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The Health Benefits of Eating Seafood

Evidence Based Science

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The content of this report will be written up as a scientific journal article by Dr Wendy Hunt and Professor Alexandra McManus within four months.

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Acronyms and Glossary of Terms

ALA	Alpha linoleic acid
CHD	Coronary heart disease
CV	Cardiovascular
CVD	Cardiovascular disease
DHA	Docosahexaenoic acid
DPA	Docosapentaenoic acid
EPA	Eicosapentaenoic acid
HDL-C	High density lipoprotein cholesterol
LC PUFA	Long chain polyunsaturated fatty acids
LDL-C	Low density lipoprotein cholesterol
PUFA	Polyunsaturated fatty acids
n-3 PUFA	Omega-3 polyunsaturated fatty acids
n-6 PUFA	Omega-6 polyunsaturated fatty acids
VLDL	Low density lipoprotein cholesterol

Oily Fish: "Oil-rich fish (or oily fish) are those that have oil distributed through their body, in contrast to white fish, where the main concentration of oils is located in the liver. Oily fish (e.g., Anchovies, Herring, Mackerels, Salmons, Trouts, Swordfish and Eels) contain higher levels of long chain polyunsaturated fatty acids (LC PUFA).

Executive Summary

Introduction

Seafood is an excellent source of energy and contains a range of nutrients that are beneficial for human health. These include Omega-3 polyunsaturated fatty acids (n-3 PUFA), protein, Vitamins A, B12, D and E, calcium, iodine, iron, zinc, selenium, copper, manganese, phosphorus and taurine. Each of these nutrients offer a range of health benefits.

This report summarises moderate to high level scientific evidence from peer reviewed journals published from January 2015 to January 2025, that focus on the health benefits of seafood consumption to human health.

Methods

Four academic search engines (PubMed, Medline Ovid, Scopus, Cochrane Reviews) were used to identify peer-reviewed journal articles that met the following Boolean search terms: seafood, fish, omega, nutrient, health and health benefits (n=9,875 articles). A four-stage culling process was independently conducted by two highly experienced reviewers (authors). A total of 281 peer reviewed articles met all criteria and were included in this literature review. Articles were assigned a classification level of graded evidence based on the rigour of study design and a moderate or high level of evidence.

Results

Key findings from published studies that fulfilled the search strategy are presented below under relevant headings.

All-cause mortality

- Fish and n-3 PUFA consumption reduce all-cause mortality
- Moderate consumption of seafood has the greatest effect on health
- The strongest n-3 PUFA evidence relates to DHA consumption
- The greatest benefit is gained from the ingestion of seafood as part of a healthy diet

Asthma and allergies

- Asthma, allergy and wheezing in infants may be mitigated by the ingestion of high n-3 PUFA seafood during pregnancy
- Consumption of fish (particularly seafood high in n-3 PUFA and Vitamin D) in the first year of life is associated with a reduced risk of eczema, allergic rhinitis, asthma and wheeze
- Infant formula fortified with n-3 PUFA aids immune development

Bone health and osteoporosis

- Fish consumption and n-3 PUFA may protect bone health and reduce the risk of hip fracture
- Consumption of ≥ 5 serves of oily fish each week reduces the incidence of osteopenia and osteoporosis, particularly in senior women
- A diet high in n-3 PUFA and low in n-6 PUFA is protective against fractures and helps to maintain bone health
- A high n-3 PUFA status is associated with a lower risk of fracture

Cancer

- A diet high in seafood and n-3 PUFA is protective against a number of cancers
- A high n-3 PUFA status is associated with lower fatigue in cancer patients
- n-3 PUFA as part of a healthy diet increases appetite and nutritional status in chemotherapy patients

- ***Breast cancer***
    - High levels of fish consumption and n-3 PUFA is associated with a reduction in all-cause mortality in women with breast cancer
    - EPA and DHA status may be predictive of breast cancer risk
    - n-3 PUFA are beneficial to the prevention, development and progression of breast cancer

