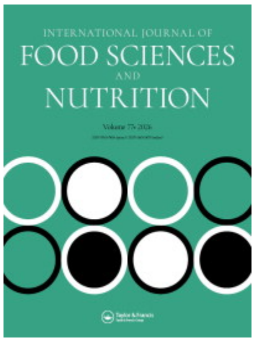

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STUDIES IN HUMANS

Consumption of fish and seafood by childbearing-aged women in the UK and potential products that could improve health outcomes

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ABSTRACT

This study quantified fish and seafood consumption by UK women of childbearing age (presented by individuals aged 20–39) relative to government dietary guidelines and identified interventions that could improve health outcomes. Data were collected from the National Diet and Nutrition Survey, including 4-day food diaries and nutrient databank records. Retail price data were collected from UK supermarkets to assess affordability. Intake of fish and seafood is far below NHS recommendations, limiting potential health benefits. Women aged 20–39 years consumed an average of 33 g of oily fish per week in the period 2008–2021. This is only 24% of the NHS recommended intake of 140 g. Despite greater need for nutrient dense foods, younger women and those from lower-income households reported significantly lower seafood intake. Efforts to increase consumption of oily fish species such as mackerel and sardines are likely to be viable and effective for improving women's public health.

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Women; pregnancy; children; nutrition; food; fish

1. Introduction

Recognising and informing the public about micronutrient rich, sustainable foods is crucial for encouraging healthy diets. Women with the potential to become pregnant should be a focus for improved dietary support due to the increased energy requirements and adapted metabolic demands of pregnancy (Zeng et al. 2017). Around the world, women of childbearing age are typically ill-prepared for the nutritional requirements of pregnancy (Stephenson et al. 2018). Optimal maternal nutrition is vital for enhancing children's long-term health outcomes (Barrett et al. 2015). Pre-conception into early motherhood (2–3 months before and after conception) has been identified as a period for gamete function and early placental development (Keikha et al. 2022), yet once a pregnancy has been recognised, women rarely increase the proportion of nutrient-dense foods in their diet (Forbes et al. 2018). Therefore, positive dietary changes before pregnancy are crucial for embedding habits that will continue if a woman becomes pregnant and will in turn aid future foetal development. It should also be emphasised that improving a woman's diet remains beneficial to her health irrespective of pregnancy occurrence. Improving nutrition for women of reproductive age will support development and improve long term health outcomes for current and future generations.

With 45% of UK pregnancies unplanned or associated with feelings of ambivalence, the window for early nutritional intervention is often missed (Wellings et al. 2013). In the UK, the contemporary nutritional risk factors during pregnancy are inadequate micronutrition and the increasing rates of obesity. As a response to micronutrient deficiencies, the NHS recommends supplement pills for vitamin D and folic acid (vitamin B9) (NHS 2022b). Ten micrograms of vitamin D daily is recommended when pregnant and breastfeeding between September and March (NHS 2022b). This is to reduce the risk of adverse outcomes such as pre-eclampsia and to improve foetal skeletal development, tooth enamel formation, and immune function (Wagner et al. 2012). From pre-conception through to 12 weeks, supplementation of 400 µg folic acid is recommended to reduce the prevalence of neural tube defects (NTDs) such as spina bifida, by as much as 70% (Stephenson et al. 2018). In England, NTDs affect

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approximately one in 1,000 pregnancies (Broughan et al. 2024). Despite a plethora of evidence supporting supplementation, only 20% of women report taking pre-conceptive folic acid, and 40% never take any supplementary pills (PHE 2018a). Approximately 240,000 babies were born in 2022 to UK mothers who did not receive any supplementation (PHE 2018a). Individuals from deprived backgrounds and women under the age of 24 are less likely to take recommended supplementation (PHE 2019). Reports of obesity are increasing for women of reproductive age in the UK, with the current estimate that 19% of all women of childbearing age are obese (BMI >30) (PHE 2018a). Maternal obesity significantly increases health risks for mother and child: increasing the risk of gestational diabetes, high blood pressure and pre-eclampsia, miscarriage, and stillbirth (Poston et al. 2016; PHE 2018b). Improving diets for women of childbearing age so that they are richer in vitamin D, folic acid and contain fewer saturated fats and sugar will have population health benefits.

Fish and seafood offer a powerful vehicle to deliver key micronutrients to women of childbearing age and to contribute towards tackling obesity. In comparison to other protein sources, seafood products typically contain elevated concentrations of micronutrients important to human health (Cai and Leung 2022; Willer et al. 2024). Studies show typical dinners with fish as the main protein contain greater concentrations of vitamin D and folate than most red meat dinners (Myhre et al. 2016). Bivalve shellfish are particularly high in micronutrients, for example containing up to 12 times the amount of vitamin B12 found in beef, and 30 times more than pork or chicken (Willer and Aldridge 2020; Willer et al. 2023). Fish products are also overall lower in calories and saturated fats than red meats (Cai and Leung 2022; Xia et al. 2024). It is suggested that frequent intake of lean fish and seafood in humans is associated with reduced total energy intake by 4-9% in comparison to terrestrial meats (Liaset et al. 2019). Omega-3 fatty acids are also essential during pregnancy for early brain development (Innis 2003). The most bioavailable forms of omega-3, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are predominantly derived from marine seafoods (Coletta et al. 2010; Willer et al. 2022). In addition to being a potentially rich protein source, fish and shellfish production can have a lower environmental footprint than other animal production systems (Béné et al. 2015; Willer and Aldridge 2020). Despite the benefits, in 2019 the National Diet and Nutrition Survey (NDNS) identified the mean consumption of oily fish was only 56 g in adults aged 19–64 (PHE 2020b), less than one third of the NHS recommendation of 140 g per week (NHS 2022a).

Highlighting the potential for seafood to be a quality, sustainable source of nutrition could be important in improving its consumption. However, it is noted that there is an upper boundary for the recommended intake of fish and seafood. Women with the potential to bear children should not consume more than two portions (280 g) of oily fish and four cans (120 g) of tuna per week. Shark, swordfish and marlin should be completely avoided due to the increased likelihood of biomagnified methylmercury (NHS 2022a).

This study aimed to determine contemporary consumption of fish and seafood amongst women of reproductive age in the UK and identify suitable fish and seafood products for promotion that would improve the health outcomes for this cohort and their potential offspring. Quantifying current intake provided critical understanding of the available scope for increased consumption, in order that suggested efforts do not go beyond the thresholds for safe consumption. Further investigation into demographic influences allowed the identification of groups who may find a change to their current fish and seafood consumption most beneficial to their personal health; information key to directing future public health initiatives. The final objective of the study was to assess fish and seafood products that may be suitable for promotion to women of childbearing age because they are affordable, popular, and rich in nutrients important during pregnancy.

2. Materials and methods

2.1. Data collection

The data interpreted in this study were sourced primarily from the National Diet and Nutrition Survey (NDNS), available from the UK Data Service (NDNS 2023). The NDNS is a database of survey responses on quantitative information of food consumption, nutrient intake, and nutritional status of the general population in the UK (PHE 2020a). The survey samples approximately 1,000 people over 18 months old annually. During our analysis in March 2023, data were available from 2008 to 2021. The NDNS collects a diversity of data; this study utilised information from the survey interview, the 4-day estimated diet diary, and the nutrient databank. Unless otherwise specified, the reference period for this study is 2008–2021.

