Research Article

Women's Health in the UK-Dietary and Health Challenges across the Life Cycle with a Focus on Micronutrients

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Abstract

Background: Women face unique health challenges across their lifespan. Nutrition plays a key role in meeting these health challenges. This paper identifies micronutrient intakes and weight, health and health risks for females in the UK from 11-65 plus and to evaluate associations between nutrient intakes and health.

Methods: Micronutrient intakes for women are calculated from the UK National Diet and Nutrition Survey Rolling Programme (NDNS-RP) and weight and health status from the Health Survey for England (HSE) 2018.

Results: Few women achieve recommended nutrient intakes across the lifespan. Intakes for several nutrients in women have fallen over the 9 years of the NDNS-RP. A significant proportion of women of all ages had micronutrient intakes below the Lower Reference Intake (LRNI) for vitamin A, riboflavin, iron, calcium, magnesium, potassium, iodine, selenium and zinc. Blood and serum levels of folate fell below WHO cut off points in up to 90 per cent of women of reproductive age and a significant proportion of women have blood levels of vitamin D below the recommended threshold. Intake of oily fish, the major source of long chain-omega-3 fatty acids is well below recommended intakes. Only 4 per cent of adult women and 2 per cent of teenage girls achieve recommended fibre intakes. More than two thirds of women are overweight or obese, 7 per cent have diabetes, 69 per cent of 45-54 year old women have raised cholesterol, 22 per cent of 17-19 year old women have poor mental health, 22 per cent of women have osteoporosis and 618,576 women in the UK have dementia.

Conclusions: These low levels of micronutrients are associated with the many health challenges faced by women: bone health, brain health, cardiovascular health, digestive health, eye health, immune function, reproductive health. Intakes of micronutrients should achieve recommended levels, but current diets are creating a nutrient gap. Whilst diets should be improved, a supplement containing recommended intakes of all micronutrients as well as omega-3 fatty acids should be recommended. This includes 10 micrograms of vitamin D and for women during their reproductive years, 400 micrograms folic acid.

Background

The majority of women care about being healthy and staying healthy throughout life. However, it is not always easy given the myriad of complex health challenges from eating healthily in the context of a busy lifestyle to being sufficiently physically active. Achieving and maintaining a healthy body weight, minimising stress and getting enough sleep, managing diet and nutrition from conception through pregnancy, as well as ensuring sufficiency of micronutrients for bone health, brain health, cardiovascular health and digestive health at every stage of life can appear to be enormous challenges.

Few women actually achieve micronutrient sufficiency at any stage of life, which is serious given that vitamins and minerals in recommended amounts are essential for health. Earlier reports from the UK National Diet and Nutrition Survey Rolling Programme (NDNS-RP), which began in 2008, have identified widespread shortfalls in micronutrient intake and status in females from the age of 11 to older age [1].

Dietary patterns and eating habits have changed dramatically over the past 50 years. Women's diets have been influenced by a range of factors, including urbanisation and the availability of different foods, busy lifestyles, more unpredictable working hours, increase in unstructured eating, more eating out and the rise in the number of women in the workforce. Food 'to go' is becoming increasingly popular at the expense of food cooked in the home. Food sensitivities such as gluten, wheat and dairy result in women cutting out whole food groups, whilst popular weight loss 'diets' can reduce micronutrient intakes [2]. The trend to reduce red meat, other animal-based food and fish to become vegan or vegetarian can prejudice intakes of iron, zinc, calcium, iodine and vitamin B12. [3]. In addition, concerns about sustainability of fish stocks or dislike of oily fish may contribute to low intakes of long chain omega-3 polyunsaturated fatty acids (LC-omega-3 PUFAs). Consumption of food high in fat, sugar and salt at the expense of fruit and vegetables and a healthy overall diet can impact digestive health as plant-based foods provide prebiotic ingredients that can have a beneficial impact on the gut microbiome [4].

Nutrient shortfalls create many health challenges for women across the lifespan. Low calcium intakes can increase risk for poor bone health, [5] lack of omega 3 fatty acids can create issues for brain [6] and heart health [7], lack of folic acid during pregnancy increases risk of neural tube defects in the offspring, [8] lack of omega 3 fatty acids in pregnancy can increase the risk of poor brain health in infants and children [9]. Lack of iron and vitamin B12 can lead to anaemia and even in the absence of iron deficiency anaemia, low intakes of iron in particular can lead to tiredness and fatigue [10].

The greatest health burdens for women, particularly in the middle and older years, are the Non-Communicable Diseases (NCDs) such as cardiovascular disease, diabetes mellitus, osteoporosis, various cancers and eye disease such as cataract and Age-Related Macular Degeneration (ARMD). A significant factor in improving women's health is therefore to reduce the risk of these conditions and nutrition plays a key role. However, consideration of health, for women as well as men, is not only about preventing illness but also promoting optimal health and wellness.

A lifespan approach is essential to achieve optimal health and wellness and reduce the risk of illness. Earlier life experiences, particularly with regard to nutrition, influence later experiences with regard to health. Additionally, women experience unique health related issues and events encompassed mainly in the reproductive cycle across the lifespan from the menarche, pre-conception and pregnancy to the menopause, and beyond that influence health and well-being. Specific beneficial lifestyle behaviours, amongst which nutrition is key, throughout the lifespan can contribute to optimal health and wellness and reduce illness in later life.

This aim of this paper is to critically evaluate the current dietary and nutrient intakes at women's different life stages, how intakes have changed in recent decades, the reasons for these changes, various health issues faced by women and to assess the impact of nutrient intakes on women's health with a UK focus.

Methods

Data on body weight and various health risks in this publication are taken from the Health Survey for England (HSE). The HSE monitors trends in the nation's health. It provides information about infants and children from 0 to 15 and adults aged 16 and over living in private households in England. The survey consists of an interview followed by a visit from a nurse who takes some measurements (e.g., blood pressure, height and weight) blood and saliva samples. Adults and children aged 13 to 15 were interviewed in person and parents of children aged 0 to 12 answered on behalf on their children on many topics. A total of 8178 adults and 2072 children were interviewed for the 2018 survey. Much of the data is available by gender, allowing identification of health issues specifically for females.

Data on dietary and nutrition intakes in women are derived from the UK on-going cross-sectional National Diet and Nutrition Survey Rolling Programme (NDNS-RP) from the time this survey began in 2008 (Year 1/2), to the latest data in 2015/2016 (Year 7/8) [1]. Specific data for females extracted from the NDNS-RP were for: energy, protein and fat, including saturated fat, intakes, free sugars, Association of Official Analytical Chemists (AOAC) fibre, fruit and vegetables, red and processed meat and oily fish intakes and micronutrient intake data for vitamin A, riboflavin, folate, iron, calcium, magnesium, potassium, iodine, selenium and zinc intakes. A full description of the methodology is provided in an earlier and separate paper [11].

In addition to data extraction on specific foods and macro- and micronutrients, the following literature searches were conducted on Medline and Google Scholar: women AND Health; women AND diet; women AND nutrition; Global Women's Health Studies, Global Burden of Disease study, US and European dietary studies. The aim of these searches was to identify the health issues affecting women and girls across the lifespan and the impact of nutrition.

Although many of the nutritional concerns covered in this paper are applicable to males, the focus is on females with males mentioned only occasionally where comparisons are deemed to be important for context.

Findings

This publication evaluates nutrient intakes according to the three key life stages (which mirror those of the NDNS-RP):

- Girls from childhood through the teenage years (age 4-18 years)
- Adult women (aged 19-64 years)
- Older women aged 65 plus years

A summary of the data extracted from the NDNS-RP for women's food and nutrient intakes can be found in Tables 1-3. The HSE publishes its data using different age ranges (i.e. 0-15 and 16-75 plus), resulting in some overlap between the NDNS-RP and HSE data.

Girls and Young Women Aged 4-18 Years

The early years are a key window of opportunity for improving girls' and women's health in later life, including reducing risk of obesity, and focusing on sufficiency of micronutrient intake to achieve optimal health for all the organ systems (e.g., the brain, heart, bone and digestive tract).

Nutrition in the first thousand days of life (pregnancy and the first two years) is fundamentally important to the growth and development of infant girls (and boys). Childhood and adolescence are periods of rapid growth, learning and development. Nutritional needs for girls and teenage women are high and differ in many respects from those of adult women. Pregnancy, if it occurs, impacts on nutrient needs of a teenage mother and her baby. The need to make appropriate dietary choices and develop and maintain healthy habits to attain and maintain healthy weight and achieve recommended intakes of nutrients is paramount.

This section looks at levels of obesity and overweight in young women, mental health and diet including micronutrient intakes. Consideration is also given to health issues linked with nutrition which begin in this age group of females and sometimes continue into adult women (e.g., risk of Neural Tube Defects (NTDs), pre-menstrual syndrome, use of oral contraceptives, heavy menstrual bleeding, endometriosis, fertility, pregnancy and skin health).

Obesity

Levels of obesity for girls remain high in the UK and are close to those in countries such as the United States, Mexico and Chile. In the 2018 Health Survey for England (HSE) almost a third of girls aged 2-15 years (28 per cent) were either obese (15 per cent) or overweight (13 per cent) [12]. Obesity levels in girls are similar to those in 2001 and have fluctuated slightly between 2006 and 2018 with a slight fall in the proportion overweight (including obese) since 2005.

The prevalence of obesity increases with age with 9 per cent of girls aged 2-4 obese compared with 21 per cent aged 13-15 years. The proportion of girls categorised as overweight or obese also increases with age. Almost a quarter (23 per cent) of girls aged 2-4 are classified as overweight or obese whilst among 13-15 year old girls the proportion is 37 per cent [12].

Many girls who are obese or overweight suffer physical health issues, including type 2 diabetes, asthma and musculoskeletal pain, and experience mental health problems, such as depression [13]. These health issues affect the quality of their lives, their education and their life chances. In later life, they can reduce their productivity, earnings and shorten their lives.

Obesity in girls can bring forward the age at which puberty occurs and as a result they will be shorter than their expected height [14]. Early puberty in girls is associated with reduced educational attainment, poorer mental health and greater risk-taking behaviour [15]. Being obese during childhood can have long term consequences for health in adulthood. Childhood obesity is a strong predictor of adult obesity [16].

Smoking and Drinking

According to the HSE for England, self-reported drinking and smoking has fallen during recent years in young females. A total of 4 per cent of girls aged 8-15 report having smoked, 6 per cent say they have tried e-cigarettes and 18 per cent have had alcoholic drink [17].

Mental health

Poor mental health disproportionately affects teenage girls relative to boys of the same age. A prevalence survey of the mental health of children and young people in England reported that 22.4 per cent of 17-19 year old women experienced an emotional disorder, compared to 7.9 per cent of boys of the same age; the prevalence in 17-19 year old women was almost double that of the prevalence in younger girls aged 11-16 years [18]. Similarly, evidence from the Millennium Cohort Study, a UK-representative cohort study, has shown that this gender difference is not present at age 11 but emerges at age 14, with girls reporting poorer wellbeing and mental health than boys [19].