- ***Colorectal cancer***
  - ≥ 2 serves of oily fish per week reduces the risk of cancer including colon, liver, and gallbladder cancers in adults
  - Higher n-3 PUFA status (in comparison to n-6 PUFA) reduces the risk of colorectal tumours
  - EPA and DHA consumption and dietary fibre are associated with a lower risk of colorectal cancer

- **Lung cancer**
  - Fish oil supplementation in adults (or ≥ 2 serves of seafood per week) reduces the risk of lung cancer
  - n-6 to n-3 PUFA ratio is inversely associated with the risk of lung cancer
  - n-3 PUFA improves nutritional status and reduces inflammation in lung cancer patients undergoing radio or chemotherapy
  - n-3 PUFA supplementation increases weight and quality of life in patients with lung cancer

- ***Other cancers***
  - n-3 PUFA (particularly DHA) reduces the risk of neck, head, oesophageal, pancreatic and endometrial cancers
  - Adequate intake of n-3 PUFA reduces inflammation and improves immune function in cancer patients

Cardiovascular disease (CVD)

- Seafood as part of a balanced diet reduces the risk of CVD mortality, coronary heart disease (CHD), myocardial infarction and stroke
- ≥ 2 serves of seafood per week is recommended to reduce the risk of congestive heart failure, CHD, ischemic stroke, and sudden cardiac death
- Consumption of fatty fish (not lean) reduces the risk of CVD and myocardial infarction

- ***n-3 PUFA supplementation***
  - Adequate intake of n-3 PUFA is associated with many health benefits including: a reduction in the risk of cardiovascular (CV) events, CHD mortality and premature death
  - There is strong evidence supporting the cardioprotective role of marine sourced EPA and DHA across the lifespan
  - Clinical grade fish oil supplementation reduces the length of stay in Intensive Care Units (ICU) and in hospital following coronary artery bypass surgery
  - n-3 PUFA supplementation (especially DHA) reduces heart rate and blood pressure which is beneficial to those at high risk of ischemic stroke
  - High doses of clinical grade n-3 PUFA supplementation are recommended to improve clinical outcomes and reduce cardiac mortality in patients with chronic atherosclerotic disease

- ***Heart surgery***
  - n-3 PUFA, particularly EPA, is associated with a substantial decrease in the risk of requiring coronary revascularizations (procedure to restore blood flow)
  - n-3 PUFA together with Vitamin C supplements significantly reduces postoperative fatigue and some adverse outcomes (including excessive bleeding) in coronary patients
  - The anti-inflammatory properties of n-3 PUFA assist in recovery following most heart-related surgeries

- ***Blood lipids***
  - n-3 PUFA supplementation and consumption of seafood high in n-3 PUFA impact favourably on maintaining appropriate cholesterol levels in the body
  - High levels of triglycerides (which increase the risk of cardiac events) may be mitigated with adequate intake of n-3 PUFA
  - Fish oil and Vitamin E supplementation are effective in reducing high cholesterol levels in menopausal women

Diabetes

- Regular consumption of seafood (or n-3 PUFA supplementation) as part of a healthy diet is inversely associated with all-cause mortality and CVD in those with type 2 diabetes mellitus
- High levels of serum DHA improve the biomarkers of insulin sensitivity
- Adequate intake of n-3 PUFA, reduces inflammation and improves retinal health
- Fish oil supplementation in pregnant women with type 2 diabetes has significant benefits to insulin resistance

Fertility

- There is strong emerging evidence that seafood consumption or n-3 PUFA supplementation can improve semen quality, concentration and motility

Healthy ageing

- The significant benefits offered by n-3 PUFA associated with healthy ageing include reduced all-cause mortality, improved cognitive function, preservation of muscle strength and improved balance (leading to a reduction in disabling falls)
- The anti-inflammatory properties of n-3 PUFA are beneficial to the ageing process
- There is strong evidence that a diet high in seafood (≥ 2 serves of seafood per week), as part of a healthy diet, has a positive effect on health across the lifespan

