clinical research, which aids in determining the research methods to undertake

Table 4.1. *(cont.)*

following a number of research criteria [52]. Further reading on the detail of each study design can be found below.[9] In brief, *RCTs* that are mentioned in this report, are a type of intervention study that are considered the gold standard in clinical research, as they help to eliminate bias that other study designs may encounter [52]. Such experimental studies are particularly useful, for example, to test the effectiveness of supplementation or a drug in treating a condition in a study population, where the subjects are randomly assigned to 'treatment' or 'control' groups, and the latter does not receive the real treatment but a placebo pill. The two groups are then compared after the intervention to identify if the treatment worked. On the other hand, *cohort studies* are a type of observational study that investigates the risk of developing a disease or condition in a large population (cohort) that is exposed to a particular factor compared to another population without this exposure, but otherwise both populations share similar characteristics. These two groups are followed forward in time to determine the risk of an outcome based on this exposure factor [52]. This type of study furthers our understanding on the relationship between exposures and disease development. However, results should be interpreted with caution as there are usually confounding factors that may interfere the relationship between exposure and outcome.

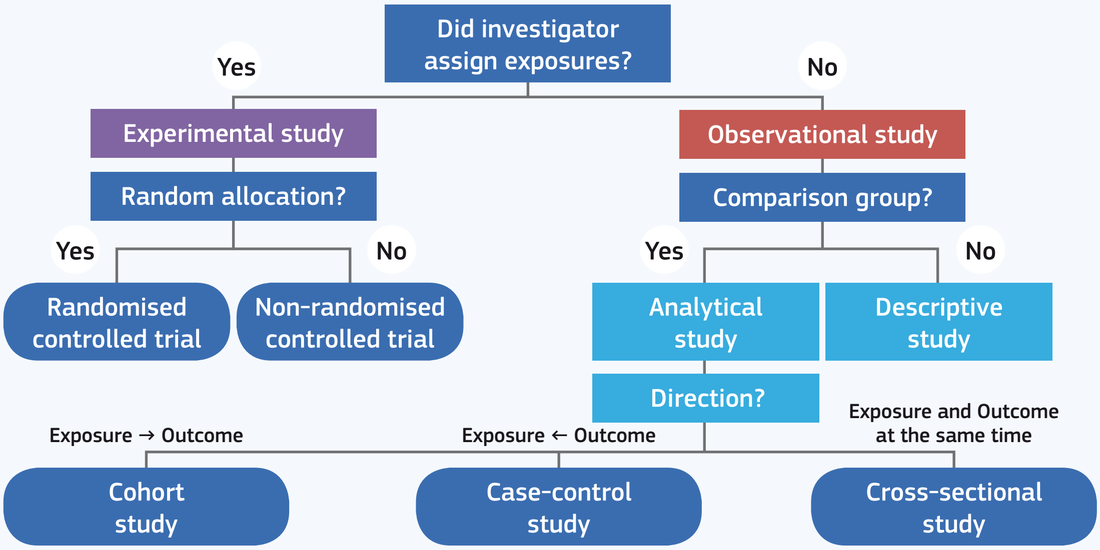

Figure 4.1. *Algorithm for classification of types of clinical research* [52]. *Reprinted from D.A. Grimes, K.F. Schulz: 'An overview of clinical research: the lay of the land',* The Lancet, *Vol. 359 (9300), pp. 57-61 (copyright 2002, with permission from Elsevier).*

Reviews (including Cochrane reviews, systematic reviews and meta-analyses) gather results from individual research studies and examine the overall strength of the evidence between the exposure factor, *e.g.* intake of a nutrient, and the outcome, *e.g.* risk of a disease. *Cochrane reviews* are a particular type of systematic review of primary research in human health care and health policy that are internationally recognised as the highest standard in evidence-based health care.[10] A *systematic review* is a high-level overview of primary research on a particular research question that tries to identify, select, synthesise and appraise all high-quality research evidence from relevant studies in order to answer the question.[11] A *meta-analysis* is the use of statistical techniques to combine the results of a systematic review. This allows the best use of all the information gathered in a systematic review by increasing the power of the analysis.[12]

9. http://www.iarc.fr/en/publications/pdfs-online/epi/cancerepi/CancerEpi.pdf.
10. http://www.cochrane.org/cochrane-reviews.
11. http://www.cochrane.org/about-us/evidence-based-health-care.
12. http://www.cochrane-net.org/openlearning/PDF/Module_12.pdf.

4.1. Water

Adequate water intake is one of the key factors to prevent chronic diseases and to fight infections in older people [53] [54]. In fact, water is essential for normal bodily functions including absorption and distribution of nutrients, thermoregulation and the excretion of wastes [54].

Dehydration is a frequent cause of morbidity and mortality in old people [54]. Studies have shown that even mild dehydration may have an adverse effect on urinary stone recurrence and broncho-pulmonary and renal disorders [53] [55]. Unfortunately, dehydration is common and often overlooked in the older population. Because older people are less sensitive to thirst and tend to have reduced food intake (*e.g.* fruit and vegetable consumption contributes a proportion of daily water intake), it is recommended that they should drink at least 1.5 l of water per day [5]. To be more accurate, the WHO indicated that a normal weight adult requires an intake of 30 ml of water per kilogram body weight per day [5]. However for underweight adults, an intake of 100 ml/kg for the first 10 kg weight, 50 ml/kg for the next 10 kg and 15 ml/kg for the remaining weight is more appropriate to prevent dehydration [56]. It is recommended that older people be offered small quantities of water and liquids regularly throughout the day and not to consume large amounts of fluids at once [57].

4.2. Energy

Starting from the age of 50y, energy requirements are on a gradual decline due to reduced total energy expenditure (TEE) [58]. TEE is determined by two main factors–basal metabolic rate (BMR), the body's internal energy requirement for normal physiological functions when a person is at rest; and physical activity level (PAL), the extra energy the body requires when doing extra work, such as exercising. With age, BMR is reduced as a result of changes in body composition – namely a decline in lean body mass (mainly muscles) and increase in body fat mass [59]. Because muscles are more metabolically active than fat (*i.e.* 1 kg of muscle burns more calories than 1 kg of fat), older people require fewer calories at rest than their younger counterparts. Previous studies have suggested that for every decade of life, the BMR of a person with normal body mass index[13] will reduce by 2.0 % for women and 2.9 % for men [58]. Similarly, PAL also decreases with increasing age. This is due to older people being less physically active than younger people, for reasons such as frailty and reduced mobility. The contribution to TEE from PAL is generally quite small, unless the individual is exceptionally active and fit for their age, in which case their BMR would also be higher due to higher lean body mass.

13. Body mass index (BMI) is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults. BMI values are age-independent and the same for both sexes. Classifications are as follow: underweight – BMI <18.50 kg/m²; normal weight – BMI ≥ 18.50 kg/m²; overweight – BMI ≥ 25.00 kg/m²; obese – BMI ≥ 30.00 kg/m². For further reading and the method of calculation, consult: http://apps.who.int/bmi/index.jsp?introPage=intro_3.html.

Table 4.2. *Average requirement for energy (kcal/day) by physical activity level for European adults. Adapted from EFSA 2013* [61].