Diets

Fruit and vegetables

Girls' dietary habits are of particular concern. Diet plays a key role in shaping a girl'shealth both in childhood and the teenage years and later in life. With regard to diet, the protective health benefits of a diet rich in fruit and vegetables have been long recognised for both adults and children. A diet abundant in fruit and vegetables can ensure an adequate intake of many essential nutrients whilst contributing to fibre intake and can help displace unhealthier foods high in saturated fats, sugar and salt. In the latest iteration of the NDNS-RP 2017 (Table 1), girls aged 11-18 consumed on average 2.8 portions of fruit and vegetables each day with only 9 per cent eating the recommended five or more portions of fruit and vegetables a day [20].

	Years 1-2 2008/9-2009/10				Years 3-4 (2010/11 - 2011/12)				Years 5-6 (2012/13 - 2013/14)				Years 7-8 (2014/15-2015/16)				per cent Change Since 2008			
	4-10y	*11-18y*	*19-64y*	*65+y*	*4-10y*	*11-18y*	*19-64y*	*65+y*	*4-10y*	*11-18y*	*19-64y*	*65+y*	*4-10y*	*11-18y*	*19-64y*	*65+y*	*4-10y*	*11-18y*	*19-64y*	*65+y*
Total energy intake (kcal/d; MJ/d)	1506	1623	1640	1535	1467	1515	1585	1482	1400	1617	1595	1488	1366**	1555**	1632	1422*	-7.4	-5.5	-1.9	-4.5
	6.3	6.8	6.9	6.5	6.2	6.4**	6.7	6.2	5.9**	6.8	6.7	6.3	5.8**	6.6	6.9	6.0**				
Protein intake (g/d)	53.7	57.0	65.9	64.8	52.4	55.7	65.0	62.6	52.2	58.7	64.4	64.3	50.4	57.9	66.6	60.5	-3.7	0	0	-4.4
Fat intake (g/d) % food energy	57.8	62.3	61.3	60.2	54.3	57.4	58.9	55.1	52.8	61.2	59.4	56.3	51.2	58.5	62.4	54.3	-9.1	-5.9	-1.6	-7.6
	34.2	34.2	33.1	33.3	32.9	33.6	33.0	32.5	33.4	33.9	33.0	33.6	33.4	33.7	32.8	33.4				
Saturated fat intake (g/d)	22.7	22.5	22.6	24.3	21.8	20.9*	21.6	21.4*	21.1*	23.0	22.1	22.2	20.3*	21.4	22.8	21.8				
%food energy	13.4	12.5	12.7	14.0	13.2	12.3	12.5	12.8*	13.5	12.7	12.7	13.3	13.2	12.3	12.7	13.7				
Free sugars (g/d) % food energy	59.8 14.6	68.5 15.8	52.6 12.2	46.7 11.4	59.8 15.2	63.0 15.4	48.2 11.6	45.4 11.5	51.7** 13.5*	68.3 15.6	50.7 12.0	41.9 10.4	49.9 13.4*	62.4 14.5	50.0 11.6	40.1* 10.6	-15.3	-14.4	-7.6	-1.2
AOAC fibre (g/d) % meeting recommended 30g/d	14.5 12	14.8 1	19.8 3	16.7 2	14.4 9	14.0* 1	19.4 3	18.1 4	13.1** 7	15.0 2	19.7 2	17.1 2	13.5* 9	14.1* 2	20.7 4	16.4 4	-6.0	-4.9	2.7	-3.3
Fruit and Vegetables† (g/d)	207	170	286	308	209	159	280	320	186	174	286	304	195	176	296	273	-3.0	-5.6	4.1	-10.9
Fruit and Vegetables (portions/d)	--	2.7	4.1	4.4	--	2.6	4.0	4.5	--	2.8	4.1	4.3	--	2.8	4.2	3.8	--	0	0	-11.3
Fruit and Vegetable (per cent achieving 5-A-Day))	--	7	28	36	--	6	28	36	--	9	28	35	--	9	32	27*	--	-20	6.8	-27.8
Red and Processed Meat (g/d)	46	48	58	56	35*	43	54	52*	39	49	47**	57	34*	44	47**	49	-17.4	-17.2	-16.2	-9.2
Oily Fish (g/d)	2	3	9	10	2	2	6	13	2	3	8	12	1	3	8	10	0	0	0	0
Oily fish (g/wk)††	14	21	63	70	14	14	42	91	14	21	56	84	7	21	56	70	--	--	--	--

Table 1: Dietary Changes in Females over the Last Decade

Fibre

The picture for dietary fibre intake (Table 1) is similarly worrying. Just 9 per cent of girls aged 4-10 and 2 per cent of girls aged 11-18 met the Scientific Advisory Committee on Nutrition (SACN) AOAC Fibre recommendations [20].

Free sugars

Mean intake of free sugars (Table 1), whilst falling, continues to exceed the government's recommendation in all age groups (no more than 5 per cent of food energy), including youngsters. Girls aged 11 to 18 years had the highest free sugar intake as a percentage of food energy (14.5 per cent of total energy) of any population group in the NDNS-RP. Girls aged 4-10 consumed 13.4 per cent of food energy as free sugars [20]. As well as contributing to obesity, regularly consuming food and drinks high in sugar is associated with tooth decay.

Micronutrients (Vitamins and Minerals)

Poor diets in young girls result in lack of vitamins and minerals. Mean daily intakes of micronutrients measured in the NDNS-RP between 2008 and 2016 are found in (Table 2). The proportions of females with intakes of the same micronutrients below the Lower Reference Nutrient Intake (LRNI) (the level at which deficiency is likely) are found in (Table 3).

	2008/9-2009/10				(2010/11 - 2011/12)				(2012/13 - 2013/14)				(2014/15-2015/16)			
	4-10y	11-18y	19-64y	65+y	4-10y	11-18y	19-64y	65+y	4-10y	11-18y	19-64y	65+y	4-10y	11-18y	19-64y	65+y
Vitamin A (µg/d)	666	638	974	1225	603	554	913	1194	547	575	850	970	536	497	825	901
Riboflavin (mg/d)	1.4	1.3	1.4	1.6	1.4	1.2	1.4	1.6	1.4	1.3	1.4	1.6	1.3	1.2	1.4	1.4
Folate (µg/d)	187	191	233	242	188	181	224	240	172	189	215	218	163	174	214	208
Vitamin D (µg/d)	1.9	1.9	2.6	2.8	1.9	1.8	2.5	3.1	1.9	2.1	2.5	3.1	1.9	1.9	2.5	3.9
Iron (mg/d)	8.3	8.6	9.8	9.5	8.5	8.2	9.5	9.4	7.5	8.6	9.4	9.3	7.4	8.3	9.3	8.4
Calcium (mg/d)	767	692	741	811	803	648	715	780	749	706	743	759	703	664	746	732
Magnesium (mg/d)	184	186	228	224	188	181	223	232	178	194	234	226	175	187	238	219
Potassium (mg/d)	2081	2112	2564	2632	2088	2018	2500	2668	2027	2153	2548	2601	1971	2029	2588	2494
Iodine (µg/d)	134	110	142	171	126	108	137	166	126	111	138	165	115	101	140	147
Selenium (µg/d)	32	35	43	41	31	35	43	40	30	37	43	42	29	36	44	38
Zinc (mg/d)	6.2	6.5	7.7	7.6	6.1	6.2	7.5	7.6	5.9	6.6	7.4	7.5	5.6	6.3	7.6	7.1
Data is from food sources only.																

Table 2: Micronutrient Changes in Females over the Last Decade (mean daily intakes).

	2008/9-2009/10				(2010/11 - 2011/12)				(2012/13 - 2013/14)				(2014/15-2015/16)				Trend			
	4-10y	11-18y	19-64y	65+y	4-10y	11-18y	19-64y	65+y	4-10y	11-18y	19-64y	65+y	4-10y	11-18y	19-64y	65+y	4-10y	11-18y	19-64y	65+y
Females																				
Vitamin A (µg/d)	5	14	5	1	9	15	5	2	12	18	8	4	11	24	10	8	↓	↓	↓	↓
Riboflavin (mg/d)	0	18	11	2	2	25	12	4	1	20	13	5	1	26	14	10	↔	↓	↔	↓
Folate (µg/d)	0	7	3	2	0	9	5	1	0	8	4	4	1	15	6	5	↔	↓	↔	↓
Iron (mg/d)	1	43	21	1	2	49	24	3	3	48	27	3	3	54	27	10	↓	↓	↓	↓
Calcium (mg/d)	2	15	6	3	3	23	10	5	1	19	8	8	1	22	11	11	↑	↓	↓	↓
Magnesium (mg/d)	1	51	9	8	5	54	14	8	3	48	11	15	3	50	11	18	↓	↔	↔	↑
Potassium (mg/d)	0	32	21	13	0	34	24	15	0	33	26	24	0	38	23	27	↔	↓	↔	↑
Iodine (µg/d)	3	19	9	2	6	26	12	3	7	26	11	8	4	27	15	7	↔	↓	↓	↑
Selenium (µg/d)	1	49	53	51	2	42	48	53	2	44	47	52	1	45	46	66	↔	↑	↑	↑
Zinc (mg/d)	10	20	4	1	11	25	5	2	13	22	6	3	14	27	8	7	↓	↓	↓	↑
Data is from food sources only. ↓Intakes have gone down. ↔ Intakes show no distinct trend; much the same. ↑ Intakes have improved.																				

Table 3: Micronutrient Changes in Females since 2008/9 by Gender (percent below LRNI).

Vitamins

Beginning with vitamin A - a total of 11 per cent of 4-10 year old girls and 24 per cent of 11-18 year old girls had intakes of Vitamin A below the Lower Reference Nutrient Intake (LRNI) in the latest NDNS-RP [20]. Vitamin A is essential for the health of the mucous membranes, eyes and skin. Since 2008 when the NDNS-RP began, the proportion of 11-18 year old girls with vitamin A intakes below the LRNI increased by 2 percentage points (CI 1, 3) per year [11]. More than a quarter of 11-18 year old girls (26 per cent) also had riboflavin (essential for the metabolism of iron and for the health of the nervous system) intakes below the LRNI.

Folate is an essential B vitamin which contributes to maternal tissue growth during pregnancy, normal blood formation, homocysteine metabolism, psychological function, immune function and low intake contributes to reduced tiredness and fatigue. Low intakes and also, importantly, lack of folic acid supplementation in women throughout their reproductive lives, increase the risk of Neural Tube Defects (NTDs) in the infant.