- ***Alzheimer's disease and dementia***
  - Two serves of fish a week is protective against cognitive decline (10% reduction in all-cause dementia and 30% reduction in Alzheimer's disease risk)
  - High seafood or n-3 PUFA consumption improves executive function, cognition, memory, and neuro inflammation (association with cognitive decline)
  - There is significant evidence that a high intake of n-3 PUFA delays the onset to Alzheimer's disease and slows progression of the disease following onset
  - A high intake of fish in mid-life may reduce the likelihood of developing dementia

- ***Other age-related issues***
  - ≥ 2 serves of oily fish or the equivalent in n-3 PUFA improves brain function and slows the rate of cognitive decline
  - Higher consumption of oily fish (or fish oil supplements) may prevent frailty in older adults
  - Oily fish consumption and n-3 PUFA (EPA and DHA) are inversely related to the incidence of pain in older adults

Hospitalisation

- The n-3 PUFA status of critically ill patients is associated with a reduced risk of infection plus shorter hospital and ICU lengths of stay
- Increased EPA and DHA emulsions improve survival rates in critically ill septic patients

Inflammatory conditions

- Consumption of oily fish and n-3 PUFA mitigate inflammatory markers which indicate levels of inflammation (particularly in those affected by diabetes and CVD)
- Consumption of a Mediterranean diet (including two meals or a minimum of 300 g of oily fish each week) significantly reduces airway inflammation in children
- n-3 PUFA supplementation reduces inflammation associated with many health-related conditions (e.g., diabetes, CV events, arthritis, metabolic syndrome, gut-related problems, systemic lupus, peripheral vascular conditions, kidney disease)

Kidney health

- Higher consumption of marine n-3 PUFA is associated with a lower risk of chronic kidney disease
- Marine n-3 PUFA supplementation significantly improves cardiac function in renal transplant patients
- n-3 PUFA supplementation reduces CV mortality in patients on haemodialysis

Liver health

- n-3 PUFA improve metabolic indicators, liver enzymes and reduce liver fat content in patients with non-alcoholic fatty liver disease

Maternal health

- There is significant evidence supporting n-3 PUFA supplementation in later pregnancy (24 weeks onwards) to prolong pregnancy (reduce incidence pre-term birth) and improve birth weight
- n-3 PUFA consumption during pregnancy can reduce the risk of preeclampsia
- Maternal n-3 PUFA intake during pregnancy and lactation reduces the risk of infant food allergy and food sensitisation and is more efficacious than consumption of n-3 PUFA during childhood
- n-3 PUFA and iodine from fish consumption reduce maternal depression and anxiety and increase neurocognitive child development

Infant health

- Consumption of fatty fish during pregnancy benefits infant cognitive function
- Consumption of fish in the first year of life reduces the risk of eczema and allergic rhinitis (severe hay fever)
- Maternal fish consumption during pregnancy may reduce the risk of neurodevelopmental delay in the domains of fine motor, problem-solving, and personal-social traits
- Consumption of n-3 LC PUFA throughout life may have a positive effect on neurodevelopment including communication, working memory, executive function and visual attention

Menopause

- n-3 PUFA can reduce night sweats in menopausal women
- Fish oil and Vitamin E supplementation reduces total and LDL cholesterol in menopausal women

Mental health – anxiety and depression

- A Mediterranean diet and supplementation with fish oil reduces depressive and dementia symptoms and improves mental health and quality of life
- High adult fish consumption (≥ 4 serves per week) is associated with 26% lower odds of depression compared with low fish consumption (< 1 serve per week), especially in females
- n-3 PUFA supplementation had a significant effect on perinatal depression
- Mild to moderate depression in pregnant and postpartum women is significantly improved by high EPA: DHA (≥ 1.5) supplementation
- n-3 PUFA (EPA and DHA) supplementation reduces the symptoms of depression