Age (years)	Average requirement (kcal/day) for energy by PAL			
	Sedentary	Moderately active	Active	Very active
Men				
18-29	2 338	2 672	3 006	3 340
30-39	2 264	2 588	2 911	3 235
40-49	2 234	2 553	2 873	3 192
50-59	2 204	2 519	2 834	3 149
60-69	2 017	2 305	2 593	2 882
70-79	1 984	2 267	2 550	2 834
Women				
18-29	1 878	2 147	2 415	2 683
30-39	1 813	2 072	2 331	2 590
40-49	1 798	2 055	2 312	2 569
50-59	1 783	2 037	2 292	2 547
60-69	1 628	1 861	2 093	2 326
70-79	1 614	1 844	2 075	2 305

It is important that older adults acquire enough energy from their diet to prevent undernutrition and related conditions, including impaired immune response, impaired muscle and respiratory function, delayed wound healing, longer rehabilitation, greater length of hospital stay and increased mortality [60]. The EFSA recently published a scientific opinion on dietary reference values for energy for the European population [61]. The average energy requirement for men and women of different ages according to their PAL is shown in *Table 4.2* [61]. Average energy requirements were not calculated for older people aged 80y+ because of a lack of anthropometric data from EU countries for this age group [61].

4.2.1. *Calorie restriction*

Calorie restriction (CR), a reduction in energy intake without malnutrition or compromised intake of other key nutrients, has been shown to increase healthy lifespan of a range of organisms such as yeast, flies, worms, rats and monkeys, as well as to protect them against age-related functional decline and diseases [62]. Whether CR has the same effect on human longevity as in other organisms is not yet clear, although there are some indications that CR may reduce risk factors for diabetes, CVD and cancer [62]. Importantly however, if CR is not performed appropriately, detrimental health effects such as sarcopenia, osteoporosis and immune deficiencies may occur [62]. Therefore, without critical evaluation of the evidence on human CR intervention studies and further recommendations from health authorities, the practice of CR is not suggested to the general public at this stage.

4.3. Protein

Sufficient intake of protein is important to maintain lean body mass and to slow down and possibly prevent musculoskeletal conditions such as sarcopenia and osteoporosis [63]. Protein, which is made up of amino acids, is one of the building blocks of muscle fibres and bones. Studies have suggested that ingestion of moderate to large portions of amino acids can promote muscle protein synthesis in both young and old healthy subjects [64]. However, with age, the ability of skeletal muscle to respond to protein is less efficient, particularly when the level of essential amino acids (EAAs) ingested is very low [64]. Older adults need higher (10-15 g/day) consumption of EAAs to have the same degree of stimulation of muscle protein synthesis as their younger counterparts [64]. Several research studies have investigated the effects of supplementation of leucine, an EAA that plays a role in stimulating insulin secretion and muscle protein synthesis, on the prevention of sarcopenia in older people. However, the results to date have been inconclusive; especially in acutely ill and frail older patients [64].

Because protein metabolism may be less efficient with increasing age, it has been suggested that older people may need to increase their protein intake to prevent muscle loss and malnutrition. It is not clear the effect of increasing protein intake in healthy older adults; however a Cochrane review (2009) examined the effects of protein and energy supplementation in those at risk of malnutrition in sixty-two clinical trials, the results showed that supplementation produced a small (2.2%) weight gain in older people in 42 trials, and in a small sample of older people who were already malnourished, mortality rate was reduced when they were supplemented with protein and energy [60].

In 2012, EFSA reviewed the evidence to establish whether there is a need for a higher protein recommendation for the older population. At the time, there were few studies available on the long term health effects of high protein intake in healthy older adults (such as on kidney function). Therefore, it was not possible for EFSA to establish a higher protein intake recommendation for older adults and it currently remains at the same level as for younger adults – at 0.8 g/kg per day – *i.e.* a 75 kg healthy adult would need 60 g of protein per day [64] [65]. There is a continual debate on protein intake and recommendation for older people nonetheless, where a recent study (2013) reviewed dietary protein needs in older people and recommended an average daily intake of 1.0-1.2 g/kg per day for those aged 65y+ and even higher intake for those who are exercising and otherwise active [66].

4.4. Fat

Fat is the most energy-dense[14] nutrient, *i.e.* it contains the most calories per gram [67]. It is an important energy source and facilitates the absorption of fat-soluble vitamins A, D, E and K, and has vital structural and regulatory functions in the human body. However, because of its high energy density, overconsumption of fat can lead to excessive total energy intake, which promotes overweight and obesity [68]. Furthermore, the consumption of *trans* fatty acids (TFA) is found to have adverse effects on cardiovascular health [69]. On the other hand, monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids are suggested to have beneficial effects on human metabolic health such as improving cardiovascular risk [70] [71] and insulin sensitivity [71] [72] [73], although the current evidence is somewhat stronger for PUFA than MUFA [71].

14. Energy density of macronutrients: Carbohydrate – 4 kcal/g; Protein – 4 kcal/g; Fat – 9 kcal/g; Alcohol – 7 kcal/g.

In recent years, long-chain omega-3 fatty acids (*n*-3 fatty acids) have been proposed to have protective effects on brain health through reducing oxidative stress and inflammation [74] and therefore may have implications on brain function in ageing adults. Thus far, the evidence mainly comes from cross-sectional and longitudinal observational studies that demonstrated some encouraging effects of *n*-3 fatty acids on cognitive function in healthy older adults; the evidence from intervention studies is less clear. One review found that 19 out of 26 studies of various study designs observed positive relationships between fish consumption or *n*-3 fatty acids intake (from diet or supplement) and cognitive status while the other seven studies found either little or no beneficial effects [75]. The evidence on supplementation from clinical trials is weaker, a review on clinical trials found only one RCT out of seven supported beneficial effects from *n*-3 fatty acids supplementation and the prevention of dementia and cognitive decline [76]. Furthermore, a recent Cochrane review (2012) examining the evidence from three *n*-3 fatty acids supplementation trials found no beneficial effect of supplementation on cognitive function or prevention of dementia and that clinical trials of longer duration were needed before a final conclusion could be drawn [77].

Long chain *n*-3 fatty acids have been proposed to have other health-promoting properties in normal ageing, including immune function, bone and muscle health [75]. Several clinical studies have found that even low doses of *n*-3 fatty acids supplementation can influence immune response in older people [75]. A systematic review of 23 clinical trials found a modest, but fairly consistent benefit of fish oil containing *n*-3 PUFA on joint swelling and pain associated with rheumatoid arthritis [77]. In addition, reduced duration of morning stiffness as well as improvement in other indicators of the disease were found [78]. Very few studies have examined the relationships between *n*-3 fatty acids and musculoskeletal health so far; however, a review which identified three relevant studies has found protective effects [75]. Further studies are needed to confirm such relationships.

Currently, there is no specific recommendation related to dietary fat intake for older adults. For European adults, EFSA has proposed a reference intake range of 20 to 35 percent of daily total energy (E%) from fat [79]. For saturated fatty acids and TFA, intake should be as low as possible within the context of a nutritionally adequate diet [79]. The EFSA panel also proposed setting 'Adequate Intake' levels for specific *n*-3 and *n*-6 fatty acids including: linoleic acid (*n*-6 fatty acids) of 4 E%, alpha-linolenic acid (*n*-3 fatty acids) of 0.5 E%, and eicosapentaenoic acid plus docosahexaenoic acid (*n*-3 fatty acids) of 250 mg/day for health-protective benefits in adults [79].

4.5. Carbohydrates

Little is known regarding the role of carbohydrates in healthy ageing. Although glucose is an important energy source for the brain, a recent Cochrane review (2011) concluded there is insufficient evidence for the use of carbohydrates to improve cognitive performance in older adults with normal or mild cognitive impairment (MCI), due to limited studies in the area [80]. On the other hand, there is some evidence from observational studies to link diabetes with cognitive decline including memory and executive functions [81] [82] [83]; particularly in older diabetics (aged 65y+), who are more likely to have cognitive decrements and to score lower in cognitive tests than younger diabetics [82]. Nonetheless, previous studies have suggested that controlling blood glucose may help prevent cognitive decline [84], although further evidence is needed to clarify this.