Since 2008, the average intake of dietary folate for girls aged 11 to 18 years has dropped and remained below the Reference Nutrient Intake (RNI). A total of 15 per cent of girls aged 11-18 years had an intake of folate below the Lower Reference Nutrient Intake (LRNI) and the proportion with intakes below the LRNI increased by 9 percentage points over the 9-year period of the NDNS-RP [11].

The NDNS-RP also measures folate status (i.e., red blood cell and serum folate). Red blood cell (RBC) folate concentration below the World Health Organisation (WHO) clinical threshold indicating risk of anaemia (305nmol/L) was found in 28 per cent of girls aged 11 to 18 years [20]. The proportion with RBC folate concentrations indicating increased risk of biochemical folate insufficiency, as defined by the estimated range within which the threshold lies (450 to 550nmol/L) was between 72 per cent and 86 per cent of girls aged 11 to 18 years. Serum folate concentration below the WHO clinical threshold indicating possible deficiency (13nmol/L) was found in 73 per cent of girls aged 11 to 18 years; this includes 12 per cent of girls aged 11 to 18 years, who had a serum folate concentration below the WHO clinical threshold for folate deficiency (7nmol/L).

These data suggest that as many as nine out of ten 11-18 year old girls are at risk of having an infant with a Neural Tube Defect (NTD) should they become pregnant. The Department of Health recommends a 400 microgram daily folic acid supplement when planning a pregnancy through to the end of the first trimester of pregnancy yet not all pregnancies are planned, particularly in teenage girls.

Low vitamin D levels are of concern across the UK population. Whilst it was once assumed that people could store sufficient vitamin D during the summer to have enough through the winter, during January to March, 25 per cent of girls aged 4-10 and 34 per cent aged 11-18 had a 25-hydroxyvitamin D (25-OHD) concentration below the threshold of 25nmol/L. This is the concentration below which risk of vitamin D deficiency and impact on musculoskeletal health increases [21]. During April-June the proportion below the threshold decreased to 10 per cent of girls aged 4-10 and 20 per cent of girls aged 11 to 18 years. During July to September 8 per cent of girls aged 11-18 had vitamin D below the threshold and this figure increased to 25 per cent between October to December.

Public Health England (PHE) recommends everyone needs the equivalent of 10 microgram daily of vitamin D. Vitamin D is found in few foods (e.g., oily fish, fortified cereals, fortified margarine, milk) and the main source is sunlight exposure on the skin. Given the lack of sunlight in the darker months of the year, PHE recommends that a 10 microgram vitamin D supplement should be considered for everyone over the age of 4 (with specific recommendations for infants and younger children) especially in the autumn and winter and throughout the year for those who do not go outside and/or who cover their skin.

Minerals

The NDNS-RP also reports worryingly low intakes of minerals and trace elements in young women. More than half (54 per cent) of 11-18 year old women have intakes of iron below the LRNI [20]. Iron requirements in females of reproductive age are relatively high compared with those of men and older women due to menstruation. Iron intakes have also fallen since when the NDNS-RP began. The largest yearly reduction was seen in girls aged 4 to 10 years (0.2 mg/day, CI 0.1, 0.2). There was a statistically significant increase of 2 (CI 0, 3) and 1 (CI 0, 2) percentage points in the proportion with iron intakes below the LRNI for girls aged 11 to 18 years [11].

For zinc, 27 per cent of girls aged 11-18 and 14 per cent of those aged 4-10 have intakes of zinc below the LRNI. A significant average yearly reduction in zinc intake of 0.1mg/day was observed in girls aged 4 to 10 years since 2008 [11]. More than a fifth of 11-18 year old girls have intakes of calcium below the LRNI whilst for magnesium the figure is exactly half (50 per cent), for potassium 38 per cent, for iodine 27 per cent and for selenium 45 per cent [11]. Several minerals, most notably calcium and magnesium, and also vitamin D, are required in sufficient amounts for the accrual of peak Bone Mineral Density (BMD), suggesting these low levels of minerals and trace elements could prejudice bone health.

Links between Nutrition and Selected Health Issues in Young Females

Unhealthy Weight Control Behaviours

Factors in young women that can exacerbate low nutrient intakes and poor health include dieting, unhealthy and extreme weight control behaviours and uncontrolled binge eating. Studies have found that these dietary behaviours are high in young women. In a US study, more than half of young women (55 per cent) and 59 per cent of young adult women were found to practice general dieting behaviour with similar proportions practicing unhealthy weight control behaviours with around one fifth practicing extreme weight control behaviours by the time of young adulthood [22]. In a further US study, only one third of young adults made no effort to control weight and girls or young women were more likely than boys or men to engage in diet pill use, vomiting after meals and laxative misuse [23]. In a Norwegian cross-sectional study among 27, 252 women, 11 per cent of women < 30 years of age reported disordered eating [24]. An Italian study reported disordered eating and attitudes in a third of adolescent females [25]. More recently a US cross-sectional, school-based study reported that unhealthy dietary behaviour remains persistently high and is highest in young females (22.7 per cent) compared with 10.1 per cent in young males [26].

Oral contraceptives

Oral contraceptives are a major class of prescription drug used by a large proportion of women from adolescence through to the end of the menopause. Data since the 1970s indicate that oral contraceptives induce depletions of nutrients including folic acid, vitamins B2, B6, B12, vitamin C and E and the minerals magnesium, selenium and zinc. Thus, the possibility to prevent vitamin and mineral deficiencies through the intake of appropriate dietary supplements should be considered as a first line approach. The ideal dietary supplement would contain vitamins of the B complex together with folic acid, vitamin E and C as well as minerals such as magnesium, zinc and selenium [27].

Combined Oral Contraceptives (COCs), to which adolescent exposure appears to be increasing, may interfere with Bone Mineral Density (BMD) accrual due to the presence of exogenous oestrogen in the pill. A meta-analysis of nine retrospective case-control studies found evidence of impairment of peak BMD in the lumbar spine in adolescents using COCs compared with controls [28]. Controlled trials are needed to evaluate this potential public health problem, and whether increased calcium via supplements could play a role.

Preliminary evidence also indicates that LC-omega-3 PUFA status may be altered in women taking oral contraceptives. In a cross-sectional German study, women taking hormonal contraceptives showed a lower eicosapentaenoic acid (EPA) level (p<0.001), a lower ratio of EPA/alpha-linoleic acid (p<0.001) and a higher ratio of docosahexaenoic acid (DHA) /EPA (p<0.001) than women without hormonal contraception [29].

The Menstrual Cycle and Pre-Menstrual Syndrome

The menstrual cycle, particularly Pre-Menstrual Syndrome (PMS) appears to be related to several nutritional factors, including lower intakes of calcium, magnesium, vitamin B6 and dietary fibre, especially in young women [30, 31]. A systematic review of 28 studies found that low serum levels of calcium and vitamin D during the luteal phase of the menstrual cycle caused or exacerbated the symptoms of PMS [32]. Oral calcium supplementation has been demonstrated to reduce the symptoms of PMS in young women [33,34] and menstrual pain intensity [35]. A systematic review found that vitamin D supplementation was effective in ameliorating PMS symptoms based upon findings from interventional studies [36]. Vitamin B1 (thiamine) has been found to reduce mental and physical symptoms of PMS possibly through affecting the performance of coenzymes in the metabolism of carbohydrates [37].

Heavy menstrual bleeding is a common but often under-recognised cause of iron deficiency anaemia and, indeed severe anaemia, in adolescent girls [38].

Endometriosis

Endometriosis is a hormone-dependent chronic inflammatory disease characterized by the presence of endometrium beyond the uterine cavity. The disease affects 5-15 per cent of women of child-bearing age, 30-50 per cent of whom suffer from infertility. Existing studies concerning nutrition and endometriosis suggest that diet is a potentially modifiable risk factor for endometriosis. Fruits and vegetables, fish oils, dairy products rich in calcium and vitamin D, and omega-3 fatty acids are likely connected with a lower risk of developing endometriosis [39]. A retrospective case-control study in 156 women with endometriosis and 50 controls found significantly lower intakes of vitamin C, B12 and magnesium in those with endometriosis [40]. Although this is preliminary work the suggestion is made that nutritional intervention might reduce the burden of this disease [40].

Fertility

Nutrition is also linked to fertility in women. Intake of supplemental folic acid and long chain omega 3 fatty acids have been related to lower frequency of infertility [41]. Higher intake of supplemental folic acid, vitamin B12, vitamin D, low- rather than high-pesticide residue produce, whole grains, dairy, soy foods, and seafood has been linked to improved outcomes in assisted reproduction [42]. Some evidence suggests that vitamin D might influence reproductive processes. A systematic review concludes that in women undergoing in-vitro fertilisation, a sufficient vitamin D level (≥30 ng/ml) should be obtained [43]. Vitamin D might protect against two of the common causes of infertility in women-endometriosis (see also above) and Polycystic Ovarian Syndrome (PCOS) [43]. Vitamin D supplementation might also improve metabolic parameters in women with Polycystic Ovary Syndrome (PCOS) [44].

Pregnancy

With regard to pregnancy, adolescents who are still growing are at greater than normal risk of having Low Birthweight (LBW) babies. Birthweight is regarded as one of the best indicators of overall nutritional status of the infant and its well-being, with low birthweight linked with infant mortality, and long-term morbidity, including deficits in growth and cognitive development in childhood and diabetes and heart disease in adult life. Even when the weight gain of a pregnant adolescent is sufficient to ensure adequate fat stores, they do not appear to mobilise these stores to enhance foetal growth in late pregnancy. Consequently, their nutritional requirements are greater. Low serum levels of selenium [45], iron [46] and copper [47] in early pregnancy may be considered to be risk markers for pregnancy-induced hypertension.

One positive potential nutritional impact on birthweight is a diet rich in long-chain omega-3 polyunsaturated fatty acids

(LC-omega-3 PUFAs) and randomised controlled trials have shown an increase in gestation (6 days) with LC omega-3 PUFAs supplements. A Cochrane review of 70 RCTs involving 19,927 women found that preterm birth <37 weeks and early preterm birth <34 weeks and risk of LBW babies were reduced in women receiving omega-3 LCPUFAs compared with no omega-3. There was a possibly reduced risk of perinatal death and of neonatal care admission [48]. Brain tissue is rich in omega-3s, particularly DHA. Some evidence suggests an association between low levels of DHA and foetal neurodevelopment [49] and that maternal concentration of LC-omega-3 fatty acids during pregnancy might be important for later cognitive development in the child [50]. That 11-18 year old girls are consuming on average 21g oily fish each week compared with the recommended weekly portion of 140g is of significant concern should pregnancy occur.