Mental health – behavioural disorders

- Low intakes of marine n-3 PUFA increases the risk of attention deficit hyperactivity disorder, autism, bipolar disorder, depression and suicide ideation
- Child n-3 PUFA supplementation can improve health status and quality of life in children especially where hyperactivity, inattention, problems with conduct or aggression exist
- Treatment with n-3 fatty acid supplementation has proven effective in improving the social and interpersonal skills of children with some personality disorders

Mental health - other issues

- Greater consumption of oily fish is associated with better sleep quality
- DHA is associated with health benefits related to autistic spectrum disorder, Alzheimer's disease, schizophrenia, stroke and traumatic brain injury
- n-3 PUFA supplementation benefits younger adults with lower n-3 PUFA status and schizophrenia in the prodromal stage of disease

Metabolic syndrome

- n-3 PUFA lower the risk of developing metabolic syndrome
- Short term fish oil supplementation in adults with metabolic disorder increased insulin sensitivity
- n-3 PUFA together with Vitamin E improves blood lipid profiles of patients with metabolic syndrome

Muscle health and performance

- n-3 LC PUFA may maintain or increase neuromuscular function during ageing
- n-3 PUFA may lead to small increases in muscle strength
- n-3 PUFA improve recovery from onset muscle soreness and improve muscle function
- Fish oil supplementation of athletes benefits the central nervous system, CV system, skeletal muscle and reduces proinflammatory cytokines

Health benefits associated with eating seafood

- The benefits of fish consumption and the role of n-3 PUFA in health at all stages of life from conception to ageing outweigh the potential risks (with the exception of a few selected species in sensitive populations)

1. Introduction

Seafood as a whole food is an important source of human nutrition. Evidence of benefits to health derived from seafood consumption is clear for many physiological systems and functions. The health benefits from specific components of seafood such as marine sourced n-3 LC PUFA (omega-3 long chain polyunsaturated fatty acids) have generated extensive research activity as well as a proliferation of fortified or functional foods and dietary supplements.

n-3 LC PUFA provide benefits to human health through the prevention and management of conditions such as coronary heart disease (CHD), stroke and cardiovascular disease (CVD) [1]. The consumption of fish or seafood offers greater benefits to health than consuming n-3 LC PUFA or other individual nutrients as supplements [2]. Seafood and fish are sources of complete protein, are rich in essential amino acids and also contain many bioavailable nutrients including Vitamins A, B and D as well as the minerals iodine, selenium, zinc, calcium, phosphorous, iron, copper, manganese, and taurine [3,4]. Table 1 outlines the main nutrients and minerals found in seafood and some of the health benefits that result from regular consumption of seafood as part of a healthy diet.

Dietary patterns that are characterised by seafood and fish consumption such as the Mediterranean diet, are linked to human health. There are many reviews and meta-analysis that provide substantive evidence for a whole of diet approach including fish and seafood. For instance a diet rich in wholegrain cereals, fruits, vegetables, nuts, legumes, dairy and fish, but not egg, red meat and processed meat and sugar sweetened beverages, is associated with reduced risk of CHD, stroke and heart failure [5]. [L1, M] Dietary consumption of virgin olive oil, nuts, legumes, wholegrains and fish improve high density lipoprotein cholesterol (HDL-C) functions in adults with a high cardiovascular risk (CV) [6]. Fish consumers and vegetarians have lower rates of ischaemic heart disease compared to meat eaters although vegetarians have a higher incidence of stroke [7].