In terms of recommendation of carbohydrates intake, there is no specific guidance for older adults. EFSA proposed a reference intake range of 45-60 E% from carbohydrates [85]. For sugars, EFSA noted that there is insufficient data to allow the setting of an upper limit for 'total' or 'added sugars' intake in the EU. There are, however, some EU countries which have established upper limits for population average intake or individual intake of added sugars of less than 10 E%, based on WHO's current recommendation,[15] in order to discourage high consumption of added sugars [85].

15. http://www.who.int/mediacentre/news/notes/2014/consultation-sugar-guideline/en/.

4.6. Micronutrients

Older adults are particularly susceptible to deficiencies in various micronutrients due to reduced intake of foods that are rich in vitamins and minerals. The prevalence of deficiency and undernutrition is highest amongst the very old, women, and those in care homes and institutions [86] [87]. Micronutrients are essential to maintaining normal physical and cognitive functions in the ageing body and inadequate intakes will subsequently lead to deterioration of health and to the development of certain diseases. The function of micronutrients and the consequences of deficiency are summarised in *Table 4.3*. Further discussion on the effectiveness of micronutrient supplementation on age-related disease prevention and treatment based on clinical studies are described below.

4.6.1. Vitamins B6, B12 and folic acid

There has been a growing interest in supplementation of three B vitamins – B6, B12 and folic acid (henceforth B-vitamins) in relation to a number of age-related vascular diseases due to their role in homocysteine metabolism. Homocysteine is an amino acid that, at high levels, is considered an independent risk factor for vascular diseases. Previous epidemiological studies on B-vitamin status and cognition found that older people with elevated homocysteine levels (hyperhomocysteinaemia) tend to have lower B-vitamin status, as well as lower cognitive tests scores [101] [102]. They were also at higher risk of vascular diseases including dementia and

AD [103] [104] [105] [106] than those who had normal homocysteine or B-vitamin status. These observations sparked the theory that adequate intake of these vitamins can lower homo-cysteine levels, resulting in the prevention of these diseases. A number of RCTs

Table 4.3. *Function of essential micronutrients prone to deficiency in older people and health consequences.*

Vitamin B6	**Main function:** essential for normal homocysteine metabolism, normal energy-yielding metabolism, normal psychological functions, normal cysteine synthesis [88]; regulation of mental function and mood [89].
	Deficiency associated with: an increase in blood homocysteine levels – a risk factor for cerebrovascular disease and possible toxic effects on the central nervous system; high homocysteine levels are possibly involved in the development of AD and other forms of dementia in older people [89]; neuropsychiatric disorders including seizures, migraine, chronic pain and depression [89].
Vitamin B12	**Main function:** red blood cell formation, neurological function and DNA synthesis [90].
	Deficiency associated with: an elevated homocysteine level similar to B6 deficiency – impact on cognition and cardiovascular health, neurological changes including poor memory and confusion, anaemia, decreased muscle strength and functional disability [90] [91].
Folic acid	**Main function:** involvement in the synthesis of nucleic acids (DNA and RNA), cell division and metabolism of amino acids [92].
	Deficiency associated with: anaemia (megaloblastic anaemia); elevated homocysteine as seen in B6 and B12 deficiency–possibly related to development of dementia, AD, depression and CVD [92].
Vitamin D	**Main function:** bone metabolism, promotes calcium absorption, and calcium and phosphorus homeostasis [93]; other roles include renal production of renin, insulin secretion, an active metabolite of vitamin D which regulates the transcription of a large number of genes [94].
	Deficiency associated with: calcium malabsorption, increased risk in bone-related conditions (fractures, osteoporosis, osteomalacia), muscle weakness, CVD, metabolic syndrome and overall mortality [93] [95].
Calcium	**Main function:** maintenance of healthy teeth and bones, cell signalling, coagulation, muscle contraction and neural transmission [96].
	Deficiency associated with: an increased bone loss and an increased risk of fracture; long-term calcium deficiency can confer predisposition to osteoporosis [97].
Antioxidant vitamins A, C, E	**Main function:** neutralise the excess of free radicals, to protect the cells against their toxic effects and to contribute to disease prevention [98].
	Deficiency associated with: numerous chronic and degenerative pathologies such as cancer, autoimmune disorders, aging, cataract, rheumatoid arthritis, cardiovascular and neurodegenerative diseases [98].
Selenium	**Main function:** exert antioxidative and anti-inflammatory properties when incorporated into protein and form various selenoproteins [99].
	Deficiency associated with: an increased risk of mortality, poor immune function and cognitive decline [99].
Zinc	**Main function:** normal growth and development, neurological function, wound healing and immune function [100].
	Deficiency associated with: an increased susceptibility to infections; diarrhoea; dermatitis [100]; reduced taste acuity [33].

have since been undertaken to examine the effectiveness of B-vitamin supplementation on cognitive function and other vascular disease outcomes. To date, relatively few trials have investigated the vitamins independently and most have had little success on preventing or treating cognitive decline. This section discusses the current evidence for each of the three vitamins, as well as the effects of multi B-vitamins on cognition or vascular disease.

4.6.1.1. Vitamin B6. A Cochrane review (2003) on the effect of vitamin B6 supplementation on cognition identified only two relevant trials in healthy older adults [89]. One study found no significant effect on mood or cognition from supplementation in older women [107]; the other found a modest but significant effect of vitamin B6 on long-term memory in older men, yet no improvements on other cognitive measures [108]. Due to the limited number of studies and very few subjects, the authors of the review concluded there is insufficient evidence to support the beneficial effects of vitamin B6 in improving mood or cognitive function.

A separate review examined the effects of vitamin B6 supplementation and the prevention of CVD recurrence in clinical trials. Similar to the cognition studies, the collective results failed to show positive effects, despite relatively consistent associations between low vitamin B6 status and CVD incidence in epidemiological studies [109].

4.6.1.2. Vitamin B12 A Cochrane review, conducted in parallel with the review for vitamin B6 (2003), examined the effect of B12 supplementation on cognitive function of demented versus healthy elderly people, to prevent the onset or progression of cognitive impairment or dementia [110]. The results, which included two trials, did not show improvements in cognitive functions in older adults with dementia [110]. A more recent review (2010) of seven intervention studies showed no effect of B12 supplementation on cognition in six studies, while one study found some improvement in the intervention group on the performance of verbal word learning test but not in other cognitive tests [111].

4.6.1.3. Folic acid At present, the effects of folic acid supplementation on cognition are inconclusive. A Cochrane review (2008) of eight clinical trials (of which four included healthy older adults and four trials recruited those with mild to moderate cognitive impairment or dementia), did not find consistent evidence that folic acid (with or without B12) can improve cognitive function or mood [112]. One trial in the review however, which recruited healthy older adults with raised homocysteine level (but normal serum vitamin B12), found that after the three-year intervention period, the folic acid supplementation group had lower homocysteine level and better performance in various cognitive tests (memory, information processing speed and sensorimotor speed) than the control group [113]. Despite that long-term use of folic acid supplementation appeared to improve the cognitive function of healthy older people with high homocysteine levels, the Cochrane review concluded more studies with positive findings and longer study durations are needed to warrant its effectiveness [112].