Two key terms were determined for this study, "seafood" and "women of childbearing age". "Seafood" referred exclusively to animal products that originate from both capture and farming. Plant based seafoods, such as edible seaweeds and marine algae were not included in this study. "Women of childbearing age" were defined as women aged 20–39. Whilst women outside of this age group can become pregnant, 94% of UK live births in 2021 were to women aged 20–39 (ONS 2023). The distribution of mothers' age at time of live birth has progressively concentrated towards women aged 20–39 every year since 2000 (ONS 2023). This information informed the decision to focus on women aged 20–39 as a group to represent women with the potential to become pregnant.

Demographic information was extracted from the NDNS published database in order to further understand consumption patterns. Age, sex, country and equivalised income information was examined from the database the NDNS Person Level Diary Data.

Information regarding the retail price of fish and seafood products was collected from the five largest (by market share) UK supermarkets: TESCO, Sainsbury's, ASDA, Aldi and Morrisons (Kantar Worldpanel 2023). RStudio 4.0.3 was used to web-scrape the price of fish and seafood products on the 10 November 2023. The search terms used were "fish" and "seafood". The prices of both processed and unprocessed fish products were collected. Data collection by this method provides a good indication of retail prices at a specific timepoint although it does not account for products that were unavailable online or available only in store at this time.

The fish and seafood nutrient characteristics were assessed using the NDNS nutrient databank. Popularity was determined using the NDNS survey interview and 4-day estimated diet diary. In total, across all years, there were 15,655 individual survey interview responses and 619,174 reported food diary entries. 2021 nutrient databank data were used, which showed the nutrient profiles for 5,927 foods reported in 4-day diet diaries.

2.2. Data analysis

Weekly fish and seafood intake in 2021 (during the period 2008–2021) of adults 18–96 years and women 20–39 years were analysed using Microsoft Excel for Microsoft 365, Version 2312 and RStudio 4.0.3, with the outputs presented in results Section 3.1 and in Figures 1–4. The nested nature for women aged 20–39 years being a subgroup of adults 18–96 years stipulated descriptive analysis between the two groups (Figure 1). Further investigation into the influence of demographic factors enabled analysis that revealed significant differences in the weekly intake of fish between subgroups of adults (18–96 years) and women (20–39 years) (Figure 2). Age groups were categorised by dividing the total number of individuals into three groups to the nearest whole age year, with this

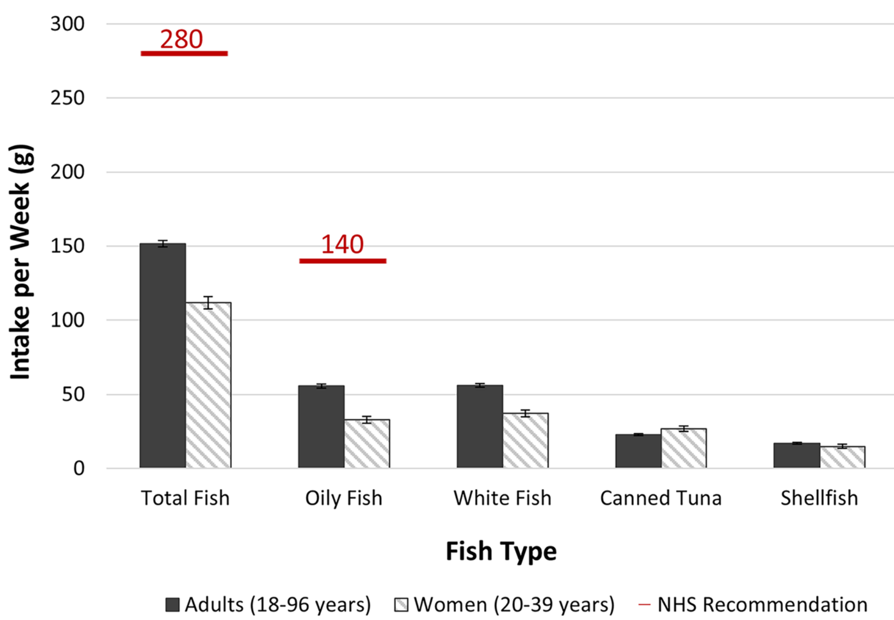

Figure 1. Reported weekly intake of various fish and seafood types by UK adults and women of childbearing age. Intake of fish per week in 2021 (g) is compared across four fish and seafood types and the total for adults and women of childbearing age. Note women (20–39 years) are nested in adults (18–96 years). The red lines indicate the NHS recommended weekly intake for total fish (280 g) and oily fish (140 g). Solid black bars are used to indicate adults, dashed bars are used to indicate women. Error bars are Standard Error of the Mean. Raw data from NDNS years 1–11 Person Level diary data (NDNS 2023).