Table 1: The health benefits of seafood as part of a healthy diet

Beneficial Nutrients and Minerals in Seafood	**Health benefits provided**
Omega-3 fatty acids	Essential for health (human bodies do not make them) Essential to brain development and function Reduces heart disease and aids blood vessel function Helps to maintain and improve eyesight May reduce asthma and allergies
Calcium	Works with Vit D to develop and maintain strong bones Vital for muscle, nerve and heart function Helps to prevent osteoporosis
Iodine	Essential for thyroid function, growth, metabolism, cellular oxygenation and maintenance of the central nervous system
Vitamin D	Seafood is the best source of Vitamin D (second only to the sun) Improves immune function, skin condition and muscle strength Oily fish are a rich source of Vitamin D
Iron	Production of energy; necessary for muscle function Facilitates blood oxygenation
Vitamin B12	Aids DNA synthesis and normal blood function Aids neurological function Helps to retain cognitive function in ageing
Zinc	Aids immunity and healing
Protein	Repairs and maintains cells (muscles, bones, fingernails, hair) Vital for digestive function and antibody production Source of energy Basis for hormones such as adrenaline
Selenium	Prevents cellular damage Regulates thyroid function Supports a healthy immune function
Vitamins A and E (antioxidants)	Important to heart and skin Essential for nervous and circulatory systems function
Copper	Keeps nerve cells and immune systems healthy Helps make red blood cells Essential for blood and nervous systems function
Manganese	Helps form connective tissue, bones, blood and sex hormones Helps metabolise fats and carbohydrate Aids calcium absorption and blood sugar regulation Essential for normal brain and nerve function
Phosphorous	Essential for bone and teeth health Helps filter waste from kidneys Helps the body store and use energy Reduces muscle pain following exercise
Taurine	Essential for heart and brain function Supports the nervous system and aids nerve growth Lowers blood pressure

Within a healthful dietary pattern, seafood as a whole food is the best dietary source for many nutrients [2]. This report is the product of a rapid review of peer reviewed journal articles providing evidence for the benefits of seafood and fish consumption to human health. Evidence for marine based n-3 LC PUFA and for dietary patterns that feature seafood and fish consumption are also reviewed.

2. Methodology

The methodology for this rapid literature review is based on several high-level literature reviews published by the authors [8-14].

The foci of this rapid literature review were to:

- identify and summarise existing moderate to high level evidence around seafood consumption as it relates to human health and health benefits;
- identify known benefits of seafood consumption to specific sectors of the population; and
- identify known benefits of seafood consumption for specific health related issues.

Peer reviewed journal articles were identified from four academic search engines being: PubMed, Medline Ovid, Scopus and Cochrane Reviews using a combination of the following Boolean terms: seafood, fish, omega, nutrient, health and health benefits. The detailed search strategy is presented in Appendix 1. Relevant articles published from January 2015 to January 2025 are included in this review.

The inclusion criterion applied to articles was that they provided moderate to high levels of evidence to support benefits to human health. Articles providing emerging or a low level of scientific evidence were excluded. The criteria for assessing the level and strength of evidence in the results section of this review are presented in Table 2. For example, a high-level systematic review of several high-quality studies with consistent results would be assigned as a Level 1 study of high strength. [L1, H]

Table 2: Classification of graded level of evidence[15]

Level 1 study design (L1)	High level systematic reviews Randomised controlled studies Meta - analyses
Level 2 study design (L2)	Quasi experimental studies Cohort studies Case - control studies
High strength of evidence (H)	Further research is very unlikely to change confidence in the estimated effect Several high-quality studies with consistent results In special cases: one large, high quality multi-centre study
Moderate strength of evidence (M)	Further research is likely to have an impact and may change estimates of effect One high quality study Several studies with some limitations

A total of 9,875 articles met the criteria under the search terms (Appendix 1). After removal of duplicate citations, 8,530 remained (Figure 1). These were reviewed independently by the authors over four stages or 'culls'. Titles and abstracts were reviewed in the first three culls and full articles for the final cull.