4.6.1.4 Multi B-vitamin studies Clinical trials with single vitamin supplementation have not demonstrated their efficacy in improving cognitive function in older people. A number of trials have since investigated the effectiveness of combined B-vitamin supplementation. A systematic review conducted in 2007 assessed the evidence from six trials that supplemented combined B-vitamins (B6, B12 and folic acid or B12 with folic acid) to healthy and unhealthy older adults (with dementia or ischaemic vascular disease) [114]. One study using the combination of all three B-vitamins found some improvement in one out of eight cognitive tests. Other trials found no dose-response relationships or that the controls performed better than the intervention groups [114]. Recent studies have shown some positive results, albeit not consistent. A small intervention trial on subjects with MCI found that combined B-vitamin supplementation slowed the rate of accelerated brain atrophy [115], as well as slowing cognitive decline especially in subjects with elevated homocysteine level [116]. In a larger trial of community-dwelling[16] older adults with depressive symptoms, a combination of folic acid and B12 for two years improved some aspects of cognitive functioning in older adults [117]. However, there were also a number of studies that found no effects of multi B-vitamin supplementation on the risk of cognitive impairment or dementia in healthy people or those with vascular disease [118] [119].

There is discordance between the associations found between low B-vitamin status or elevated homocysteine levels and vascular disease risk in observational studies and the lack of efficacy of B-vitamin supplements in such diseases in clinical trials. Differences in the dose of supplements used in studies, the duration of the interventions, the possibility of an unknown therapeutic window for the supplements to be effective, compliance of the subjects, and the variations in individual responses to interventions between subjects are some of the potential reasons for the lack of beneficial effects seen in various clinical studies [120]. The differences in results between clinical and observational studies could be due to the varying chemical forms and bioavailability between B-vitamins from supplements and from food sources. In addition, the combination of nutrients obtained from food (as seen in observational studies) may have interactive and synergistic effects on health; such beneficial effects may be absent in supplementation trials.

4.6.2. Vitamin D and calcium

Vitamin D and calcium are well known for their important roles in bone health. Calcium is an essential architectural component of bones and teeth – where 99 % of total body calcium is found [96]. Vitamin D plays a role in calcium absorption and maintaining serum calcium and phosphorus homeosta-

16. Community-dwelling older adult are those who are not in assisted living or nursing homes.

sis [94]. When vitamin D status is low, calcium absorption is disturbed and triggers the compensatory release of a specific hormone called parathyroid hormone that promotes bone resorption and accelerates bone loss [121]. Vitamin D is synthesised in the skin by the action of UVB light from the sun. However in older people, the production of vitamin D from sun exposure is limited due to the reduction of vitamin D precursor in the ageing skin and also the time spent outdoor is usually lower in older people [122]. Therefore, in older adults who are prone to deficiency, increasing intake of vitamin D is important for bone health.

A Cochrane review (2009) evaluated the effects of vitamin D supplementation with or without calcium in preventing bone fractures in older adults. The review which included 45 clinical trials and more than 84 000 participants found that vitamin D alone appeared to have little effect on the risk of fractures [123]. In trials where subjects were supplemented with vitamin D and calcium, hip fractures reduced by 16%. However, further analysis showed it was mainly older people in institutional care that had a significant reduction in hip fractures but not the older adults in community-dwelling. Furthermore, subjects who received an active form of vitamin D3 (calcitriol)[17] as supplements were more susceptible to elevated calcium in blood (hypercalcaemia) and experiencing gastrointestinal symptoms and renal disease [123]. Another Cochrane review (2011) further evaluated the evidence on various types of vitamin D supplementation and prevention of mortality. A specific form of vitamin D (cholecalciferol) appeared to decrease mortality in predominantly older women who were in institutions and dependent care, whereas other forms had no effect on mortality. This review also found that active forms of vitamin D3 – alfacalcidol and calcitriol – increased the risk of hypercalcaemia significantly, and that combining vitamin D and calcium in supplements increased the risk of kidney stone formation [124].

Calcium and vitamin D supplementations are often used in postmenopausal women to prevent osteoporosis. While some studies have indicated such supplements, in particular calcium, may be related to increased rates of cardiovascular events seen in older women [125], both observational studies and clinical trials have shown inconsistent results. In 2012, the EFSA Panel on Dietetic Products, Nutrition and Allergies evaluated the existing data to determine a tolerable upper intake level of calcium. In relation to its risk on CVD, the Panel concluded that, calcium intakes up to about 2 000 mg/day from food and supplements have not been associated with an increased risk of CVD events [96]. Furthermore, the Panel concluded that long-term calcium intakes from diet and supplements up to 2 500-3 000 mg/day are not associated with an increased risk of CVD in all adults [96].

17. Vitamin D3 is synthesised in the skin as cholecalciferol or is obtained from dietary sources or supplements as alfacalcidol and calcitriol.

4.6.3. Vitamins A, C and E – antioxidant vitamins

The mitochondrial free radical theory of ageing was proposed several decades ago and has been actively investigated [126]. Free radicals are produced in the mitochondria during respiration [98] and, if in excess, they cause oxidative damage in cells and tissues, which over time, has been hypothesised to lead to the development of a number of age-related degenerative conditions including AD, dementia, cancer, CVD and AMD [98] [127] [128]. To protect cells from damage, antioxidants are needed to neutralise free radicals through a series of chemical reactions [98]. Antioxidants come from two sources: 1) the body's internal production or 2) through the intake of antioxidant nutrients, such as vitamins A, C and E, as well as a number of polyphenolic compounds [98]. Reviews of epidemiological studies have indicated that consuming a diet rich in antioxidants may lower CVD risk [129], the risk of cognitive decline, AD and dementia [130], as well as age-related eye diseases [131].

Numerous clinical investigations have since been undertaken to determine whether antioxidant supplementation can prevent or slow down the progression of various age-related diseases, particularly cognitive impairment, AMD and cataracts. One Cochrane review (2012) investigated the use of vitamin E and beta-carotene to prevent the development of AMD and found no effects in preventing the condition in over 60 000 trial participants [132]. A similar Cochrane review (2012) was performed on subjects with existing AMD to determine whether antioxidant supplementation (beta-carotene, vitamins C and E and zinc) could slow down AMD progression. In trials with a short follow-up duration, there were no beneficial effects seen from the use of supplements. One large trial on the other hand, found that subjects taking antioxidant supplements were less likely to lose visual acuity over the 6.3 years of follow-up [128]. However, because of inconsistencies in the results across the trials, it was concluded that the effects of antioxidants on reducing the risk of AMD progression were only moderate [128]. In terms of age-related cataracts, another Cochrane review (2012) found no evidence that supplementation with beta-carotene, vitamins C or E can prevent or slow the progression of cataracts, despite including over 117 000 subjects with considerable durations of follow-up between 2 to 12 years [133].

There is also little evidence to support the use of vitamin E to improve cognitive function or to protect against the development of brain disease. A Cochrane review (2012) assessed the efficacy of vitamin E in treating AD and preventing the progression of MCI to dementia [134]. Three trials were included of which two were based on patients with AD and the other recruited subjects with MCI. One of the AD studies found some beneficial effects on patients when a high-dose of vitamin E (2 000 IU/day) was administered. The other AD study used a lower dose of vitamin E (800 IU/day) and detected lower oxidative stress in some patients but overall there were no differences in cognitive test scores between the test and control groups.

For subjects with MCI, high-dose vitamin E (2 000 IU/day) had no effects on slowing down the progression of MCI to AD [134].

A recent systematic review and meta-analysis of RCTs investigated the efficacy of vitamin and antioxidant supplements in prevention of CVD. Fifty clinical trials with approximately 300 000 subjects were included in the review. Similar to the abovementioned Cochrane studies, the authors found no evidence to support the use of vitamin and antioxidant supplements to prevent CVD [135]. Another meta-analysis also found no positive effects of vitamins A, C and E supplementation and the incidence of major cardiovascular events and mortality [136].