Skin Health and Acne

Several vitamins have a role in maintaining skin health and acne, which is a skin condition occurring mainly in adolescence and young adulthood that has often been studied for dietary connections, with some evidence of benefit for a low glycaemic diet. Vitamin D has also been implicated in acne and a trial in 80 people with acne and 80 controls found that vitamin D deficiency was more frequent in patients with acne, and serum 25(OH)D levels were inversely correlated with acne severity, especially in patients with inflammatory lesions [51]. Evidence is not however consistent, [52] but a recent 3-month clinical trial in 100 people with acne again found low levels of serum 25(OH)D levels in those with acne and administration of the prescription vitamin D medication, alfacalcidol (0.25 micrograms daily), showed reduced levels of inflammatory mediators (IL-6 and TNFα), suggesting that alfacalcidol might have a beneficial impact in the treatment of acne [53].

Women Aged 19-64

Nutrition is important for women throughout the lifespan and there are particular nutrition-health relationships that arise for women from the third to the seventh decade, which include the age of 16-49 years when pregnancy is most likely, and the menopause which occurs on average at the age of 51 but can occur as early as the 30s or as late as the 60s.

Women in this age group have many of the nutritional and health needs of their younger counterparts as well as those of older women, in particular the need to maintain a healthy body weight and ensure sufficient intake of all micronutrients, dietary fibre and LC-omega-3 PUFAs whilst avoiding excessive intakes of saturated fatty acids, trans fatty acids, free sugars and salt to reduce the risk of nutrition-related health issues in later life. Women in this age group often face challenges related to changes in family and work related roles, economic stability and health status leading to stress, lack of sleep and anxiety and depression. Work stress may reduce the quality of the diet, [54] and work-family conflict has been linked to unhealthy eating [55].

In this section, data on obesity, health and health risks for adult women, which are taken from the Health Survey for England cover women aged 16-75 plus, whereas data on nutrient intakes, which are derived from the NDNS-RP, cover women aged 19-64 years. Whilst many of the nutritional impacts on health relating to younger women (see above) are also pertinent to this age group, this section focuses on additional nutritional links with health, such as the menopause, which specifically impact women of 19-64 years.

Obesity

Being overweight or obese is associated with an increased risk of a number of common diseases and causes of premature death, such as diabetes, cardiovascular disease and some cancers, [56,57] including endometrial cancer, [58] post-menopausal breast cancer, [59,60] and survival from pre-and post-menopausal breast cancer [61]. For women with excess weight, the risk of poor health increases sharply with increasing Body Mass Index (BMI) [62].

According to the Health Survey for England 2018 in adults (which evaluates individuals from the age of 16 to 75 plus), 60 per cent of adult women are overweight (Body Mass Index 25-<30) or obese, including 30 per cent who were obese BMI>30) [12]. Four per cent of women were morbidly obese (BMI>40). The proportion of adult women who are obese or overweight increases with age with the highest obesity in women aged 55-64 (37 per cent).

More than obesity per se, central obesity is associated with risk of cardiometabolic disease. Almost half of adult women (48 per cent) had a very high waist circumference (>80 cm) and a further 20 per cent had a high waist circumference (80-88 cm). In the HSE 2018, diabetes prevalence was associated with central obesity, measured by waist circumference. Almost one in 10 (9 per cent) of women with a very high waist circumference (>88 cm) had either diagnosed or undiagnosed diabetes. This compared to 2 per cent of women with high waist circumferences (80-88 cm) and 1 per cent of women with a desirable waist circumference (<80 cm).

Taking into account measures of BMI and waist circumference together, 58 per cent of adult women were at increased, high or very high risk of chronic disease. Women were more likely than men to be in the high or very high risk categories (46 per cent and 35 per cent respectively).

Obesity in Pregnancy and Mothers

More women are obese during pregnancy than a decade ago. A Scottish study presented at the European Congress on Obesity in Glasgow in 2018 found that the proportion of pregnant women with obesity doubled from 22 per cent in 2010 to 44 per cent in

2018 [63]. Obesity in pregnancy substantially increases the risk of maternal complications [64] such as gestational diabetes, pre-eclampsia, and miscarriage and the number of pregnant women having a caesarean section is one in four with a normal BMI compared with one in two with morbid obesity (BMI>40).

Obesity in women who are mothers is linked with obesity in their children. Obesity and overweight is most common in children (26 and 58 per cent respectively) with obese mothers, a difference more pronounced among girls than boys.

Diets

Fruit and Vegetables

Women aged 19-64 consume on average 4.2 portions of fruit and vegetables each day with only 32 per cent eating the recommended five or more portions of fruit and vegetables a day (Table 1) [20]. Interestingly, in a cross-sectional study of the NDNS data in 19-64 year olds (women and men) long sleepers (>8 hours a day) and short sleepers (<7 hours a day) consumed less total fruit and vegetable than those who slept 7-8 hours [65].

Fibre

The picture for dietary fibre intake is similarly worrying. Mean intake of AOAC dietary fibre was 20.7 g and only 4 per cent met the 30 g daily SACN AOAC fibre recommendation [20]. A 2019 review paper [66] which revisits Denis Burkitt's hypothesis (developed from his fieldwork in Uganda in the 1960s) that middle aged people (aged 40-60) in England have higher incidence of diseases such as colon cancer, diverticulitis, appendicitis, hernias, varicose veins, diabetes, atherosclerosis, and asthma due to low fibre intake, demonstrates that epidemiological data over time. This confirms that low fibre increases the risk of colon, liver, and breast cancer and increases all cancer mortality and death from cardiovascular, infectious, and respiratory diseases, diabetes, and all non-cardiovascular, non-cancer causes. What has developed over time is the knowledge from mechanistic studies which have now provided molecular explanations for these associations. These are typified by the role of short-chain fatty acids and products of fibre fermentation in the colon in suppressing colonic mucosal inflammation and carcinogenesis. Evidence suggests that short-chain fatty acids can affect the gut microbiome (the totality of microorganisms, bacteria, viruses, protozoa, and fungi, and their collective genetic material present in the gastrointestinal tract) through metabolic regulatory receptors in distant organs. This can potentially reduce obesity, diabetes, atherosclerosis, allergy, and cancer [66], as well as promoting gastrointestinal health, reducing constipation andadding other additional benefits.

Free Sugars

Mean intake of free sugars in women aged 19-64 was 11.6 per cent of dietary energy and exceeded government guidelines

that intake should not exceed 5 per cent of energy. Only 13 per cent of women in this age group had an intake of free sugars at or below 5 per cent of dietary energy.

Oily Fish and Long Chain Omega-3 PUFAS

Oily fish intake was also low in this group of women, averaging 56g each week compared with the recommended intake of 140g each week. Oily fish is the main source of LC-omega-3 PUFAs. Long chain omega-3 PUFAs – Eicosapentaenoic Acid (EPA) and Docosahexaenoic Acid (DHA) are widely regarded as cardioprotective [67]. In a cross-sectional study, low LC n-3 PUFA status in middle-aged German women (40-60 years) was related to an increased risk of cardiovascular diseases [29]. LC omega-3s benefit cardiovascular risk factors including blood pressure, blood vessel function, heart function and blood lipids, as well as having antithrombotic, anti-inflammatory and anti-oxidative actions [7].

Omega-3s are a major component of nerve cell membranes, regulating neurotransmission and neuroinflammation, and they are of importance for brain health across the lifespan in facets of brain development, function and ageing. Of note is that these processes are altered in various conditions such as depression and dementia. Low intakes of LC-omega-3s have been linked to depression and dietary supplementation with omega-3 fatty acids rich in EPA during pregnancy or postpartum has been shown to reduce some symptoms associated with depression. DHA supplementation to healthy pregnant women can also reduce the risk of post-partum depression [68], although other research has shown no benefit of supplementation in maternal depression throughout pregnancy [69]. Studies on the impact of omega-3 supplementation in overall depression have been conflicting, but there is mounting evidence that they may play a role and warrant greater research efforts.

Omega-3 fatty acids have been subject to intensive study in cognitive health and decline. Higher intakes of marine omega-3s have been associated with reduced risk of dementia and Alzheimer's disease [70,71]. (See also section on women over 65 years).

Human and animal studies have highlighted the ability of omega-3 PUFAs to influence the gut-brain axis, acting through gut microbiota composition with emerging evidence that omega-3s may be able to exert a positive impact on the gut microbiota and increase the production of anti-inflammatory compounds which could - results from clinical trials pending - contribute to the maintenance of gut health, ensuring intestinal wall integrity and the reduction of gastrointestinal diseases such as irritable bowel [72,73]. Interestingly the gut microbiota has also been linked with cognitive function [74] with research in animal models suggesting the concept of a gut-brain regulation of cognitive function in which omega-3 fatty acids might contribute as well as paving the way for new research into identifying new mechanisms and new approaches in the management of dementia.

Health

Between 1993 and 2018, the proportion of adult women (16-75 plus) reporting very good and good general health in the HSE fluctuated between 73 per cent and 76 per cent [75]. In 2018, 17 per cent of women (compared with 12 per cent of men) reported acute sickness (defined as any illness or injury (including any longstanding condition) that has caused the participant to cut down in the last two weeks on things they usually did).

Chronic illness

Prevalence of longstanding illness was higher in women (45 per cent) than men (40 per cent) [76]. This was true for a number of types of conditions, including musculoskeletal conditions; mental, behavioural and neurodevelopmental conditions; diabetes and other endocrine and metabolic conditions; digestive system conditions; nervous system conditions; and genito-urinary conditions. Heart and circulatory conditions were less commonly reported by women (10 per cent of women 12 per cent of men). Anxiety and depression was reported by 35 per cent of women (compared with 30 per cent for men) [75].

The number of longstanding conditions increases with age. Overall the proportion of women with long-standing conditions increased from 25 per cent amongst 16-24 year olds to 74 per cent amongst women of 85 and over. Under the age of 45, the most common type of longstanding conditions amongst women were mental, behavioural and neurodevelopmental conditions, followed by musculoskeletal and respiratory conditions. From the age of 45, musculoskeletal conditions were most common, followed by heart and circulatory conditions, then diabetes and other endocrine and metabolic conditions [76].

Most longstanding conditions are managed in the community, but some require hospital stays, or domiciliary or residential care. People with long term conditions account for 50 per cent of NHS GP appointments, 64 per cent of outpatient visits, and 70 per cent of inpatient bed stays. Seventy per cent of the total health budget is spent on those with long-term conditions [77].

Pain

In the HSE 2018, 48 per cent of women reported pain or discomfort (compared with 30 per cent of men), and pain increased with age from 20 per cent in 16-24 year old women to 40 per cent in 35-55 year old women to over 50 per cent in women over the age of 65. Chronic pain has far-reaching consequences for its sufferers, including a lower quality of life, impacts on mental health, job losses, and can limit daily activities [78,79]. It is estimated that there are almost five million GP appointments in UK each year due to chronic pain [80], with back-pain alone thought to cost the economy around £12.3 billion per year [78].