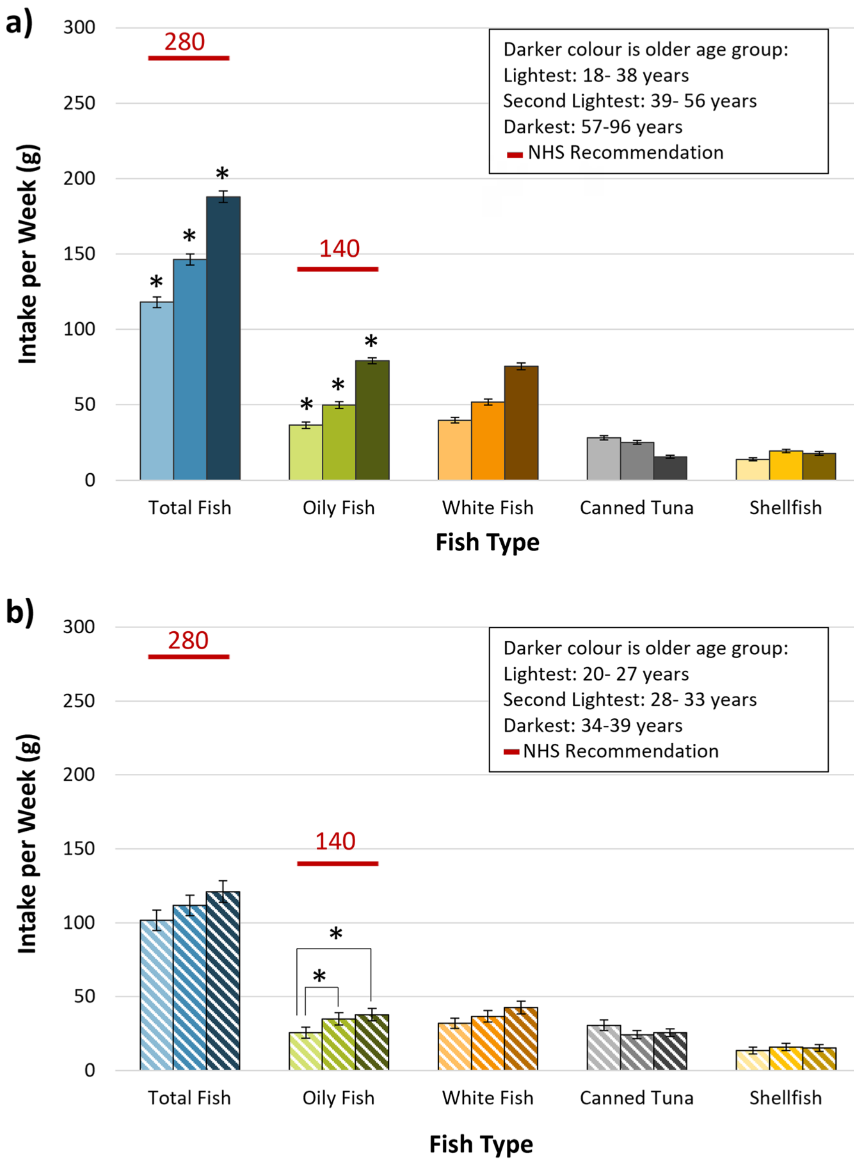

Figure 2. Increasing fish intake with age for adults and women of childbearing age for all fish types, except canned tuna. (a) refers to adults, (b) refers to women of childbearing age. Intake of fish per week in 2021 (g) is compared across four fish and seafood types and the total for adults and women of childbearing age, across three equally distributed age categories. The red lines indicate the NHS recommended weekly intake for total fish (280 g) and oily fish (140 g). Blue colours are used for total fish, green for oily fish, orange for white fish, grey for canned tuna, and yellow for shellfish, with darker shades of colour used for older age groups. Error bars are Standard Error of the Mean. Note age categories differ between (a) and (b). Raw data sourced from NDNS years 1–11 Person Level diary data (NDNS 2023).

distribution method ensuring each data group had similar sample sizes. To investigate geographical relationships data were split into England, Scotland, Wales, and Northern Ireland (Figure 3). The impact of household income on fish and seafood consumption was also analysed (Figure 4). Equivalised household income was calculated by first having a McClements equivalence scale score assigned to each household (dependent on number, age and relationships of adults and children in the household) and then dividing the total household income by the output score. This method of presenting household income by accounting for household size and composition encourages fairer, more representative comparisons between income groups (ONS 2015). In Figures 2, 3 and 4, subgroups were confirmed as being non-normal in distribution by Shapiro-Wilks tests and so non-parametric Kruskal-Wallis tests were used to determine significance, with *post-hoc* Dunn's tests used to determine which specific groups significantly differed from one another. Total fish and oily fish were assessed using this method, so comparisons could be made with

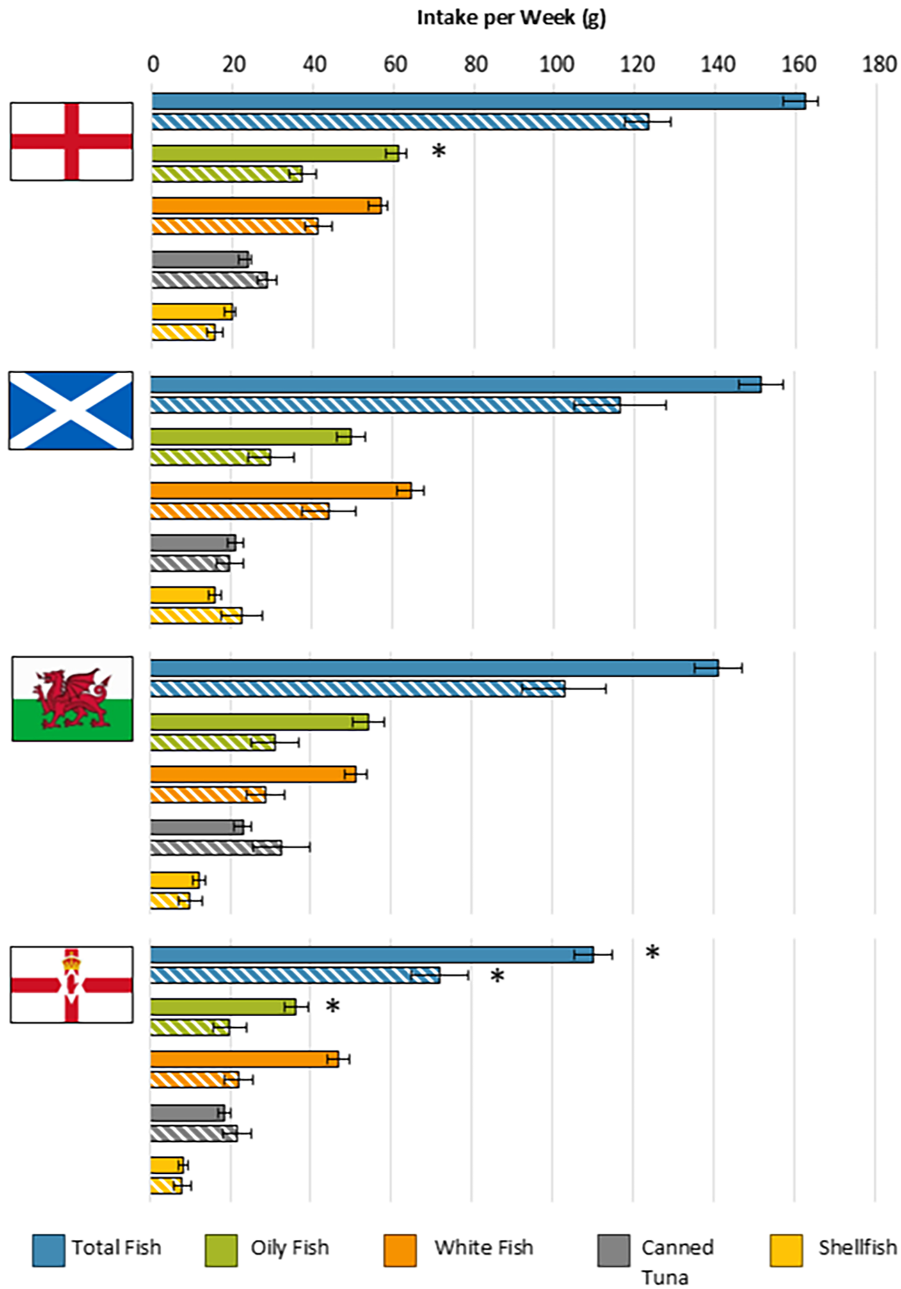

Figure 3. Reported weekly intake of various fish types grouped by country. Solid bars are adults 18–96 years, hashed bars are women 20–39 years. Countries from top: England, Scotland, Wales, Northern Ireland. Note respective sample sizes for adults (18–96 years): 5018, 1210, 1034, 1085 and women (20–39 years): 874, 214, 176, 246. Intake of fish per week in 2021 (g) is compared across four fish and seafood types and the total for adults and women of childbearing age. Blue colours are used for total fish, green for oily fish, orange for white fish, grey for canned tuna, and yellow for shellfish. Error bars are Standard Error of the Mean. Raw data from NDNS years 1–11 individual data (NDNS 2023).

NHS recommended intake (NHS 2022a). Sample sizes for demographic figures differ because not every question was answered by individuals during data collection.