There are discussions regarding the safety of antioxidant vitamin supplements as a number of previous clinical trials have indicated taking antioxidant supplements beyond the body's needs may increase mortality. A Cochrane review (2012) assessed the risk of increased mortality from taking antioxidants in 56 clinical trials on healthy subjects. It was found that the intake of beta-carotene, vitamin E and high doses of vitamin A supplements correlated significantly with increased mortality [137]. Some clinical trials found smokers taking beta-carotene supplements were at higher risk of lung cancer than controls [138]. Several trials in the abovementioned Cochrane reviews have also observed yellowing of skin in participants taking antioxidants, in particular beta-carotene [133].

4.6.4. Other antioxidants – selenium and zinc

Selenium is a trace element that has antioxidative and anti-inflammatory properties when incorporated into certain proteins to form selenoproteins [99]. Dietary sources of selenium vary vastly between countries, but usually include meat and offal, fish, eggs, grains and cereals, as well as certain fruits and vegetables (garlic bulbs, onion and broccoli), and Brazil nuts [99] [139]. This trace element is less well-researched compared to vitamin antioxidants, however it has been suggested that selenium may have a beneficial effect on lowering gastrointestinal cancer occurrence [140]. Low selenium status may also be associated with increased risk of mortality, poor immune function and cognitive decline [99]. Similar to the use of antioxidant vitamin supplements, some studies have indicated that the use of selenium supplements in people with normal selenium status may be detrimental, *e.g.* by increasing the risk of type 2 diabetes [99]. A Cochrane review (2013) found limited evidence on the use of selenium supplementation to prevent CVD events or related mortality [141]. Overall, more rigorous clinical trials are needed to confirm the link between selenium intake and its effects on various age-related diseases.

Zinc is also a micronutrient that can have antioxidative functions in the body. It has been suggested that zinc deficiency is linked to neuronal damage seen in AD, as zinc may be important in lowering the level of copper in the brain, which in excess, can act as a pro-oxidant and may increase the risk of AD [142]. However, there is a lack of consistent evidence to confirm this link. Zinc has also been suggested to be potentially beneficial for eye health. A systematic review assessed the evidence on zinc in preventing and treating AMD [143]. One RCT showed that zinc supplementation significantly reduced the risk of progression to advanced AMD, two RCTs showed positive results in visual acuity in older people with early AMD and the remaining RCT showed no effect. The results from the cohort studies on the other hand, were inconsistent on zinc's role in AMD prevention [143].

Zinc has an essential role in the immune system. It is known that the immune system undergoes alterations with advancing age; the ability to respond to infections and to develop immunity after vaccination deteriorate with age and leads to a higher risk of mortality caused by infections in older people [144]. One small RCT with fifty elderly subjects investigated the effectiveness of 12 months supplementation of zinc and the incidence of infections. Zinc supplementation was able to reduce oxidative stress in the treated subjects and their mean infection incidence was also lower than in the controls [145]. These results and zinc's potential role in reducing infections and related mortality are encouraging. However, more research is needed, as currently, there are very few studies in this area with a specific focus on older people.

Old people are more susceptible to upper respiratory diseases – the leading cause of death due to infections [146]. A Cochrane review (2013) assessed the role of zinc in treating common colds [147]. Rhinovirus is responsible for around 80% of common colds and it has been suggested that zinc may exert an antiviral effect by attaching itself to the virus and blocking its action in infecting the nasal cells [147]. It was found that when zinc was taken within 24 hours of onset of the cold, the average duration of the symptoms in healthy people was reduced, and their symptoms were less likely to persist beyond seven days of treatment, but there were no differences in the severity of symptoms between the treatment and the control groups [147]. However, the authors warned to interpret the results with caution due to the variability of methods used between studies [147].

4.7. Phytochemicals

4.7.1. Catechins

There has been widespread interest in the role of certain antioxidative phytochemicals to prevent chronic diseases. Tea leaves for example, contain catechins – a family of polyphenolic compounds which are believed to have strong antioxidative properties [148]. Various clinical trials have studied the effects of tea catechins, mainly from green tea, on the prevention of CVD and cancer as well as weight loss. A Cochrane review (2013) investigated the effects of green and black tea on CVD risk factors in eleven RCTs. Black tea was found to lower low-density lipoprotein (LDL) cholesterol and blood pressure, whereas green tea was associated with lower total cholesterol, LDL and blood pressure [149]. However, the long-term effects of tea and CVD events remained unclear due to a lack of trials of sufficiently long duration, although one Australian prospective study found that older women aged 75 years and older with a habitual high intake of polyphenols from tea over a five year period had a lower risk of CVD death [150]. Another Cochrane review (2009) assessed the relationship between green tea catechins and cancer prevention. The studies included in the review were of mixed quality, varied in methodologies and reported conflicting results regarding incidence of cancer. Overall, there was not enough evidence to support drinking green tea to prevent cancer; however, the authors concluded that regularly drinking three to five cups or up to 1.2 l/day (providing 250 mg/day of catechins) appeared to be safe [151].

4.7.2. Resveratrol

Resveratrol is another antioxidative polyphenol molecule that is found in grape skins and seeds, and medicinal plants and its intake is mainly from red wine [152]. Previous studies have shown that resveratrol could increase lifespan, lower fasting glucose, improve insulin sensitivity, prevent liver damage and improve performance in animals (*e.g.* invertebrates and mice) [152]. Because of the health benefits seen in animals, it is believed that resveratrol may have similar effects in humans. Currently, resveratrol is being actively investigated in human clinical studies. So far, no Cochrane review has been conducted to assess the evidence on possible health effects of this molecule. In one comprehensive review on resveratrol and human health, the authors wrote that 'the evidence is sufficiently strong to conclude that a single dose[18] of resveratrol is able to induce beneficial physiologic responses, and that either weeks or months of resveratrol supplementation produces physiologic changes that are predictive of improved health, especially in clinical populations with compromised health' ([153], p. 1138). Despite such conclusions, further meta-analyses are needed to critically assess the combined effects of resveratrol on different aspects of human health. It is too early to determine the efficacy of resveratrol supplementation in increasing lifespan or preventing chronic diseases in humans, particularly in the long-term.

4.7.3. Other bioactive compounds

There are on-going research studies on other polyphenolic compounds with antioxidative and anti-inflammatory properties, such as anthocyanins found in berries, grape seeds and blood oranges, as well as glucosinolates found in cruciferous vegetables, *e.g.* broccoli and broccoli seeds and sprouts [154]. Some of these studies are still at the very early stages and the mechanisms of action in the human body are not yet well understood. The effects of these compounds on human health should be evaluated when more evidence is available.

18. Quantity of dose not stated.

4.8. Probiotics and prebiotics

The gut flora or microbiota (*i.e.* all the micro-organisms living in the human gut and the metabolites they generate) are essential for the maintenance of gut health. Changes in microbiota composition have been linked to inflammation and metabolic disorders such as inflammatory bowel disease, irritable bowel disease, diabetes, CVD, colorectal cancer, and frailty in old people [155]. Healthy adults have a relatively stable microbial composition in the gut. However, in older people, the composition tends to vary greatly between individuals and the microbiota diversity declines with age [155]. Therefore, improving the microbial balance and composition in older people may help to reduce their risk for inflammation and metabolic diseases.