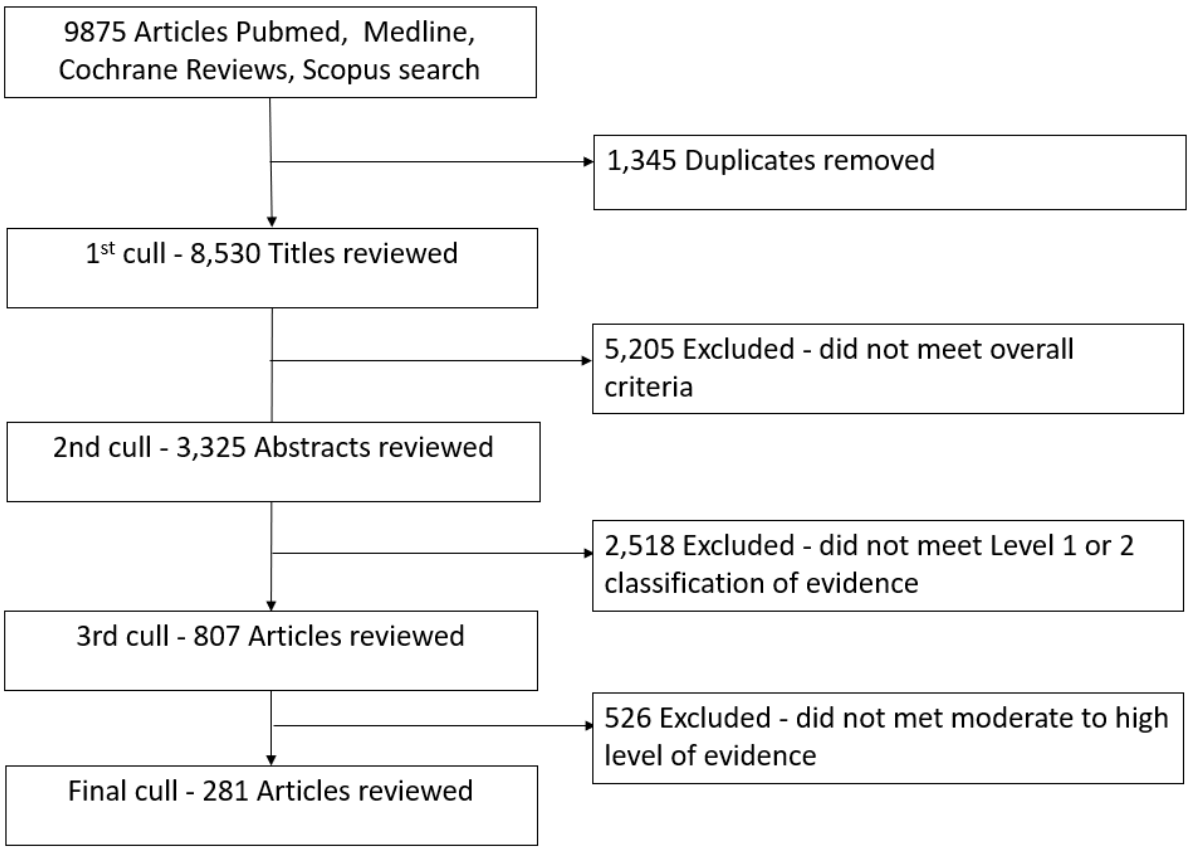

Figure 1: Process for review of peer-reviewed journal articles

3. Literature Review Results

Key findings from published studies that fulfilled the search strategy are presented herein under relevant headings, in dot point form. Each publication reviewed has been assigned a level of evidence based on the Classification of Graded Level of Evidence outlined in Table 1 in the methodology being:

- Level 1 study design, high confidence in quality. [L1, H]
- Level 1 study design, moderate confidence in quality. [L1, M]
- Level 2 study design, high confidence in quality. [L2, H]
- Level 2 study design, moderate confidence in quality. [L2, M]

3.1 All-cause mortality

- Fish and n-3 LC PUFA consumption reduce all-cause mortality [16,17]. [L1, M-H]
- Consumption of fish (not fried) and n-3 LC PUFA is associated with a reduction in mortality [18]. [L1, H]
- Fish consumption may have a U-shaped dose response to reducing all-cause mortality, especially in women, where moderate consumption has the greatest effect [19]. [L1, M]
- Dietary marine n-3 PUFA has strong links to reduced all-cause mortality [20]. [L1, H]
- Docosahexaenoic acid (DHA) status reduces the risk of all-cause mortality including cardiovascular disease (CVD) and cancer related death [21,22]. [L1, H]
- There is strong evidence that high levels of DHA support healthy ageing [23]. [L1, H]
- Consumption of fish, whole grains, fibre and n-3 PUFA are inversely associated with all-cause mortality in individuals with type 2 diabetes [24]. [L1, M]