Fish and seafood products that may have the potential to be accessible, marketable, and healthy were identified, and outputs presented in Results Section 3.2, and in Tables 1 and 2 and Figure 5. The fish and seafood items highest in folate, vitamin D and omega-3 fatty acids were identified using the NDNS nutrient databank (Table 1). The 2021 NDNS nutrient databank contained 437 fish and seafood products and dishes; of these only cooked items were included in the analysis; dried, raw and processed (e.g. fish fingers and fish pie) items were excluded. The popularity of each fish and seafood item was then quantified as a percentage of total reported fish and seafood entries (Table 2). Cost, popularity and nutritional data were

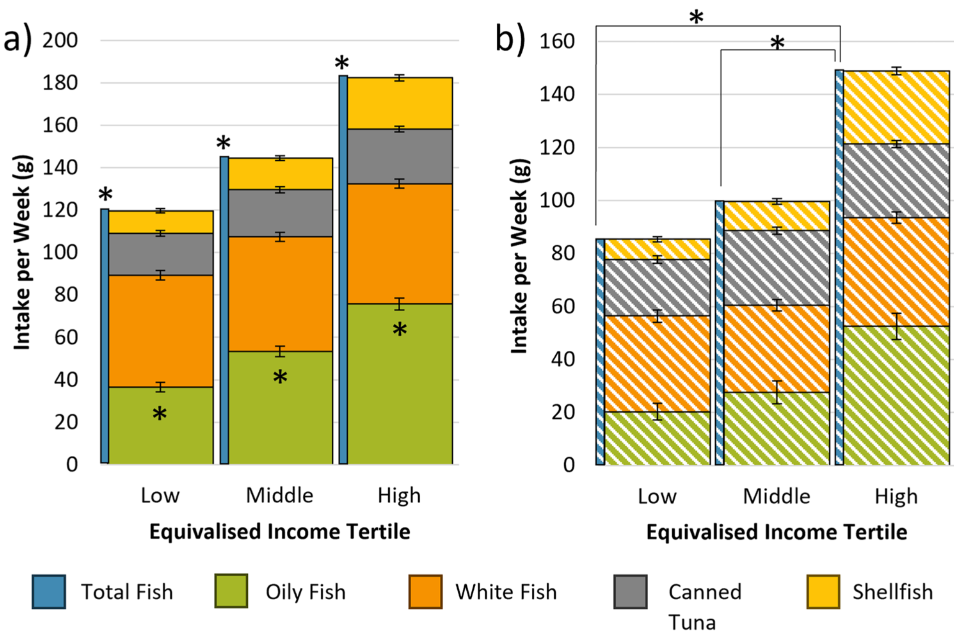

Figure 4. Lower total fish and oily fish intake in adults and women with lower incomes. Reported weekly intake of various fish types are grouped by equivalised income tertile (see methods). Note different scale between panel (a) and panel (b). Solid bars in (a) are adults 18–96 years, hashed bars in (b) are women 20–39 years. Blue colours are used for total fish, green for oily fish, orange for white fish, grey for canned tuna, and yellow for shellfish. Error bars are Standard Error of the Mean. Raw data from NDNS years 1–11 individual data (NDNS 2023).

Table 1. Nutrient content of the three fish items with the greatest levels of folate, vitamin D and omega-3 fatty acids in 100 g.

		Nutrient richness					
		1st most		2nd most		3rd most	
	Recommended daily intake (RDI)	Food name	Nutrient content per 100 g	Food name	Nutrient content per 100 g	Food name	Nutrient content per 100 g
Folate (µg)[a]	200–600	Cockles, boiled without shells	37.0	Squid boiled	31.0	Mussels boiled	25.0
Vitamin D (µg)	10–20	Bloater, grilled	25.0	Herring No bones, coated blended	21.7	Cod roe fresh grilled	19.4
Omega-3 fatty acids (g)[b]	1.1–1.4	Mackerel, Smoked not canned	5.6	Sprats, Fried	5.0	Mackerel Unsmoked, baked/ grilled, no bones	4.8

Recommended daily intakes for folate and vitamin D are from the NHS and NIH (National Institutes of Health) for omega-3 (NHS 2020, 2022b; NIH 2023). Food item nutrient content obtained from NDNS year 11 nutrient databank (NDNS 2023).

[a]All adults need 200 µg a day- if currently pregnant, trying for a baby, or could get pregnant it is recommended that a 400-µg folic acid supplement is taken daily until 12 weeks post conception.

[b]NHS does not provide a recommended intake for omega-3 fatty acids. Value from the USA National Institutes of Health. Adequate intake for non-pregnant women is 1.1 g and for pregnant women is 1.4 g (NIH 2023).

Table 2. The three most popular fish and seafood items for adults and women of childbearing age in the UK.

	Popularity					
	1st most		2nd most		3rd most	
	Food name	% of reported fish items	Food name	% of reported fish items	Food name	% of reported fish items
Adults (18–96)	Tuna Canned in Brine Fish Only	10.2	Prawns, Boiled Flesh Only	9.5	Salmon, Grilled or Baked	8.5
Women (20–39)	Tuna Canned in Brine Fish Only	14.6	Prawns, Boiled Flesh Only	8.8	Salmon, Grilled or Baked	7.7

The table shows the popularity of the three fish items with the greatest number of times reported consumed in four-day diet diaries, as a percentage of total entries. In total, 238 unique fish dishes were reported in food diary data collection. These appeared 10,247 times in the 4-day food diaries of adults 18–96 years and 1,859 times for women 20–39 years. Data sourced from NDNS years 1–11 food Level diary data (NDNS 2023).

collated in Figure 5. In Figure 5, pollock, herring, sardines and mackerel were chosen for inclusion because web-scraped cost data identified them as the four cheapest fish types. Fish and seafood types that were sold in less than five products across all retailers were excluded, as were undefined minced white fish