Probiotics and prebiotics have been proposed to promote gut health, particularly in older people [155]. Probiotics are live micro-organisms that, when administered in adequate quantities, can confer a health benefit on the host [155]. Common types of probiotics include *Lactobacilli* and *Bifidobacteria* that are found in yoghurt and fermented milk products, as well as probiotic drinks and some fortified fruit juices [156]. Prebiotics are non-digestible molecules that act as the substrate for the probiotic bacteria and selectively promote their growth and activity in the gut [155] [156]. Prebiotics can be found naturally in some vegetables, as well as in synthetic forms of non-digestible carbohydrates (*e.g.* oligosaccharides) [155] [156]. To date, there are few clinical studies that have investigated the effects of probiotics and prebiotics on the health of older people. However, some benefits have been recorded including improving bowel functions, *e.g.* reducing faecal transit time and relieving constipation [157], preventing antibiotic associated diarrhoea [156], increasing immune defence, and reducing inflammation, infections and allergies in older people [156].

4.9. Food-based evidence –The *Mediterranean Diet*

As discussed above, although micronutrient supplementation appeared to hold great promise to benefit older adults in combating age-related physical and mental conditions, particularly if they are at risk of deficiency, the evidence to date has not yet conclusively demonstrated such health-promoting effects. Therefore, it is crucial to obtain adequate levels of nutrients through diet. The *Mediterranean Diet* (MD) (*Table 4.4*) is suggested to have health benefits such as reducing the risk of developing type 2 diabetes, CVD, some neurodegenerative diseases and certain diet-related cancers [158]. A recent Cochrane review (2013) examined the effectiveness of a Mediterranean dietary pattern for the primary prevention of CVD [159]. It was found that although the evidence was still limited to date, there were some favourable effects seen on cardiovascular risk factors. In particular, the more comprehensive interventions with more components of the MD produced more beneficial effects on lipid levels than those interventions with fewer MD components [159]. The Mediterranean Diet Foundation produced a MD pyramid (*Figure 4.2*) that illustrates the main

Table 4.4. *Description of the* Mediterranean Diet*.*

The *Mediterranean Diet* includes high consumption of plant foods (*e.g.* fruit, vegetables, legumes, grains, nuts and seeds), complex carbohydrates such as bread and pasta, moderate consumption of fish, eggs, poultry and dairy products (*e.g.* cheese and yoghurt), low consumption of red meat and processed meat, low-to-moderate consumption of red wine with meals, and using olive oil as the main source of fats instead of animal fats. It covers a range of natural food sources high in key nutrients (*e.g.* protein, MUFAs and PUFAs, dietary fibre, antioxidant vitamins, minerals and polyphenols) and low in saturated and trans fats and added sugars [158] [160].

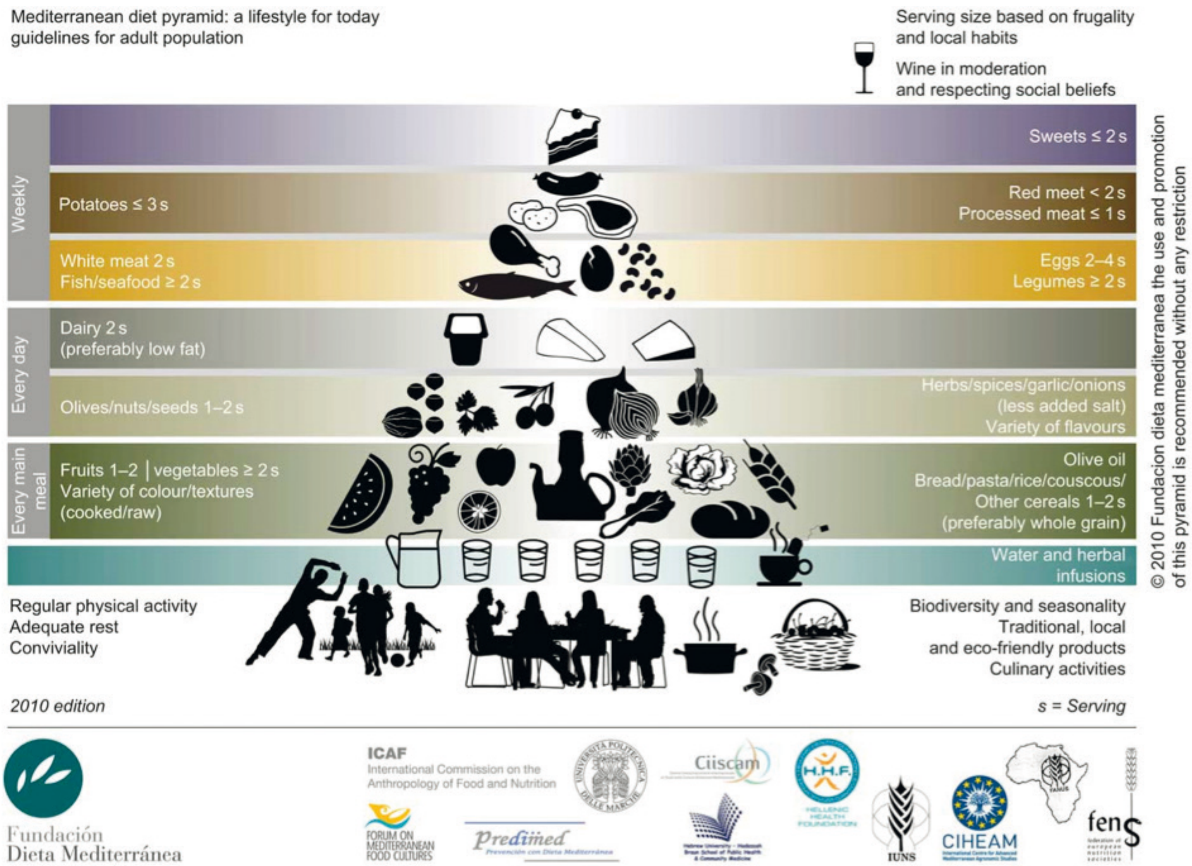

Figure 4.2. *The* Mediterranean Diet *pyramid.*
Source: Bach-Faig *et al.* 2011 [158]

principles of the MD as well as taking into account healthy lifestyle behaviours; adapting to the various geographical, socio-economic and cultural contexts of the Mediterranean region [158].

The current evidence suggests that the health benefits of the MD may go beyond reducing CVD risks. A number of small cohort studies have suggested that adherence to the MD increases longevity in several European populations, for example in various Greek islands [161], Sicily [162], Spain [163], and even in non-Mediterranean populations such as UK [164] and Sweden [165] when the main MD principles were applied in the studies. Adherence to the MD is usually measured using variants of a food group scoring system to produce MD scores or indices; generally, the higher the score, the better the adherence to the MD. Large multi-country studies observed comparable positive findings. The EPIC-elderly (European Prospective Investigation into Cancer and Nutrition) prospective cohort study followed over 74 000 older adults aged 60y+ in nine European countries (Denmark, France, Germany, Greece, Italy, the Netherlands, Spain, Sweden and the UK) and found that those who adhered to the MD had lower mortality rates [166]. For every 2-point increase in the MD scores (on the scale of 0 to 9), overall mortality was reduced by 8% [166]. A recently updated meta-analysis on the MD and health status including over 4 million subjects also indicated that for each 2-point increase in adherence score (scale 0 to 18), there was an 8% reduction of overall mortality risk as well as a 10% reduction in CVD risk [167]. Similarly, the HALE project (The Healthy Ageing: a Longitudinal study in Europe), which followed over 2300 healthy older men and women (aged 70 to 90y) for ten years in eleven European countries, found that those adhering to the MD had a lower risk of all-cause mortality [168]. Furthermore, combining MD adherence with three other lifestyle behaviours – moderate alcohol consumption, physical activity and not smoking, the rate of all-causes and cause-specific mortality (*e.g.* CVD and cancer) was reduced by more than 50% [168].