Migraine

Migraine is a disabling condition that affects three times as many women as men, so possibly linked to hormonal factors, with a reported prevalence in women of 5-25 per cent [81]. Deficiency of nutrients including magnesium, niacin, riboflavin, vitamin B12 and vitamin D, have been associated with migraine [82]. Due to potential side effects of medication, the use of nutrient supplements has been proposed, a suggestion which requires evidence from interventional trials.

Diabetes

Diabetes is characterised by high blood glucose levels (hyperglycaemia). Untreated, hyperglycaemia is associated with damage and possible failure of many organs, especially the eyes, kidneys, nerves, heart, and blood vessels. Diabetes substantially increases the risk of Cardiovascular Disease (CVD) [83], and tends to worsen the effect of other risk factors for CVD such as dyslipidaemia (abnormal levels of blood fats), hypertension, smoking and obesity. Being overweight or having a very high waist measurement are risk factors for Type 2 diabetes [84], findings which were confirmed in the HSE (2018) in which a total of 7 per cent of adult women had diabetes (5 per cent diagnosed, 2 per cent undiagnosed). Diabetes was associated with BMI status (12 per cent of obese women had diabetes, compared with 6 per cent overweight and 2 per cent not overweight) and central obesity in that 10 per cent of women with a very high waist circumference, 3 per cent with a high waist circumference and 4 per cent with a desirable waist circumference had diabetes.

Increased risk of cardiometabolic disease, including Type 2 Diabetes occurs at lower BMI in Asian women than in white women [85]. In the HSE 2018, 88 per cent of Black women, and 73 per cent of Asian women were at increased or high risk, compared with 58 per cent of White women and 55 per cent of women from mixed ethnic backgrounds. In Black and Asian groups, women were more likely than men to be at high risk.

Health Risks

Risk factors such as cigarette smoking, heavy alcohol consumption, physical inactivity, having a diet low in fruit and vegetables, and obesity are leading modifiable causes of Non-Communicable Diseases (NCDs) worldwide. Elevated levels of factors such as raised blood pressure, cholesterol and blood sugar are leading risk factors for heart and stroke in women as well as men.

Smoking

Smoking has fallen significantly. The proportion of women who weSmoking has fallen significantly. The proportion of women who were current smokers decreased from 26 per cent in 1993 to

15 per cent in 2017, while the proportion who had never regularly smoked increased from 52 per cent to 61 per cent in the same period [86].

Alcohol

In 2017, 79 per cent of women had drunk alcohol in the last 12 months and the proportions of non-drinkers were highest in the youngest and oldest age groups. A total of 42 per cent of women usually drank alcohol at least once a week or more often. Whilst 64 per cent of women drank at levels which put them at lower risk of alcohol-related harm, (i.e., 14 units or less in the last week), 14 per cent of women drank over 14 units. The proportion of women usually drinking over 14 units in a week varied across age groups and was most common among women aged 55 to 64 (20 per cent). Proportions of women drinking at these levels then declined from the age of 65 [86].

High cholesterol

High cholesterol is considered one of the risk factors for cardiovascular diseases, including narrowing of the arteries (atherosclerosis), heart attack, and stroke. In 2017, 50 per cent of adult women had raised cholesterol (cholesterol equal to or greater than 5mmol/L. The proportion of women with raised cholesterol increases with age up to 65 from 29 per cent in 25-34 year olds, to 40 per cent in 35-44 year olds, 69 per cent in 45-54 year olds and 76 per cent in 55-64 year olds, but falls after the age of 65 to 62 per cent in 65-74 year old women and 51 per cent in women over 75.

Of note is that the proportion of women with raised cholesterol is lower up to the age of 45 than that in men of the same age, whilst after the age of 55 years the proportion of women with raised cholesterol is higher (69 per cent vs 62 per cent in women and men respectively aged 45-54); (76 per cent vs 58 per cent in women and men respectively aged 55-64); (62 per cent vs 40 per cent in women and men respectively aged 65-74); (51 per cent vs 26 per cent in women and men aged 75 and over) [87].

Hypertension

In 2017, the prevalence of hypertension, a risk factor for cardiovascular disease, particularly stroke) in women was 25 per cent (including 11 per cent with untreated hypertension). High systolic blood pressure increased more steeply with age for women than men. One per cent of women aged 25 to 34 had systolic blood pressure of 140 mmHg or above, rising to 39 per cent of women aged 75 and over; among men these proportions were 10 per cent and 31 per cent respectively [87].

Multiple Risk Factors

Adult women in the UK have multiple risk factors for health. Addressing multiple risks is important from a public health perspective as evidence suggests that the combination of risks is more detrimental to people's health than can be expected from the added individual risks alone. In the Health Survey for England (2016-17) among the health risk factors measured (reported current cigarette smoking, above recommended alcohol consumption, below recommended fruit and vegetable consumption, physical inactivity and obesity) only 13 per cent of women had no risk factors [86]. Almost half (47 per cent) had two or more risks and 17 per cent had three or more risks. Overall, 38 per cent of women had only one risk factor.

The most prevalent single risk was consuming fewer than the recommended five portions of fruit and vegetables per day (26 per cent of women). Other common single risks were obesity (5 per cent of women) and drinking more than 14 units of alcohol a week (3 per cent of women). Almost a third (31 per cent) of women had two risk factors. The most common combination of two risks among women was consuming fewer than five portions of fruit and vegetables per day and being obese (10 per cent). Overall, 14 per cent of women had three risks and 5 per cent of women exhibited the three risks of low fruit and vegetable consumption, inactivity, and obesity.

Micronutrients (Vitamins and Minerals)

Vitamins

The NDNS-RP shows that low micronutrient intakes resulting from poor diets are prevalent in women aged 19-64. One in 10 have a vitamin A intake below the LRNI, a figure that has doubled in this age group of women since 2008, and 14 per cent have a riboflavin intake below the LRNI.

A total of 6 per cent have an intake of folate below the LRNI, a figure that has changed little since 2008. A total of 57 per cent of women specifically of childbearing age (16-49 years) had a serum folate concentration below the clinical threshold indicating possible folate deficiency (13nmol/L), including 15 per cent who had a serum folate concentration below the WHO clinical threshold for folate deficiency (7nmol/L). Between 36 and 63 per cent of women in this age group had a serum folate concentration indicating increased risk of biochemical folate insufficiency, as defined by the estimated range within which the threshold lies (10-15nmol/L). During the nine years of the NDNS-RP, the percentage of women of childbearing age (16 to 49 years) with serum folate concentration below 13nmol/L increased significantly by 3 percentage points (CI 2, 5) per year, an overall increase of 31 percentage points over the 9 years.

Red Blood Cell (RBC) folate concentration below the WHO clinical threshold indicating risk of anaemia (305nmol/L) was found in 16 per cent of women of childbearing age (16 to 49 years). Between 60 and 74 per cent of women in the same age range had RBC folate concentrations indicating increased risk of biochemical folate insufficiency, as defined by the estimated range within which the threshold lies (450 to 550nmol/L), whilst 91 per

cent had a RBC folate concentration below the threshold indicating elevated risk of Neural Tube Defects (NTDs) (748nmol/L).

Given that more than nine out of 10 women of childbearing age (91 percent) had a RBC folate concentration below the threshold indicating elevated risk of NTDs (748nmol/L), it is of significant concern that two thirds of women in the UK are not taking a folic acid supplement before pregnancy [88]. A UK study found that the proportion of women taking folic acid supplements before pregnancy declined from 35 per cent in 1999-2001 to 31 per cent in 2011-2012. Just six per cent of women aged under 20 took folic acid supplements before pregnancy compared with 40 per cent of women aged between 35 and 39 [88].

Minerals

Low intakes of minerals are also of concern in this age group of women and have not improved since 2008, in some cases worsening with time. More than one quarter (27 percent) of women aged 19-64 have intakes of iron below the LRNI, a level at which the risk of deficiency, and as a consequence, iron deficiency anaemia, increases. Since 2008, there was a statistically significant increase of one percentage point in the proportion of adult women with iron intakes below the LRNI [11]. Red meat is a source of highly bioavailable haem iron and reductions in iron intake appear to coincide with reduced meat intakes. For example, mean intakes of red and processed meat in women aged 19 to 64 declined from 58 g/d in 2008 to 47 g/d by the period during which the proportion of women in that age group with iron intakes below the LRNI increased for 21 to 27 percent. Plant-based sources of iron (pulses, grains, vegetables etc.) contain iron, but in a less bioavailable form than the iron in meat. Where red meat is being reduced a general lack of nutrition knowledge may result in alternative sources of iron not being included.

Over the NDNS-RP to date, there was a statistically significant one percentage point increase per year in the proportion of women aged 19 to 64 years with zinc intakes below the LRNI and a total of 8 per cent of women in this group have an intake below the LRNI. Zinc plays a key role in many biochemical processes throughout the body as a part of enzymes; it also plays a part in reproduction and is essential, alongside most other micronutrients for immune function. Red meat makes a particularly good contribution to zinc intakes, in fact a greater contribution to zinc intakes in females than to iron. Reducing meat intake amongst those with lower intakes of zinc as well as those with lower iron intakes could drive up the risk of deficiency of these essential minerals.

More than one in ten women (11 percent) aged 19-64 had a calcium intake below the LRNI, and there was a statistically significant one percentage point increase per year in the proportion of women aged 65 years and over with calcium intakes below the LRNI [11]. Such low intakes are likely to prejudice bone health. The National Institute for Health and Care Excellence (NICE)

recommends calcium (with vitamin D) supplementation in people with low calcium intakes and risk of fragility fractures. Calcium supplementation has been demonstrated to delay the tendency of bone mineral density to decrease after the menopause [89].

A total of 11 per cent of 19-64-year old women had magnesium intakes below the LRNI. Magnesium, alongside calcium, is important for bone health and women failing to meet recommended intakes for magnesium have been shown to have a higher risk of fracture whilst higher magnesium intake has a protective effect on future osteoporotic fractures [90]. Evidence also links magnesium with cardiometabolic health. Low serum concentrations of magnesium have been found in people with various common diabetes complications such as diabetic nephropathy and diabetic retinopathy [91]. Studies have shown that oral magnesium supplementation reduces insulin resistance and improves glycaemic control indicators [92,93] and cardiovascular risk factors [94] among people with type 2 diabetes.

The proportion of women aged 19-64 not achieving the LRNI for iodine has increased from nine to 15 per cent over the nine years of the NDNS-RP. The median urinary iodine for women of childbearing age (16 to 49 years) in Year 7 and 8 (combined) was 102 µg/L with 17 per cent of the population below 50 µg/L. While these values met the WHO criterion for adequate intake for the general population, they do not meet the criterion for iodine sufficiency in pregnant and lactating women (i.e., median urinary iodine concentration within 150-249 µg/L). Given the crucial importance of iodine for the growing foetus these low iodine intakes in women of reproductive age are a cause for concern.