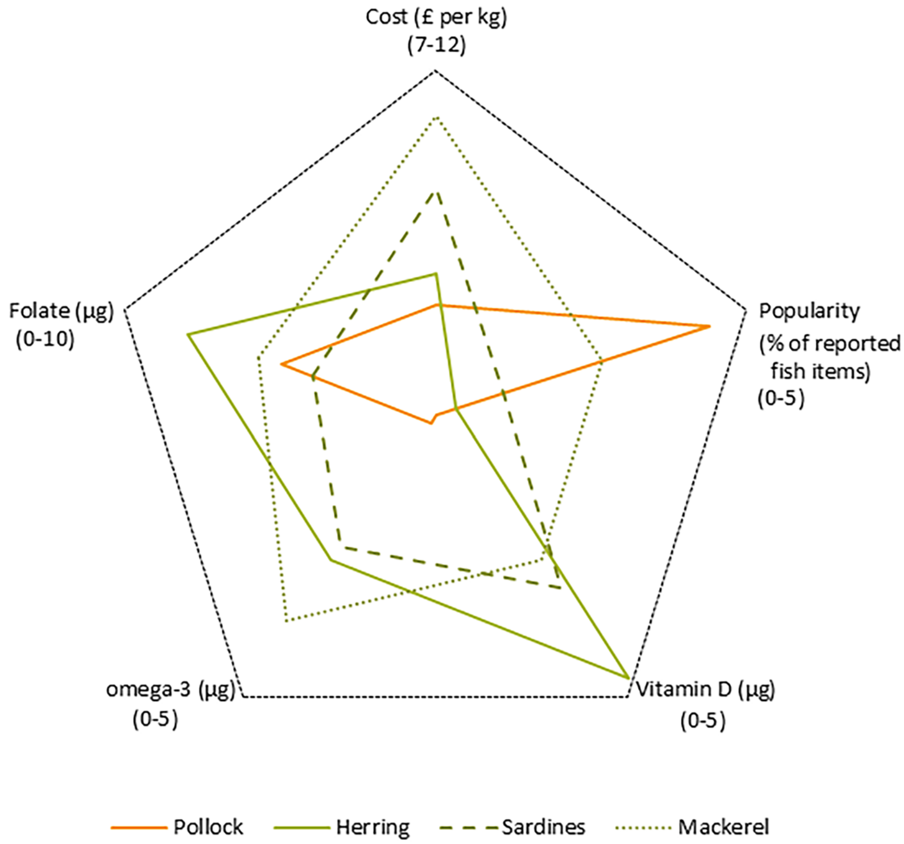

Figure 5. Trade-offs between cost, popularity and nutrient content between four of the UK's most popular fish types. The radar plot compares pollock (orange), herring (green solid), sardines (green dashes) and mackerel (green dots), which were selected because web-scraped cost data identified them as the four cheapest fish types. Cost per 100 g, percentage occurrence frequency in reported food diaries, micronutrient level per 100 g are compared. The numbers in brackets below each axis label refer to the maximum and minimum values for the given axis, and the black dashed line refers to the maximum values. Note the Central axis is not zero for all variables. Raw data sourced from NDNS year 11 nutrient databank, NDNS years 1–11 food Level diary data and web-scraped cost data from 5 leading UK supermarkets (NDNS 2023).

and mixed seafood products. The final four selected also had nutrient data available from the NDNS. Cost per 100 g was determined from an average across all products of this fish type on sale across all five retailers; this method represents the average cost of all products available to consumers but does neglect the potential for consumers to favour cheaper items. Popularity was the sum of all the times the specified fish type was cooked using any preparation method and recorded in the food diary. Nutritional data was averaged for all preparation methods of each fish type.

3. Results

3.1. Participant characteristics

In total, there were 15,655 individual person level data entries for the NDNS survey years 1–11. Of these, 8,347 were aged between 18 and 96 years. These adults were distributed across three age categories: 2,713 were aged 18–38, 2,870 were aged 39–56, and 2,764 were aged 57–96 years. Among the adult participants, 1,510 were women aged between 20 and 39 years. Across three age categories 497 women were aged 20–27, 488 were aged 28–33, and 525 were aged 34–39 years.

A total of 5,018 adult (aged 18–96) participants reported their country as England, 1,085 Northern Ireland, 1,210 Scotland, and 1,035 in Wales. Of the 1,510 women aged 20–39 that reported their country, 874 were from England, 276 from Northern Ireland, 214 from Scotland, and 146 from Wales.

Equivalised income tertiles were calculated from optional income questions. There were data available for 7,135 adults (aged 18–96). 2,152 were in the lower income tertile, 2,372 in middle income, and 2,611 in higher income. Among women aged 20–39, 1,231 had available equivalised income information. 501 fell into lower income, 381 into middle income and 439 into higher tertile.

3.2. Current fish and seafood consumption

Assessment revealed that all UK adults and all women of childbearing age consumed less fish than the NHS recommendations (Figure 1). In 2021, Total fish consumption by adults aged 18–96 was 151.5 ± 2.2 g (± indicates Standard Error of the Mean), just 54.0% of recommendations. For childbearing women consumption was even further below recommended intake, with women aged 20–39 consuming 111.6 ± 4.1 g per week, representing 39.8% of recommendations. The difference in reported total fish intake between all adults (18–96) and women (20–39) was 39.9 g. Oily fish consumption was even further below recommended intakes. Adults aged 18–96 consumed just 55.7 ± 1.4 g of oily fish per week, representing 39.7% of recommendations. As with total fish, women aged 20–39 consumed less oily fish than the adult population as a whole, just 32.8 ± 2.3 g per week, 23.5% of recommended intake. The difference in reported total fish intake between all adults (18–96) and women (20–39) was 22.8 g. Overall, UK women of childbearing age were eating less per week than UK adults of every fish type except canned tuna.

When investigating demographic factors in more detail, the data highlight how fish intake tended to increase with population age for all fish types, except for canned tuna (Figure 2). Across all adults, total fish consumption increased significantly with each step up in age category (Kruskal-Wallis X^2 = 243.2, $df = 2$, $p < 0.001$, post-hoc Dunn's test 18–38 and 39–56 $p < 0.001$, 18–38 and 57–96 $p < 0.001$, 38–56 and 57–96 $p < 0.001$), and the same significant relationship was seen for oily fish consumption (Kruskal-Wallis X^2 = 218.5, $df = 2$, $p < 0.001$, post-hoc Dunn's test 18–38 and 39–56 $p < 0.0001$, 18–38 and 57–96 $p < 0.001$, 38–56 and 57–96 $p < 0.001$) (Figure 2a). For women of childbearing age, there was a trend for increased total fish consumption with greater age, although this was only near significant (Kruskal-Wallis X^2 = 5.7, $df = 2$, $p = 0.058$). Oily fish consumption in women of childbearing age did increase significantly with greater age, being significantly greater in women aged 28–33 and 34–39 than in women aged 20–27 (Kruskal-Wallis X^2 = 9.9, $df = 2$, $p < 0.01$, post-hoc Dunn's test for ages 20–27 and ages 28–33 $p < 0.001$, ages 20–27 and ages 32–39 $p < 0.01$) (Figure 2b). Critically, the data overall shows that younger individuals are the furthest from the NHS recommended intakes.

Regarding geographical differences, the key finding was that fish and seafood consumption was lower in Northern Ireland than in the rest of the UK. Data revealed that total fish consumption for both adults and women of childbearing age was significantly lower in Northern Ireland than in England, Scotland, or Wales (Figure 3) (adults: Kruskal-Wallis X^2 = 60.7, $df = 3$, $p < 0.001$, all post-hoc Dunn's tests $p < 0.001$. Women: Kruskal-Wallis X^2 = 16.4, $df = 3$, $p < 0.001$, all post-hoc Dunn's tests $p < 0.05$). Oily fish intake for adults (18–96 years) was significantly different between all countries, except from Scotland and Wales (Kruskal-Wallis X^2 = 51.8, $df = 3$, $p < 0.001$, post-hoc Dunn's test Scotland and Wales $p = 0.20$, all other countries $p < 0.01$). For women aged 20–39, oily fish consumption did not significantly differ between countries (Kruskal-Wallis X^2 = 6.8, $df = 3$, $p = 0.08$). Overall, the data suggest that fish and seafood consumption varied between UK countries and that people in Northern Ireland consumed the least.