There is evidence to suggest that adherence to MD is also related to better cognition in older people. A meta-analysis assessed the association between the MD and cognitive decline (MCI and AD) from five prospective cohort studies with at least one year of follow up. Participants in the high adherence group had a reduced risk (33% lower) in both MCI and AD, compared to those in the low adherence group [169]. Furthermore, high MD adherence scores reflected lower risk in developing MCI and AD among those with normal cognitive functions while those with existing MCI were less likely to progress to AD if they were strict MD adherers [169]. Another meta-analysis, which included case-control studies, prospective cohorts and cross-sectional studies, investigated the association between MD and a number of brain-related conditions [170]. The pooled analysis showed that high adherence was strongly associated with reduced risk for stroke, depression, and cognitive impairment (MCI, dementia and AD) [170].

5. Concluding remarks

The EU is facing a future challenge of demographic change. It is important for all levels and sectors of society to prepare for this challenge as early as possible and to embrace it as an opportunity, not only to prevent the development of a number of age-related problems that are known to affect current older people, but also to enable them to contribute to society as they grow older. To promote AHA, collective efforts and the interplay of the six key determinants: (1) economic determinants; (2) health and social services systems; (3) physical environment; (4) social environment; (5) cultural and personal determinants; and (6) behavioural determinants are essential.

This report, addresses the contribution of nutrition in determining AHA. To increase healthy life years, it is essential to reduce and delay for as long as possible age-related functional decline and disability, to which undernutrition plays a large role. Given the importance of nutrient deficiency in disease development, we reviewed the current evidence on the effect of key nutrient supplementation in age-related disease prevention and treatment. At this stage, limited benefit is seen with supplementing single nutrients in older people to prevent or treat specific cognitive and functional impairments. It does not mean that supplementation is not effective; there are many possible explanations for the lack of effects seen in the studies reviewed here. However, another alternative to ensure proper nutrition in older people is to maximise their intake of essential vitamins, minerals and bioactive compounds from natural food sources. Indeed, the evidence so far on the *Mediterranean Diet* as a whole diet approach to promote health, increase longevity and reduce the risks of various age-related diseases supports this in a number of observational studies. It is possible that the natural micronutrients ingested from food can interact with each other and exhibit synergistic effects on health that are absent from supplementation of nutrients in synthetic forms. Although there are other nutrition-related issues relevant to the older population (*e.g.* dietary risk factors in non-communicable diseases), the research described already indicates that there is a vast potential to focus further on promoting health through adequate intake from diet in this age group. The table below outlines several potential areas for future research in this important field.

It is our hope that this report will raise awareness of diet as a key contributor to healthy ageing, and that more attention will be given to diet and nutrition in policymaking to protect our older citizens.

5.1. Further research opportunities

Table 5.1. *A list of potential areas for future research.*

• Given that most supplementation trials have not convincingly demonstrated high rates of success in age-related disease prevention and treatment, it is important that older people obtain adequate nutrients through diet. However, **age-specific and up-to-date guidelines or recommendations specifically for older Europeans** are not easy to find. A previous set of recommendations for older people from the WHO dates back from 2002 [5], and currently, there are no standard European recommendations/guidelines available for older individuals. As a first step, there is a need to have an understanding on how many EU Member States have recent dietary recommendations for older people, and whether such recommendations can be harmonised across Europe.
• Nutrition is one of the key lifestyle determinants of AHA, along with physical activity, smoking and alcohol consumption patterns. It does not act on ageing independently. In this report, we established that age-related functional declines are causes as well as consequences of undernutrition. However, there are also **wider AHA determinants such as social, economic and environmental aspects** that can influence how well older people eat as well as age. An important area of research is the **interrelationships of such factors on dietary behaviour and how they can ensure older people eat better**. For example, social contact, health literacy, use of technology, accessibility and availability of food, are some of the factors that deserve further research.
• In relation to this, to encourage self-care and responsibility to achieve AHA, translating scientific evidence into key and simple public health messages that can be easily understood by the older population, such as drinking fluids regularly to prevent dehydration; eating adequate fruit and vegetables per day (*e.g.* 5-a-day); and being physically active, are very important. Future research should also focus on **identifying the most effective strategies to promote these public health messages to the older population**.
• The evidence base focuses on the current older population; however, it is **not known whether observations and projections at present are applicable to the older population in the future**. For example, the proportion of the current older population that was overweight or obese during their childhood or adulthood was very low. Therefore, the current observations on disease trends and rates are most likely to be based on individuals who are normal weight. With the current obesity epidemic, it is unknown whether obese children and young adults will age the same way as the current older population. It is therefore **important to have pregnancy and birth cohorts to study ageing from the life-course perspective** to observe how people age according to different biological as well as lifestyle attributes.
• With the aim to extend healthy life years and to encourage active and healthy ageing in many national public health agendas, it is important to **identify the best measures or markers for AHA**. Often, studies use mortality rate reduction or, in clinical studies, specific biomarkers such as telomere length as positive outcomes of ageing. However, there should also be a number of other **validated, agreeable, cost-effective, and non-invasive measures and tools to quantify, for example, the quality of diet, fitness, and well-being in older people** throughout different stages of ageing. Furthermore, it is important to **recognise the diversity of old age**. Research should distinguish different extents of ageing (*e.g.* the young-old, the old-old, and the very old).

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Annex: *Factsheet on European Innovation Partnership on Active and Healthy Ageing*

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About the Partnership

The European Innovation Partnership on Active and Healthy Ageing (hereafter referred as the Partnership or EIP on AHA) is one of the European Commission's answers, within the framework of Europe 2020 Strategy, to the demographic challenges that Europe is facing. The Partnership aims to improve the quality of life of older people and enable them to stay active for longer. It pursuits a triple win for Europe: a better life, with active ageing and independent living, for older people; the sustainability of social and health care systems and enhanced competitiveness of European industry through new markets and business expansion.

The Partnership is a new stakeholder-driven approach to research and innovation. It pools available resources and expertise by bringing together committed and motivated actors, from both the public and private sector that are active particularly in health policy at European, national and regional level.

The work is structured in three pillars reflecting the 'life stages' of the older individual in relation to care processes: A) prevention, screening and early diagnosis; B) care and cure and C) active ageing and independent living. There are three ways that stakeholders contribute to the Partnership: the *Reference Sites*, the *Action Groups* and the *Marketplace*; to which the European Commission (EC) provides general guidance and support to the coordination of efforts.

One of the Partnership's key achievements has been the mobilisation of stakeholders across Europe. Today, over 3 000 organisations, representing all EU Members States from different regions, are engaged in the implementation of individual voluntary commitments, under the banner of the EIP on AHA. The partners estimated to impact with their actions 30 million EU citizens and 2 million patients across Europe.

About Nutrition within the Partnership

Within the Partnership, a specific A3 Action Group (AG) on Prevention of Frailty[19] is currently implementing a common action plan. Partners have committed to implement innovative solutions to better understand the underlying factors of frailty, to explore the association between frailty and adverse health outcomes in older people and to better prevent and manage the frailty syndrome and its consequences.

19. The Action Group (AG) on 'implementing integrated programmes for prevention, early diagnosis and management of functional decline, both physical and cognitive, in older people' started work in June 2012. The AG is normally referred to as *Prevention of Frailty*. 160 partners expressing a total of 131 commitments are working together in this multidisciplinary Action Group.