Intakes of selenium are also a cause for concern. In the latest iteration of the NNDS-RP, 46 per cent of 19-64-year-old had selenium intakes below the LRNI [20]. Women aged 19 to 64 years showed an average decrease of one percentage point per year in the proportion with selenium intake below the LRNI [11]. Selenium is essential for immune function [95] and thyroid function [96]. Reductions in selenium intakes and status have been linked to the replacement of milled wheat grown on selenium rich North American soils with UK-sourced wheat having low grain levels of selenium due to it being grown on low selenium soils.

Links between Nutrition and Selected Health Issues in Adult Women (19-64 Years)

Reproductive Health

Poor nutrition can have a variety of health consequences for this age group, as for all age groups, of women. For those of reproductive age, poor nutrition also potentially impacts on the health of the next generation. Evidence suggests that early nutritional status during foetal and infant life (as indicated by low birthweight and other parameters) modifies the risk of disease (notably cardiovascular) in later life [97]. Evidence shows that

air pollution-to which many women are exposed throughout life - can also increase the risk of low birthweight babies [98] and accelerated biological ageing in the new born [98].

Adult women, like younger woman and girls, as well as older women, benefit from a diet and lifestyle that maintains a healthy weight, a diet that is healthy with plenty of fruit and vegetables, wholegrains, and moderate amounts of lean protein (lean meat, fish, eggs, legumes), dairy or alternatives, and nuts and seeds. This analysis has shown that very few women appear to consume such a diet, which is to the detriment of their overall health, including their heart health, brain health, bone health and digestive health. Good nutrition is essential for reproductive health and the health of the next generation. That so few women take the recommended folic acid supplements and have such poor folate status is worrying.

Stress

Additionally many women in this age range are juggling multiple roles in our increasingly complex society and experiencing psychological stress, poor sleep, anxiety and depression. Such stress can also further compromise healthy eating habits with impacts for nutrition. A systematic review of 14 randomised controlled trials found that essential fatty acids may be effective in reducing pre-natal stress and may reduce anxiety during pre-menstrual syndrome and during menopause. In the same research, magnesium and vitamin B6 may be effective in combination in reducing premenstrual stress, and vitamin B6 alone may reduce anxiety effectively in older women. High-dose sustained-release vitamin C may reduce anxiety and mitigate increased blood pressure in response to stress [99].

Gastrointestinal Disorders

Gastrointestinal disorders such as constipation and Irritable Bowel Syndrome (IBS) are more common in women than men, with pregnancy also known to increase the risk of constipation. IBS tends to appear between the age of 20 and 30. Whilst the cause of IBS is often unknown and the most effective treatment for each individual unclear, fibre, particular soluble fibre, with plenty of daily fluid is often recommended where constipation is the main presenting gastrointestinal symptom. (IBS can also cause a range of symptoms such as tiredness, headaches, indigestion, back pain, feeling sick).

Evidence suggests that disturbance of the gut microbiota (gut flora) characterised by a reduction in Bifidobacteria may be implicated in IBS [100]. Probiotic supplementation trials [100-102] suggest intentional modulation of the gut microbiota may be effective in treating IBS. A smaller number of prebiotic supplementation studies have also demonstrated effectiveness in IBS whilst increasing Bifidobacteria. Interestingly the low FODMAP (low fermentable oligosaccharides, disaccharides, monosaccharides and polyols) diet, which reduces Bifidobacteria,

is also used to treat IBS [100], indicating, not surprisingly that different management approaches are required for different individuals.

Adults with constipation have significantly decreased numbers of Bifidobacteria in faecal samples, which may contribute to aberrant gut motility and constipation [103]. Modifying the gastrointestinal environment with certain probiotic strains may affect motility and fluid secretion in the gut and, hence, provide a benefit for patients with constipation. Preliminary clinical trial evidence [104] suggests a specific prebiotic could affect alterations in gut microbiota composition, including a decrease in Firmicutes and an increase in butyrate-producing bacteria, which could contribute to reduction in symptoms of constipation [104].

Menopause

The menopause, which occurs at an average age of 51 years, can be a challenging, but also liberating transition for women. Symptoms such as hot flushes, poor sleep and poor mental health can be managed partly by lifestyle changes, including attention to nutrition, and/or prescription medication (e.g., Hormone Replacement Therapy-HRT).

Not all women want to take HRT and natural approaches, including herbal remedies, are becoming increasingly popular. St John's wort has shown benefit in mild to moderate depression [105] and in vasomotor symptoms of postmenopausal women [106]. Evidence is emerging for *Rhodiola rosea* as a possible antidepressant [107,108]. *Gingko biloba* has shown some-albeit limited – cognitive benefits in post-menopausal women [109].

Evening primrose oil has often been used for menopausal symptoms and a 6-week randomised controlled trial in 56 menopausal women found that evening primrose oil improved intensity of hot flush attacks and improved quality of daily life [110]. *Foeniculum vulgare* (fennel) can be an effective treatment for menopausal symptoms [111] and for anxiety and depression in menopausal women [112]. Valerian is an herb traditionally used for anxiety and sleep disorders with some preliminary evidence for treating menopausal hot flushes [113]. Isoflavones from red clover have been reported to reduce hot flushes [114] with evidence of safety in short-term use but insufficient data to determine safety in longer term use. Black cohosh is also used by women experiencing hot flushes with meta-analysis evidence from controlled trials supporting its use [115]. In a recent trial involving 80 post-menopausal women with hot flushes, black cohosh was found to be as effective as evening primrose in reducing severity of hot flushes [116], and also appears to improve sleep quality [117].

Nutrition can impact on the age at which the menopause occurs. In the UK Women's Cohort Study, a high intake of oily fish and fresh legumes were associated with delayed onset of natural menopause by 3.3 years per portion/day (99% CI 0.8 to 5.8) and

0.9 years per portion/day (99% CI 0.0 to 1.8), respectively. Refined pasta and rice was associated with earlier menopause (per portion/day: -1.5 years, 99% CI -2.8 to -0.2). A higher intake of vitamin B6 (per mg/day: 0.6 years, 99% CI 0.1 to 1.2) and zinc (per mg/day: 0.3 years, 99% CI -0.0 to 0.6) was also associated with later age at menopause [118]. Given that retaining the protective effects of oestrogen (before the menopause) for as long as possible is likely important for women's health, including cardiovascular, mental and bone health, poor diets in women of this age, including low intakes of oily fish omega-3s is a concern.

Women Over 65 Years

People over 65 years are the fastest growing group in the UK population. Of the 11.9 million people over 65 in the UK, 55 per cent are women, a population that is becoming increasingly diverse. Some women in this age group are working, some are caring for their children, grandchildren and older relatives, whilst some are pursuing new vocations and interests.

Health trajectories in this group of women are, moreover, highly variable. Whilst changes in organ system function, physical performance and body composition occur in all women as they age, wide variations exist in the degree to which functions decline – both between individuals and in the same individual. As women become older, the more dissimilar they become from their contemporaries of the same chronological age.

Ageing is a multifactorial process with genetic factors, and also lifelong accumulation of a wide variety of molecular and cellular changes, some of which are determined by lifestyle and some by environmental factors, right across the lifespan, making a contribution to how women age. Healthy lifestyle behaviours (for instance, never smoking, moderate alcohol consumption, physical activity and daily consumption of fruits and vegetables) have all been associated with better health outcomes in later life (e.g., successful ageing, increases in lifespan and years spent in good health, a reduced risk of mortality and lowered risk of poor cognitive function) [119,120].

Increasing research is showing that good nutrition plays a role in healthy ageing. Of the 20 leading risk factors for chronic disease, disability and death, a number are nutrition related and may increase the risk of, amongst other conditions, cardiovascular disease, type 2 diabetes, osteoporosis, Alzheimer's disease and certain types of cancer.

In this section, data on obesity are taken from the Health Survey for England cover women aged 16-75 plus, whereas data on nutrient intakes, which are derived from the NDNS-RP, covers women aged over 65 years. Whilst many of the nutritional impacts on health relating to younger women (see above) are also pertinent to this age group, this section focuses on additional nutritional links with health, such as bone health, brain health, cardiovascular health, which, with origins often from younger ages, specifically impact women over 65 years.

Obesity

Overweight and obesity increases in both women and men with age. The 2018 HSE shows that amongst older women, overweight and obesity is highest in those aged between 65 and 74 (73 percent), whilst 70 per cent of over 75 year old women are overweight or obese [12].

Approximately 84 per cent of older women have a high waist circumference. Amongst 65-74 year old women and women over 75, 64 and 62 per cent respectively have a very high waist circumference [12]. Systematic reviews conducted to determine the effect of an elevated BMI on all-cause mortality risk in women and men over 65 years have concluded that those with overweight (BMI 25-29) do not have increased mortality, whilst a BMI in the obese range is associated with a modest increase in mortality, regardless of sex, disease status and smoking [121,122].

Diets

In some respects, diets of women aged over 65 years do not differ significantly from those of younger women.

Fruit and Vegetables

In the latest iteration of the NDNS (years 7/8) [20], the mean number of portions of fruit and vegetables in women aged 65-74 was 4.2 portions, with only 32 per cent achieving 5-a-day. Mean consumption for women over the age of 75 was 3.2 portions daily, lower than the four portions consumed in this age group in 2008. A total of 30 per cent of women over the age of 75 met the 5-a-day recommendations. There were no significant differences in the proportions of women over 65 meeting the 5 A Day recommendation between Years 7 and 8 (combined) compared with Years 1 and 2 (combined) in 2008/9-2009/10. In the UK Women's Cohort Study, total fruit intake was associated with lower risk of CVD and CHD mortality, with a 6-7% reduction in risk for each 80 g/day portion consumed (99 % CI 0.89, 1.00 and 0.85, 1.01 respectively) [123].

Free Sugars

Intake of free sugars was 10.4 per cent of food energy (higher than the recommended 5 per cent of food energy) in women aged 65-74 and in those over 75.

Fibre

Mean intake of AOAC dietary fibre was 17.4 g in 65-74 year old women and 15.1 g in women over 75 and only 4 per cent met the 30 g daily AOAC fibre recommendation. Meta-analysis studies show that higher dietary fibre intake has been associated with reduced CVD and all-cause mortality [124] and a reduced risk of mortality from CVD and all cancers [125]. In the UK Women's Cohort Study, greater total fibre and fibre from cereals was associated with reduced risk of stroke [126] particularly in overweight women [127].

Oily Fish and Long Chain Omega-3 PUFAS

Amongst women aged 65-74, intake of oily fish, the key source of LC-omega-3 PUFAs was 12 g daily, and in those aged over 75 was 8 g daily, i.e., well below the recommended one portion (140 g) each week. In a meta-analytic review of 10 studies low levels of EPA and DHA were found in people with dementia and low levels of EPA in people with pre-dementia [128]. Potential benefit of omega-3 supplementation in dementia indicates that supplementation may be most beneficial at the time of disease onset [129]. Although some improvements in cognitive scores have been observed in more severe cases [129], overall benefits of supplementation are negligible in people with established Alzheimer's disease.