A critical finding was that lower income in adults and women was associated with lower fish consumption (Figure 4). For adults aged 18–96, both total fish and oily fish intake increased significantly with ascending equivalised income tertile (total fish: Kruskal-Wallis X^2 = 143.2, $df = 2$, $p < 0.001$, all post-hoc Dunn's tests $p < 0.001$; oily fish: Kruskal-Wallis X^2 = 189.7, $df = 2$, $p < 0.001$, all post-hoc Dunn's tests $p < 0.001$) (Figure 4a). For women of childbearing age, intakes of total and oily fish were significantly lower in both the low and middle income tertiles than in the high income tertile (total fish: Kruskal-Wallis X^2 = 53.3.2, $df = 2$, $p < 0.001$, post-hoc Dunn's test, highest and low/middle income tertile $p < 0.001$; oily fish: Kruskal-Wallis X^2 = 62.4, $df = 2$, $p < 0.001$, post-hoc Dunn's test, highest and low/middle income tertile $p < 0.001$). Mean total fish and oily fish intake for women in the lowest income tertile were 85.4 ± 6.5 g and 20.3 ± 3.2 g respectively, 42.6% and 62.1% lower than the 148.9 ± 8.3 g and 53.5 ± 5.0 g in the highest income tertile.

3.3. Potential for improving consumption

Data were gathered on specific fish and seafood food items richest in key nutrients and the specific items that are most popular to consumers, with the view that this could help identify opportunities to increase consumption in women of childbearing age. Table 1 highlights how low-trophic pelagic fish such as mackerel, sprat and herring ("mackerel smoked not canned", "mackerel unsmoked baked/grilled no bones", "sprats, fried", and "herring, no bones, coated blended") provide the richest source of the key micronutrients vitamin D and omega 3 fatty acids, with an 100 g serving of any of these species meeting or exceeding Recommended Daily Intakes (RDI). Molluscs such as cockles, squid, and mussels provide one of the richest sources of folate from fish and seafood, with a 100 g serving contributing to at least 10% of RDI. Regarding popularity, Table 2 highlights how tuna, then prawns, then salmon are consistently the most popular fish and seafood types for both all adults and women of childbearing age.

Trade-offs between nutrient context, cost, and popularity were assessed to help further elucidate candidate seafoods for consumption by women of childbearing age. Figure 5 shows the cost of the UK's four most affordable major fish types, their popularity and richness in nutrients needed during pregnancy. Pollock, herring, sardines and mackerel were chosen for inclusion because web-scraped cost data identified them as the four cheapest fish types. Pollock is the cheapest (£8.68 per 100 g) and most popular (4.4% of reported fish dishes for women ages 20–39) but contains no vitamin D (0 µg per 100 g) only a small amount of omega-3 fatty acids (0.14 g per 100 g) and folate (5 µg per 100 g). In comparison, herring, sardines and mackerel are greater in vitamin D and omega-3 fatty acids, and only sardines are lower in folate than pollock. Herring contains 5 µg, 2.74 g, and 8 µg of vitamin D, omega-3, and folate per 100 g respectively, and is also cheap at £9.17 per 100 g. However, herring is unpopular with only 0.16% of the fish reported by women in their four-day diary being herring. Sardines are more popular than herring (1.08% reported fish meals for women), slightly more expensive (£10.48 per 100 g), and comparably nutritious (3.27 µg vitamin D, 2.50 g omega-3, and 4.0 µg folate per 100 g respectively). Whilst the most expensive of the four fishes assessed (£11.58 per 100 g), mackerel is more than twice as popular as sardines (2.69% of meals), relatively rich in vitamin D (2.74 µg per 100 g), the richest in omega-3 (3.91 g per 100 g) high in folate (5.75 µg per 100 g).

4. Discussion

This study confirmed that women of childbearing age in the UK are eating far below the NHS recommended daily intakes of fish and oily fish and indicates that incentives to increase consumption are unlikely to result in women exceeding any safe limits. Below recommended consumption was expected and is in line with previous studies (Derbyshire 2019; Beasant et al. 2023). The NHS website currently acknowledges low UK consumption and states "Most of us should have more fish in our diet, including more oily fish" (NHS 2022a). For women of reproductive age, the guidance is to consume at least 280 g of fish per week, with at least 140 g being oily fish. It is important to understand contemporary intakes, particularly for this group, because of the balance between the health benefits from eating the recommended amount and health risks from overconsuming potentially harmful fish and seafood. The safe upper limit of oily fish intake is 280 g due to pollutants such as dioxins and dioxin-like PCBSs (SACN, 2004). The aim of this guidance is to minimise the risks associated with of microbiological and toxicological effects. The findings of this study that women of childbearing age are only eating approximately 33 g of oily fish per week, a small fraction of what is recommended (140 g) and considerably below the upper boundary for safe consumption (280 g), indicates that there is scope and opportunity for safely increasing nutrient-rich oily fish intake for women of reproductive age in the UK. The other fish type with an upper safe limit is canned tuna (560 g per week), this study estimates intake for women of reproductive age to be 27 g per week. This suggests that there is low concern that recommending increased nutritious fish intake will drive women above safe limits. Therefore, promotion of nutritious fish and seafood should be encouraged to improve health outcomes.

Further investigation into demographic influences on weekly fish and seafood intake revealed that women from young, poor households in Northern Ireland were disproportionately affected, indicating these groups as a key target for public health intervention. Past publications examining patterns across all adults concluded similar findings (Olsen 2003; Love et al. 2022). The intertwined nature and close relationship of age, location and income means that there will be groups within the UK who are likely to have an even lower weekly fish intake than presented in this study. This is significant because, as previously highlighted, young women from deprived backgrounds are less likely to take pre-conception supplements and so diet is potentially the sole nutrient source for many women in this group (PHE 2019). Overall, women from socially disadvantaged groups have poorer perinatal outcomes (Grand-Guillaume-Perrenoud et al. 2022). The results of this study contribute to the evidence that young women from low-income households are exposed to increased risk of preventable health conditions (Kapur and Hod 2020). Therefore, improving the consumption of nutritious fish and seafood amongst these individuals will have a positive impact on public health.

The significant increase in fish and seafood consumption amongst higher income groups observed in this study, suggests that cost may be a barrier to increased consumption, and that provision of more affordable options is a critical action moving forwards. Many previous studies concur that the perceived cost of fish is a key factor limiting increased consumption (Love et al. 2022; Gawel et al. 2023). The cost analysis highlighted in this paper demonstrated that there are cheaper fish and seafood options available. These can also be nutritious, such as small pelagic sardines or herring, with high concentrations of nutrients required during pregnancy (Willer et al. 2024). However, there is a significant lack of popularity for these fishes amongst women of childbearing age. UK consumers are known to rely on a few fish products rather than a diverse selection of fish species (Harrison et al. 2023; Willer and Aldridge 2023). Analysis in our study confirmed that this behaviour was maintained for women of reproductive age. Variation by age and UK country also suggests that cultural preferences may influence choices and consumer preferences, a pattern observed in other studies (Govzman et al. 2021). Moreover, the especially low levels of seafood consumption in Northern Ireland may reflect the fact that it has the lowest average household income of any region of the UK, yet has some of the highest food prices (Corfe 2018) which may result in consumers purchasing cheaper alternatives to seafood. Identifying affordable, popular and nutritious seafood is important for ensuring effective promotion (Carlucci et al. 2015; Willer et al. 2021).