Part of their objectives and activities address the challenges regarding nutritional care for older people (including hydration and promoting physical activity) in social and healthcare settings.

There seems to be a closed association between frailty and the nutrition status in older people. Malnutrition in particular can increase the age-associated loss of muscle and strength and therefore play a role in the development of sarcopenia and physical impairment. Hydration status is also of particular importance in older people.

Moreover, given that the causes and consequences of malnutrition fall across multiple policy spheres (*e.g.* no single health professional is accountable for malnutrition), concerted action is needed, as well as coordination amongst different stakeholders.

What the AG on frailty is working on:

Building on already known aspects, the frailty group's current work provides examples of good practices of interventions and research in different settings and circumstances. Some examples of their work are presented in *Table 1*. They refer to the following areas: screening for undernutrition; delivering information and guidance to the general population, patients and care-givers to improve their food intake and food habits; dietary interventions to counteract inflammatory status and contribute to a better understanding of nutritional needs in older people; research in the fields of biomarkers, functional food and dietary supplements; analyse the association between malnutrition, muscle strength and frailty; creating linkages between the healthcare system and the community; screening programmes to identify food habits for disease prevention; elucidating the molecular mechanisms by which natural products retard the onset of frailty and functional decline; and creating and marketing appropriate foods or diet supplements to reduce frailty and maintain sensory perception.

More information on the Action Group and the Good practices is available at:

https://webgate.ec.europa.eu/eipaha/action-group/index/a3
https://webgate.ec.europa.eu/eipaha/library/index/show/id/727

The added value of A3 AG

Although it is not always easy to disentangle the specific impact of the Action Group itself, it is important that all EU, national and regional initiatives move in the same direction and build up critical mass in the most important areas; frailty and nutrition being one of them.

The collection of good practices and the work implemented by the Partnership are contributing to: make health and nutrition national and EU priority; raise awareness of nutrition for health; implement screening for malnutrition; implement targeted interventions; get recognition of the role of hydration and supplements; and the role of technology and screening.

The EC is prepared to support the transfer and scaling up of successful initiatives (such as the Good practices of the Action group partners) to other regions or sectors to help transform the good practices into regular activities that will end up improving the nutritional status and healthy diet of the European population.

The EC welcomes collaboration with stakeholders active in the field of active and healthy ageing in general as well as in specific related domains (*e.g.* nutrition) to enhance coordination of resources and reduce duplication of efforts.

Table 1. *Examples of commitments and good practices in nutrition.*

Country	Organisation	Example	Content
Belgium	Flanders region	A gastrological approach to malnutrition	A gastrological practice-based and an evidence-informed nursing approach – resulting in a mutual and customised set of interventions focused on the resident, his/her individual needs and wishes on food, the ward and the institution has a positively influence on the seriousness and the frequency of malnutrition in the elderly. Also an intervention in innovative homecare delivery to prevent undernutrition, in Bruges for 600 elderly at home. The interventions consist of a learning programme, a systematic risk screening/monitoring, a hierarchy of actions starting with normal food driven by a gastroteam and good communication between the different actors involved in the nutritional care.
Belgium	European Nutrition for Health Alliance (ENHA)		Provides routine nutritional screening and monitoring of undernutrition among persons aged 75 years or older.
Italy	Campania region	Food Against Frailty	Creates and markets appropriate foods or diet supplements designed to reduce frailty in older people and to maintain sensory perception. Currently collaborating with industries. They are focused on the administration of vitamin D supplement through the diet, with oil, to improve prevention of osteoporosis, at the same time reducing osteoporotic fractures.
Portugal		Bioactive Natural Food Ingredients for aging-people functional diet	They search for molecular structures present in natural matrices (including food industry residues) that could be active in age-related diseases, namely with impact in mental and cardiovascular health and diabetes. Different biomarkers for age-related diseases are studied in order to gain a better understanding of the impact that natural food/ingredients have in an aging-person's diet.

Table 1. *(cont.)*

Country	Organisation	Example	Content
Spain	CSIC	Healthy ageing with innovative functional foods/ leads for degenerative and metabolic diseases	Implementation of a project to develop functional foods that could be incorporated in the normal diet of the elderly to target specific needs, leading to improved quality of life. Through regional, governmental and private industry collaboration, they have developed a technology that allows conducting caramelisation of food carbohydrates under conditions that favour the formation of prebiotic oligosaccharides and incorporate them in the diet in a 'natural' manner (caramel is a common ingredient in the food industry with the GRAS – 'generally recognised as safe' label). The technology has been licensed and is undergoing the scale up process.
UK	Aston Ageing Centre	Baseline nutritional status, metabolic phenotype and interventions to improve function	Obesity has previously been shown to reduce lifespan by approximately ten years and to enhance the ageing process. Little is known as to why this happens, however, altered metabolism and storage of macro- and micro-nutrients is postulated to play an important role. A cohort of healthy volunteers and type 2 diabetic / obese subjects of varying age have their body fat analysed and a sample of blood will be taken for phenotyping. It will establish normative population data and explore the effects of interventions that modulate lipid profiles on oxidative damage markers.
UK	Northern Ireland	Malnutrition screening and guidance for their use for the pre-vention of frailty	Improve the quality of nutritional care of adults in Northern Ireland receiving health and social care, through the prevention, identification and management of malnutrition in all health and social care settings. They are promoting systematic, routine screening for pre-frailty stages in at risk patients and older people. Relevant templates for malnutrition screening guiding principles to support person-centred care planning in relation to nutritional screening have been developed. Recommendations on how to raise awareness among practitioners of the screening tools available for use are available.
The Netherlands	Hanze University		Currently developing an application for self-assessment of malnutrition risk and the monitoring of diet and physical activity.
Spain	ISC III Madrid	Non-Invasive Neurofunctional Evaluation	A project currently developed based on dietary interventions with nutritional supplements that could prevent or delay the development of age-related hearing loss. It involves the industry creation of new nutritional products and it studies the impact of malnutrition on hearing in older people in the general population with animal models.

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Abstract

Europe is facing an ageing population. Life expectancy is at its highest and many European populations are experiencing major demographic changes and transition towards a much older population structure. However, despite living longer, many people suffer ill-health or disability in the last 15 to 20 years of life. To encourage active and healthy ageing and to help increase healthy life expectancy, the European Commission has launched the *European Innovation Partnership on Active and Healthy Ageing* (the Partnership), which aims to add an average of two healthy life years in Europe by 2020.

This report aims to support the Partnership and to review the contribution of diet and nutrition in increasing healthy life years and promoting active and healthy ageing (AHA). The report gives a description of the main determinants of AHA including economic, social and behavioural factors and how they may relate to diet. It focusses on the issue of undernutrition in older people – both a cause and consequence of functional decline. Given the importance of undernutrition and that micronutrient deficiency is a common problem in older adults, this report summarises the evidence regarding micronutrient supplementations in the prevention and treatment of age-related diseases and conditions. At this stage, the current evidence seems insufficient to support the use of vitamin and mineral supplementation to prevent or treat specific cognitive or functional impairments in older people, although it does not imply that supplements are not effective. As it stands, another approach to ensure proper nutrition in older people is to maximise their intake of essential vitamins and minerals from natural food sources. Indeed, evidence so far on the *Mediterranean Diet* supports this whole diet approach to promote health, increase longevity and reduce the risks of various age-related diseases in observational studies. A number of research gaps are also highlighted in this report. Above all, there is a need to provide better guidance on diet and nutrition for older people and a set of age-specific, up-to-date dietary recommendations is essential to achieve this.

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