Micronutrients

Vitamins

Micronutrient intakes are of concern in older women as much as in younger women. A total of 8 per cent of women over 65 had vitamin A intakes below the LRNI, for riboflavin the figure was 10 per cent and for folate 5 per cent.

A total of 5 per cent of women over 65 have a folate intake below the LRNI but red blood cell folate concentration below the WHO clinical threshold indicating risk of anaemia (305nmol/L) was found in 10 per cent of women aged 65 years and over. Serum folate concentration below the WHO clinical threshold indicating possible deficiency (13nmol/L) was found in 27 per cent of women aged 65 years and over [20].

A higher proportion of women aged 75 years and over had intakes below the LRNI compared to women aged 65-74 and also men in both older age groups for most micronutrients. For example, 12 per cent of women aged 75 years and over had intakes below the LRNI for iron and zinc compared with 8 per cent and 3 per cent respectively in women aged 65 to 74 years. A total of 10 per cent of women aged 75 years and over had intakes below the LRNI for vitamin A and 13 per cent for riboflavin. For selenium, 57 per cent of women aged 65 to 74 years and 76 per cent of women aged 75 years and over had intakes below LRNI.

Mean intakes of vitamin D (excluding supplements) were below the RNI in women over 65 with women over 75 being in a worse position than those aged 65-74. Women aged 65-74 had an intake of 35 per cent of the RNI from food whilst for women over 75 the equivalent figure was 28 per cent of the RNI. Inclusion of intakes from dietary supplements brought the mean intake up to 60 per cent and 53 per cent of the RNI for women aged 65 to 74 years and women aged 75 years and over respectively. These low intakes from food are not surprising given that few foods contain vitamin D, but with average intakes across this age group when supplements are included remaining below the RNI pose serious consequences for musculoskeletal health.

Minerals

In women over 65 intakes below the LRNI for minerals and trace elements are no better with estimates showing these to be: for iron (10 percent), calcium (11 percent), magnesium (18 percent), potassium (27 percent), iodine (7 percent), selenium (66 percent) and zinc (7 percent).

Since 2008, for iodine, women aged 65 years and over had a significant average yearly reduction in iodine intake of 3 micrograms/day. The proportion of women of 65 and over not achieving the LRNI for potassium has more than doubled has from 13 to 27 percent. For magnesium, there was an average increase of 1 percentage point per year in the proportion of older women with a magnesium intake below the LRNI and there was an average increase in the proportion with a selenium intake below the LRNI of two percentage points [11].

Links between Nutrition and Selected Health Issues in Women Over 65

Bone health

More than a fifth (21.7 percent) of women over the age of 50 have osteoporosis and 17.2 per cent have a risk of hip fracture [130]. In women over 45 years of age, osteoporosis accounts for more days spent in hospital than many other diseases, including diabetes, myocardial infarction and breast cancer [131].

The protective role of nutrients such as calcium, vitamin D and vitamin K for the integrity of the skeleton is well understood. In addition, integrity of the skeleton is positively influenced by certain trace elements (e.g. zinc, copper, manganese, magnesium, iron, selenium, boron and fluoride) [132].

Individuals with high levels of homocysteine exhibit reduced Bone Mineral Density (BMD), alteration in microarchitecture and increased bone fragility. Given the growing body of evidence linking low bone mineral density and/or increased fracture risk with low B-vitamin status and elevated homocysteine, optimal B-vitamin status may play an important protective role against osteoporosis [133].

Overall, ensuring adequate intakes of vitamins and minerals in older women, which the NNDS shows does not happen, is likely to contribute to bone health. Calcium and vitamin D are an important focus and NICE recommends supplementation for people at risk of fragility fractures. There has been recent interest in the possibility that calcium supplements may increase the risk of Myocardial Infarction (MI) and cardiovascular events. A meta-analysis published in 2010 [134] showed that use of calcium supplements (without vitamin D) was associated with an increased risk of MI and the authors suggested a re-assessment of calcium supplementation in the management of osteoporosis. These conclusions have been criticised on the grounds that data from RCTs

were overemphasised[135] with the Women's Health Initiative Study criticised widely for poor study design and compliance. A subsequent meta-analysis, which included studies with calcium and vitamin D, but excluded studies in men, concluded that these supplements did not increase the risk of cardiovascular outcomes [136].

Brain Health

Women are more likely than men to develop dementia in their lifetimes partly because of their longer life expectancies. A total of 65 per cent of the people in the UK living with dementia are women - equivalent to 618,576 women in January 2020, a figure predicted to rise to 1,308, 244 by January 2051 [137].

Nutrient deficiencies impair brain function and researchers are exploring the impact that long term sub-clinical, moderate nutrient deficiencies can have on memory impairment in older adults. Vitamin D deficiency has been associated with cognitive decline in an older US population [138]. Deficiency of dietary minerals such as calcium, magnesium, and potassium plays an important role in a wide variety of critical cellular processes associated with cognitive impairment and dementia [139]. Reduced ionized free magnesium concentrations have been observed in plasma obtained from Alzheimer's disease patients [140], which were related to cognitive dysfunction severity. Serum magnesium levels have been shown to be inversely associated with Alzheimer's disease severity scales (Global Deterioration Scale and Clinical Dementia Rating), further confirming a potential protective role of magnesium in cognitive function [141].

Polyunsaturated Fatty Acids (PUFAs) are essential components of nerve cells, preserving membrane fluidity for neurotransmitter function. The most widely studied PUFAs with regard to cognitive decline are the omega-3 PUFAs. A systematic review reported data supporting a role for long-chain omega-3 PUFAs in the reduction of cognitive decline in persons without dementia [142].

Studies looking at micronutrient supplements in cognitive decline have shown inconsistent results (see review [143]).One RCT of 900 people aged 60-74 years showed that folic acid and vitamin B12 were significantly superior vs. placebo for improving cognitive tests [144]. In the Canadian Study of Health and Aging, subjects reporting a combined use of vitamin E and C supplements and/or multivitamin consumption at baseline were significantly less likely to experience significant cognitive decline during a 5-year follow-up period [145]. Other trials have shown no improvements possibly because of a lack of detailed understanding of the interactions of micronutrients with molecular mechanisms in the brain possibly affecting their design.

Cardiovascular Health

Cardiovascular health is associated with a number of

risk factors, including lifestyle and nutritional factors, such as dyslipidaemias, hypertension, diabetes, obesity, thrombogenesis (e.g., platelet aggregation and coagulability of the blood), inflammatory markers such as C-reactive protein, impaired foetal nutrition, raised plasma homocysteine levels and antioxidant status. Controversy continues regarding the significance of high homocysteine and the possibility of lowering homocysteine with B vitamins to reduce cardiovascular risk, although there is evidence of benefit for folic acid supplementation in reducing the risk of stroke in people with cardiovascular disease [146].

Controversy also continues with regard to antioxidants. Experimental evidence has clearly demonstrated the potential for antioxidant nutrients) e.g., vitamin E, vitamin C, beta-carotene and flavonoids) to reduce the oxidizability of LDL cholesterol in vitro. Prospective studies have shown a decreasing risk of CHD with increasing intake of these nutrients and flavonoids, which occur in a variety of foods and beverages such as tea, apples, onions and berries. Whilst results from studies evaluating antioxidant vitamins have been inconsistent, higher dietary polyphenol intake has been associated with reduced CVD in post-menopausal women [147], pointing to the potential health benefit of increasing polyphenol intake in this group of women.

Several cardiovascular risk factors including high cholesterol, hypertension, diabetes and obesity, were found amongst adult women in the Heath Survey for England. For example, 50 per cent of adult women had high blood cholesterol, 25 per cent had hypertension, 60 per cent were overweight or obese (amongst whom 30 per cent were obese), 48 per cent had a high waist circumference, 24 per cent a very high waist circumference and 7 per cent had diabetes.

Associations between cardiovascular disease and a number of dietary factors-(e.g., dietary fats, dietary cholesterol and carbohydrates), types of diet (e.g., the DASH Diet and the Mediterranean Diet) and foods (e.g., fruits and vegetables, oily fish, nuts, wholegrains, fibre, legumes, garlic, eggs, red and processed meat) have been intensively studied. Given the below recommended intakes of several vitamins and minerals in the NDNS-RP this paper looks at some of the associations between vitamins and minerals and cardiovascular health.

Increased potassium intake has been shown to reduce both systolic and diastolic blood pressure. However, a total of 27 per cent of women over the age of 65 had a potassium intake below the LRNI (and 23 per cent of women aged 19-64 also had a potassium intake below the LRNI) (Table 3). A meta-analysis of 22 RCTs and 11 cohort studies [148] and a meta-analysis of 23 RCTs [149] found that increased potassium intake and oral potassium supplementation respectively reduced blood pressure in people with hypertension. Research has also demonstrated an interaction between sodium and potassium, indicating a benefit of

reducing the sodium/potassium ratio in the diet. There is an inverse relationship between magnesium intake and blood pressure [150], and a cause effect relationship of supplemental magnesium (mean intake 368mg daily) on blood pressure lowering [151].

A meta-analysis of 16 cohort studies confirmed a well-established inverse association between potassium intake and stroke risk, with potassium intake of 90 mmol (≈3500 mg)/day associated with the lowest risk of stroke [152]. Magnesium has also been found to reduce the risk of stroke. In a systematic review and meta-analysis, high-risk females who had a body mass index (BMI) ≥25 kg/m2 and who were subjected to a ≥12 year follow-up exhibited a greater decrease in relative risk of stroke as a result of magnesium intake [153]. In a Swedish [154] and a US cohort of women [155], both potassium and magnesium intakes were inversely associated with stroke risk.

Omega-3 fatty acids are cardioprotective. These benefits arise from a variety of complex biochemical pathways, including inflammatory mediators, lipid metabolism, cardiac cell membrane chemistry and anti-thrombotic pathways to name a few. Many prospective studies have shown a reduced risk of CHD associated with consumption of fish, particularly oily fish, which are rich sources of LC-omega-3 PUFAs. Overall evidence of omega-3 supplementation in cardiovascular disease is not uniform but the GISSI-Prevenzione [156] and REDUCE-IT [157] have provided support for the clinical benefits of fish, fish oils and omega-3 fatty acids, especially in high risk individuals.

Eye Health

Another link between nutrition and health of particular relevance to older women is eye disease such as cataract and Age Related Macular Degeneration (ARMD). In 2013, 47 per cent of women over 65 (and the same proportion of men) had undergone surgery for cataracts whilst by 2020 approximately 1.8 million people in the UK were expected to have early ARMD and more than half a million to have neovascular ARMD.