This study highlighted how the oily fishes mackerel and sardines could provide a highly nutritious and relatively low-cost fish option. The challenge is to increase consumption of these fishes by women of childbearing age. A plethora of research explores ways of improving fish and seafood in diets around the world (Farmery et al. 2020; Govzman et al. 2021; Liu and Ralston 2021). However, there is limited information regarding how effective these methods are for improving consumption amongst women of childbearing age. One study highlighted mackerel and sardines as having a low environmental cost which could also aid with improving uptake, particularly amongst young people who are more likely to make purchasing decisions based on environmental impacts (Robinson et al. 2022; Willer et al. 2024). Labels advertising environmental sustainability of a seafood product have been shown to improve consumer preference and behaviour (Jacobs et al. 2018). Mackerel may be a good candidate for increasing consumption as it can be substituted in many recipes for salmon or tuna, currently very popular fishes in the UK amongst women of reproductive age. Women of this age group are likely to be in full time work and therefore convenience may be an important driver in consumer choice (House of Commons Library 2023). Effective advertisement strategies for fish and seafood specifically to women aged 20–39 years should be further explored.

We highlight several areas where further investigation is needed. The cross-sectional design of this study means that all variables were measured at a single point in time, which limits our ability to draw conclusions about causality or changes over time. NDNS data could be used in future to investigate temporal changes. Although we observed associations between demographic factors and fish intake, we cannot determine the direction of these relationships or the underlying mechanisms that may explain them. It is also important to acknowledge the complexity of demographic factors and how they interact in real-world settings. While this study examined characteristics such as age, income, and geography independently, these factors rarely operate in isolation. For example, income may intersect with education, cultural background, or household composition in ways that influence dietary habits. Future research would benefit from approaches that consider multiple overlapping demographic variables to better reflect the complexity of real-world behaviours and decision-making.

More detailed work should also be carried out to examine fish and seafood prices over longer time periods in the UK. This study analysed a snapshot of average prices; a rolling analysis would allow for the assessment of price fluctuations and the identification of more affordable product options.

Our research has shown that UK women of childbearing age consume less than the recommended intake of fish, particularly oily fish. By evaluating cost, popularity, and nutritional value, we identified mackerel and sardines as accessible and nutritious options for women aged 20–39. A key next step would be to investigate the reasons behind low intake and to develop effective strategies to increase consumption of nutrient dense foods among women of childbearing age.

In conclusion, active steps should be made to improve fish and seafood consumption in women of reproductive age in the UK. Current intake is far below NHS recommended amounts which means that potential health benefits are not being realised. Such low consumption also indicated that there should be low concern that recommended increased consumption will place women above safe limits. As a priority, women who are young and from low-income households should be encouraged to increase fish and seafood intake. Positive changes, particularly for this group, would have great potential benefits to public health. Effort needs to be made to improve the popularity of nutritious, affordable fishes such as mackerel and sardines. Increasing nutritious fish and seafood intake will have positive health outcomes for the current and next generation.

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Data availability statement

All datasets for this study and the supplementary files available at: https://drive.google.com/drive/folders/1iKDKcxNNQUnJEmzb_PgrCnEqFho9mwdb?usp=sharing

References

Barrett G et al. 2015. Why do women invest in pre-pregnancy health and care? A qualitative investigation with women attending maternity services. BMC Pregnancy Childbirth. 15(1):236. https://doi.org/10.1186/s12884-015-0672-3

Beasant L, Ingram J, Taylor CM. 2023. Fish consumption during pregnancy in relation to national guidance in England in a mixed-methods study: the PEAR Study. Nutrients. 15(14):3217. https://doi.org/10.3390/nu15143217

Béné C et al. 2015. Feeding 9 billion by 2050 – Putting fish back on the menu. Food Sec. 7(2):261–274. https://doi.org/10.1007/s12571-015-0427-z

Broughan JM et al. 2024. Prevalence of neural tube defects in England prior to the mandatory fortification of non-wholemeal wheat flour with folic acid: a population-based cohort study. Arch Dis Child. 109(2):106–112. archdischild- https://doi.org/10.1136/archdischild-2023-325856

Cai J, Leung P. 2022. Unlocking the potential of aquatic foods in global food security and nutrition: a missing piece under the lens of seafood liking index. Global Food Secur. 33:100641. https://doi.org/10.1016/j.gfs.2022.100641

Carlucci D et al. 2015. Consumer purchasing behaviour towards fish and seafood products. Patterns and insights from a sample of international studies. Appetite. 84:212–227. https://doi.org/10.1016/j.appet.2014.10.008

Coletta JM, Bell SJ, Roman AS. 2010. Omega-3 fatty acids and pregnancy. Rev Obstet Gynecol. 3(4):163–171.

Corfe S. 2018. What are the barriers to eating healthily in the UK? The Social Market Foundation. Retrieved Febuary 3, 2023, from https://www.smf.co.uk/wp-content/uploads/2018/10/What-are-the-barriers-to-eating-healthy-in-the-UK.pdf

Derbyshire E. 2019. Oily fish and omega-3s across the life stages: a focus on intakes and future directions. Front Nutr. 6:165. https://doi.org/10.3389/fnut.2019.00165

Farmery AK, Putten IEv, Phillipov M, McIlgorm A. 2020. Are media messages to consume more under-utilized seafood species reliable? Fish and Fisheries. 21(4):844–855. https://doi.org/10.1111/faf.12467

Forbes LE, Graham JE, Berglund C, Bell RC. 2018. Dietary Change during Pregnancy and Women's Reasons for Change. Nutrients. 10(8):1032. https://doi.org/10.3390/nu10081032

Gawel JPF, Aldridge DC, Willer DF. 2023. Barriers and drivers to increasing sustainable bivalve seafood consumption in a mass market economy. Food Front. 4(3):1257–1269. https://doi.org/10.1002/fft2.282

Govzman S et al. 2021. A systematic review of the determinants of seafood consumption. Br J Nutr. 126(1):66–80. https://doi.org/10.1017/s0007114520003773

Grand-Guillaume-Perrenoud JA, Origlia P, Cignacco E. 2022. Barriers and facilitators of maternal healthcare utilisation in the perinatal period among women with social disadvantage: a theory-guided systematic review. Midwifery. 105:103237. https://doi.org/10.1016/j.midw.2021.103237

Harrison LOJ, Engelhard GH, Thurstan RH, Sturrock AM. 2023. Widening mismatch between UK seafood production and consumer demand: a 120-year perspective. Rev Fish Biol Fish. 33(4):1–22. https://doi.org/10.1007/s11160-023-09776-5

House of Commons Library. 2023. Women and the UK economy. Retrieved January 17, 2024, from https://researchbriefings.files.parliament.uk/documents/SN06838/SN06838.pdf

Innis SM. 2003. Perinatal biochemistry and physiology of long-chain polyunsaturated fatty acids. J Pediatr. 143(4 Suppl):S1–S8. https://doi.org/10.1067/s0022-3476(03)00396-2

Jacobs S, Sioen I, Marques A, Verbeke W. 2018. Consumer response to health and environmental sustainability information regarding seafood consumption. Environ Res. 161:492–504. https://doi.org/10.1016/j.envres.2017.10.052

Kantar Worldpanel. 2023. Grocery Market Share. Retrieved September 8, 2023, from https://www.kantarworldpanel.com/grocery-market-share/great-britain

Kapur A, Hod M. 2020. Maternal health and non-communicable disease prevention: an investment case for the post COVID-19 world and need for better health economic data. Int J Gynaecol Obstet. 150(2):151–158. https://doi.org/10.1002/ijgo.13198

Keikha M, Jahanfar S, Hemati Z. 2022. A neglected critical time to prevent maternal and offspring's adverse outcomes: the preconception period. Int J Reprod Biomed. 20(1):65–67. https://doi.org/10.18502/ijrm.v20i1.10237

Liaset B, Øyen J, Jacques H, Kristiansen K, Madsen L. 2019. Seafood intake and the development of obesity, insulin resistance and type 2 diabetes. Nutr Res Rev. 32(1):146–167. https://doi.org/10.1017/s0954422418000240

Liu C, Ralston NVC. 2021. Seafood and health: what you need to know? Adv Food Nutr Res. 97:275–318. https://doi.org/10.1016/bs.afnr.2021.04.001

Love DC et al. 2022. Affordability influences nutritional quality of seafood consumption among income and race/ethnicity groups in the United States. Am J Clin Nutr. 116(2):415–425. https://doi.org/10.1093/ajcn/nqac099

Myhre JB, Løken EB, Wandel M, Andersen LF. 2016. Differences in nutrient composition and choice of side dishes between red meat and fish dinners in Norwegian adults. Food Nutr Res. 60(1):29555. https://doi.org/10.3402/fnr.v60.29555

NDNS. 2023. National Diet and Nutrition Survey Years 1-11, 2008-2019. Retrieved February 3, 2023, from https://beta.ukdataservice.ac.uk/datacatalogue/studies/study?id=6533

NHS. 2020. Vitamin D. Retrieved February 3, 2023, from https://www.nhs.uk/conditions/vitamins-and-minerals/vitamin-d/

NHS. 2022a. Fish and shellfish. Retrieved February 3, 2023, from https://www.nhs.uk/live-well/eat-well/food-types/fish-and-shellfish-nutrition/

NHS. 2022b. Vitamins, minerals and supplements in pregnancy. Retrieved February 3, 2023, from https://www.nhs.uk/pregnancy/keeping-well/vitamins-supplements-and-nutrition/

NIH. 2023. Omega-3 Fatty Acids. Retrieved August 8, 2023, from https://ods.od.nih.gov/factsheets/Omega3FattyAcids-Consumer/

Olsen SO. 2003. Understanding the relationship between age and seafood consumption: the mediating role of attitude, health involvement and convenience. Food Qual Preference. 14(3):199–209. https://doi.org/10.1016/s0950-3293(02)00055-1

ONS. 2015. Chapter 3: equivalised income - Office for National Statistics. Retrieved January 17, 2024, from https://www.ons.gov.uk/peoplepopulationandcommunity/personalandhouseholdfinances/incomeandwealth/compendium/familyspending/2015/chapter3equivalisedincome#introduction

ONS. 2023. Births by parents' characteristics - Office for National Statistics. Retrieved February 3, 2023, from https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/livebirths/datasets/birthsbyparentscharacteristics

PHE. 2018a. Health matters: reproductive health and pregnancy planning - GOV.UK. Retrieved February 3, 2023, from https://www.gov.uk/government/publications/health-matters-reproductive-health-and-pregnancy-planning/health-matters-reproductive-health-and-pregnancy-planning

PHE. 2018b. Making the case for preconception care. Retrieved November 21, 2023, from https://assets.publishing.service.gov.uk/media/5b585b3a40f0b6338218d6f1/Making_the_case_for_preconception_care.pdf

PHE. 2019. Health of women before pregnancy: health behaviours, risk factors and inequalities. Retrieved February 3, 2023, from https://assets.publishing.service.gov.uk/media/5dc00b22e5274a4a9a465013/Health_of_women_before_and_during_pregnancy_2019.pdf

PHE. 2020a. National Diet and Nutrition Survey - GOV.UK. Retrieved February 3, 2023from https://www.gov.uk/government/collections/national-diet-and-nutrition-survey

PHE. 2020b. NDNS: results from years 9 to 11 (2016 to 2017 and 2018 to 2019) - GOV.UK. Retrieved February 3, 2023, from https://www.gov.uk/government/statistics/ndns-results-from-years-9-to-11-2016-to-2017-and-2018-to-2019

Poston L et al. 2016. Preconceptional and maternal obesity: epidemiology and health consequences. Lancet Diabetes Endocrinol. 4(12):1025–1036. https://doi.org/10.1016/s2213-8587(16)30217-0

Robinson JPW et al. 2022. Navigating sustainability and health trade-offs in global seafood systems. Environ Res Lett. 17(12):124042. https://doi.org/10.1088/1748-9326/aca490

SACN. 2004. SACN Advice on Fish Consumption. https://assets.publishing.service.gov.uk/media/5a7dbedc40f0b65d88634277/SACN_Advice_on_Fish_Consumption.pdf

Stephenson J et al. 2018. Before the beginning: nutrition and lifestyle in the preconception period and its importance for future health. The Lancet. 391(10132):1830–1841. https://doi.org/10.1016/s0140-6736(18)30311-8

Wagner CL, Taylor SN, Johnson DD, Hollis BW. 2012. The role of vitamin D in pregnancy and lactation: emerging concepts. Womens Health (Lond). 8(3):323–340. https://doi.org/10.2217/whe.12.17

Wellings K et al. 2013. The prevalence of unplanned pregnancy and associated factors in Britain: findings from the third National Survey of Sexual Attitudes and Lifestyles (Natsal-3). The Lancet. 382(9907):1807–1816. https://doi.org/10.1016/s0140-6736(13)62071-1

Willer DF, Aldridge DC. 2020. Sustainable bivalve farming can deliver food security in the tropics. Nat Food. 1(7):384–388. https://doi.org/10.1038/s43016-020-0116-8

Willer DF, Aldridge DC. 2023. Enhancing domestic consumption to deliver food security in a volatile world. Glob Sustain. 6:e18. https://doi.org/10.1017/sus.2023.17

Willer DF et al. 2023. Naked Clams to open a new sector in sustainable nutritious food production. Npj Sustain Agric. 1(1):4. https://doi.org/10.1038/s44264-023-00004-y

Willer DF et al. 2024. Wild fish consumption can balance nutrient retention in farmed fish. Nat Food. 5(3):221–229. https://doi.org/10.1038/s43016-024-00932-z

Willer DF, Nicholls RJ, Aldridge DC. 2021. Opportunities and challenges for upscaled global bivalve seafood production. Nat Food. 2(12):935–943. https://doi.org/10.1038/s43016-021-00423-5

Willer DF, Robinson JPW, Patterson GT, Luyckx K. 2022. Maximising sustainable nutrient production from coupled fisheries-aquaculture systems. PLOS Sustain Transform. 1(3):e0000005. https://doi.org/10.1371/journal.pstr.0000005

Xia S et al. 2024. Unlocking the potential of forage fish to reduce the global burden of disease. BMJ Glob Health. 9(3):e013511. https://doi.org/10.1136/bmjgh-2023-013511

Zeng Z, Liu F, Li S. 2017. Metabolic adaptations in pregnancy: a review. Ann Nutr Metab. 70(1):59–65. https://doi.org/10.1159/000459633