Nutrients are associated with both of these conditions with those of interest being vitamins C and E, the carotenoids, lutein and zeaxanthin, zinc and omega-3 fatty acids. There is biological plausibility to support a role of these dietary components in the protection of the lens and the macula from sunlight damage. Low vitamin C is associated with risk in developing cataracts [158]. Dietary vitamin E intake, dietary and supplemental vitamin E intake, and high level of serum tocopherol might be significantly associated with reduced age related cataract risk [159]. Higher consumption of vitamins A, C and E and carotenoids was associated with a significant decreased risk of age related cataract risk in a meta-analysis of cohort studies [160] Low serum selenium levels may constitute a potential risk factor for age-related cataract [161]. Vitamin D levels have been found to be low in people with posterior subcapsular cataract [162].

Low concentrations of omega-3 fatty acids are associated with higher risk of ARMD [163]. The Age-Related Eye Disease Study (AREDS) found significant risk reduction for advanced ARMD with antioxidants and zinc [164]. A Cochrane review of AREDS found the benefit of the AREDS multivitamin antioxidant vitamin and mineral supplement in potentially delaying the progress of ARMD [165].

Immune Function

Immune function varies throughout life, being generally low during infancy and childhood until the immune system reaches maturity in young adulthood, before declining in older age. Several factors influence the immune system, including nutrition. Micronutrients have vital roles throughout the immune system throughout life, and nutrients most needed to sustain immune function include vitamins A, C, D, E, B2, B6 and B12, folic acid, iron, selenium, and zinc [166,167]. Below LRNI intakes were seen in a significant proportion of females, including women over 65 in the NDNS-RP. These low intakes and poor nutritional status may increase the risk of poor immune function, predisposing to infection such as influenza. Immune function may be improved by restoring deficient micronutrients to recommended levels.

Drug-nutrient interactions

Drug nutrient interactions are an issue of high clinical relevance particularly in older people, first because drugs have different effects due to changes in body composition, nutrient intake may decrease and the use of polypharmacy is very high in this group.

Age UK estimates that almost two million people over 65 are likely to be taking at least seven prescribed medicines. This number doubles to approaching four million for those taking at least five medicines. In England overall more than one in 10 people aged over 65 takes at least eight different prescribed medications weekly, and this increases to one in four among people who are aged over 85.

There are a number of ways in which drugs can impact on nutrition-increasing nutrient need, reducing appetite and gastrointestinal effects, taste and hence affect food intake [168]. Laxatives and diuretics may reduce potassium, some diuretics can deplete magnesium, potassium, and calcium. Proton pump inhibitors can cause low calcium and magnesium levels, as well as low B12 levels. Anticonvulsants and corticosteroids may reduce levels of calcium and vitamin D; Metformin may reduce levels of folic acid and vitamin B12; and the Parkinson's drugs, levodopa and carbidopa, may reduce levels of vitamin B6, vitamin B12, and folic acid [169].

Discussion

Given the health challenges that women face across the

lifespan these findings of low micronutrient intakes across the lifespan are concerning.

Girls and young women have particularly low mineral and trace element intakes. Of note is the higher proportion of young women (11-18 years) than any other age group of females with below LRNI intakes of calcium, which could lead to impaired accrual of peak bone mass and the potential for further increase in osteoporosis in the future [5]. Below LRNI magnesium intakes found in 50 per cent of young women in the NDNS-RP are also of concern for bone health. In a 2017 US study, women meeting the recommended magnesium intake were at a 27 per cent decreased risk for future fractures [90]. For the 54 per cent of young women (aged 11-18) with intakes of iron below the LRNI, the risk of fatigue and poorer cognitive function (especially verbal learning and memory) is increased with additional increased risk of developing iron-deficiency anaemia in the context of rapid growth and onset of menstruation, including for those adolescent girls who suffer heavy menstrual bleeding [10].

More than a quarter of young women in the UK have intakes of iodine below the LRNI and sub-optimal iodine intakes have been associated with impaired child neurodevelopment at 3 years of age [170], child Attention Deficit Hyperactivity Disorder (ADHD) symptom scores at the age of 8 [171] and poor language skills in infancy and toddlerhood [172]. Further research is required to clarify the benefits of maternal iodine supplementation in infant and child neurodevelopment at different ages [173], though it would appear rational to ensure that iodine intakes meet recommended levels in women of reproductive age because of the potential impact of low intakes on infant and child health. The NDNS-RP found below LRNI intakes of selenium in almost half of girls aged 4-10 (45 percent) and 11-18 (46 percent). Appropriate status of selenium as well as iodine and iron is crucial for thyroid health [174].

Young women may further compromise their nutritional status through extreme weight control behaviour with as many as half of young women dieting to some extent. Nutrition is also linked to fertility in women with evidence indicating that folic acid (beyond its role in reducing the risk of neural tube defects), omega-3 fatty acids and vitamin D, amongst other micronutrients, have a key role in fertility including assisted reproduction. Pre-menstrual syndrome has been linked to lower levels of calcium, magnesium and dietary fibre, nutritional factors found in significant proportions of young women in the NDNS-RP. Oral contraceptives are linked to depletion of B vitamins, including folic acid, vitamins C and E, magnesium, selenium and zinc. Low vitamin D levels have been implicated in acne.

Significant proportions of women in the 19-64 age range also have intakes of micronutrients-vitamin A, folate, iron, calcium, magnesium, zinc, potassium, iodine, selenium, zinc, to name those

measured in the UK NDNS-RP - below the LRNI. Less than a third (32 percent) achieve their five-a-day fruit and vegetables, only 4 per cent achieve recommended fibre intakes and weekly intake of oily fish – 56 g- is well below the recommended 140 g portion each week, so minimising LC-omega-3 PUFA intakes. Nine out of ten women of child-bearing age now have such low levels of folate that if they became pregnant, their child would be at increased risk of Neural Tube Defects (NTDs).

Women in this age group face a number of health challenges from the increasing risk of chronic conditions, amongst which heart disease risk increases beyond that of men around the time of the menopause, chronic pain, menopause, as well as reproduction from pre-conception and conception through to pregnancy, birth and lactation. Anxiety, depression and mental health challenges are prevalent in this age group of women, and can prejudice diets and nutrient intake. Gastrointestinal conditions such as IBS are also quite common in this age group and evidence is growing for the importance of the gastrointestinal flora – and the capacity of fibre, prebiotics, and probiotics to modulate the flora - in the health of the GI tract and also for the potential of the gut microbiota to reduce the risk of obesity, cardiovascular disease and some cancers. Menopause with its associated symptoms is a health challenge for many women for which they may seek a range of natural products such as St John's Wort, Gingko biloba, evening primrose oil, valerian and so on.

Older women, as younger women, face a variety of micronutrient deficits due to poor diets. Preventive measures to limit nutrition related disease should begin early in life but that does not preclude nutrition modifications in older age. Improvements in nutrition can benefit health regardless of age. As women age, health challenges likely increase, although increasing numbers of women remain fit through their 60s and 70s. However, bone health, brain health, cardiovascular health, eye health and immune function become of increasing concern with age. Low micronutrient status has been observed in many of the conditions associated with the health of these different organ systems, and it seems likely that older women in whom the NDNS-RP shows intakes of micronutrients below the LRNI would be at increased risk of poor bone, brain, cardiovascular and eye health. Micronutrients have vital roles in supporting the immune system throughout life, and nutrients most needed to sustain immune function include vitamins A, C, D, E, B2, B6 and B12, folic acid, iron, selenium, and zinc [166]. Poor nutritional status predisposes to infection such as influenza. Immune function may be improved by restoring deficient micronutrients to recommended levels.

Reasons for these poor micronutrient intakes are unclear. However, poor diet may be observed in adults with a hectic and stressful lifestyle and ready access to fast food or energy-dense, micronutrient-poor convenience food. Recent studies suggest that an increasing dietary contribution from this type of food is linked

with poor nutrient intake. In a US study, intakes of fibre, vitamins A, C, D, and E, zinc, potassium, phosphorus, magnesium, and calcium in the US diet decreased significantly across quintiles of the energy contribution of ultra-processed foods [175]. Similar findings have been observed in Canada [176] with lower intakes of fibre, vitamins A, C, D, B6 and B12, niacin, thiamine, riboflavin, as well as zinc, iron, magnesium, calcium, phosphorus and potassium. Analysis of the UK NDNS data found that intakes of protein, dietary fibre and potassium were reduced as ultra-processed food consumption increased [177].

Essential micronutrients may be lacking in vegetarians and vegans [178]. In a study of vegans and vegetarians in Switzerland vegans reported low intakes of calcium and a marginal consumption of the vitamins D and B12, but omnivores had the lowest intake of magnesium, vitamin C, vitamin E, niacin and folic acid. With regard to micronutrient status, 58 per cent of the omnivorous group had low folic acid. In the vegetarian group, 58 per cent had low vitamin B6 and 34 per cent low niacin. In the vegan group, 47 per cent had low zinc. Prevalence of iron deficiency was comparable across all diet groups in this study. Despite negligible dietary vitamin B12 intake in the vegan group, deficiency of this particular vitamin was low in all groups thanks to widespread use of supplements [179].

Increasing numbers of women are reducing meat intake and following a flexitarian approach. Figures from Waitrose in 2018 [180] suggested that a third of people in the UK had reduced or stopped eating meat and a 2019 YouGov White Paper [181] indicated that 14 per cent of people in the UK consider themselves to be flexitarian following a plant-based diet with occasional meat. An analysis showed that UK females consuming less than 40 grams total red meat daily were more likely to have reduced micronutrient intakes, especially zinc and vitamin D [182]. These findings demonstrate that there could be 'unintended' consequences where the dietary shifts impact on micronutrients intakes [182]. Public concerns about sustainability of fish stocks may contribute to ongoing poor oily fish intakes.

Low carbohydrate diets are becoming increasingly popular but few studies have assessed micronutrient intake with these diets. The ketogenic diet, which is low or no carbohydrate has been associated with less than recommended intakes of magnesium, calcium, iron, phosphorus, and potassium and water soluble vitamins [183]. A systematic review found intakes of thiamine, folate, magnesium, calcium, iron, and iodine all decreased significantly with any carbohydrate restricted diet [184]. Weight loss diets such as Atkins have been associated with low intakes of thiamine, folic acid, vitamin C, iron, and magnesium [185,186].

Conclusion

Given the low micronutrient intakes in a significant proportion of women across the lifespan in the UK, the essentiality of all micronutrients for health and the links between low intakes of several micronutrients and health issues, intakes of all nutrients should be at recommended levels. All women should ideally take a multivitamin and multimineral, a supplement providing 10 micrograms of vitamin D with the addition of omega-3 fatty acids as a routine part of their daily life. For women of reproductive age the supplement should include 400 micrograms folic acid.

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Author's Contributions

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