3.2 Asthma and allergies

- Maternal fish consumption is associated with a reduced risk of infant allergy [25] [L1, H] with plasma PUFA inversely related to asthma, wheeze (from 24 weeks gestation) [26] [L1, M] and allergic sensitisation [27]. [L1, H]

- Consumption of fish in the first year of life is associated with a reduced risk of eczema, allergic rhinitis [25] [L1, H], asthma and wheeze [28]. [L1, H]
- Fish oil supplementation in children up to five years of age may be protective against the effects of traffic pollution [29]. [L1, M]
- Antenatal Vitamin D augments the positive relationship between plasma PUFA and reduced asthma and wheeze [30] [L2, H]. Additionally, Vitamin D and LC-PUFA can reduce asthma and allergic disease in adolescence [31]. [L2, M]
- n-3 LC PUFA supplementation to reduce asthma and allergies is most effective where there is a family history of allergy and when higher dose supplementation is taken in late pregnancy and early lactation [32-34]. [L1, H]
- Maternal supplementation with LC-PUFA during pregnancy and / or lactation reduces the risk of an infant developing any Immunoglobulin E (IgE) mediated allergy to 36 months of age but not beyond [33]. [L1, H]
- Infant formula fortified with n-3 LC PUFA can reduce the risk of allergic disease and respiratory illness suggesting LC PUFA are clinically important to immune development [35]. [L2, H]

3.3 Bone health and osteoporosis

- Fish consumption and dietary n-3 PUFA may protect bone health and reduce the risk of hip fracture [36]. [L1, M]
- Consumption of ≥ 5 serves of oily fish each week by senior women reduces the incidence of osteopenia and osteoporosis [37]. [L1, H]
- A low n-6:n-3 PUFA ratio (higher n-3) is associated with higher bone density [38] [L2, H] and a reduced risk of fragility fractures [39]. [L1, M]
- Higher PUFA status is associated with a lower risk of fracture in older adults, especially men [40]. [L1, H]
- n-3 PUFA supplementation during chemotherapy improves bone density and survival in cancer patients [41]. [L2, M]

3.4 Cancer

- Consumption of seafood, fish (non-fried) and n-3 PUFA is associated with a reduced risk of:
    - breast cancer [42], [L1, H]
    - colorectal cancer [43], [L1, H]
    - gastrointestinal cancer [44], [L1, M]
    - endometrial cancer [45], [L1, M]
    - hepatobiliary (liver) cancer [46], [L2, H]
    - oesophageal and head and neck cancer [47], [L1, M] and
    - pancreatic cancer [48]. [L1, H]
- Greater serum n-3 PUFA status is associated with lower fatigue in cancer patients [49]. [L1, M]
- Eicosapentaenoic acid (EPA) supplementation together with dietary counselling increases appetite and nutritional status in chemotherapy patients [50]. [L1, H]
- n-3 PUFA supplementation during chemotherapy improves bone density and survival in cancer patients [41]. [L2, M]
- n-3 PUFA is beneficial to patients with certain cancers [51] [L1, M]; they modulate cellular signalling, expression of genes associated with cancer pathogenesis and reduce inflammation with negligible adverse effects [52]. [L2, M]
- n-3 PUFA supplementation is associated with a reduction (non-significant) in the risk of cancer in adults consuming low levels of seafood [53]. [L1, H]

3.4.1 Breast cancer

- High levels of fish consumption and n-3 LC PUFA is associated with a 16-34% reduction in all-cause mortality in women with breast cancer [54,55]. [L1, H]
- EPA and DHA status may be predictive of breast cancer risk [56]. [L1, M]
- n-6 PUFA may be associated with increased breast cancer risk [57] [L1, H] and increasing n-3 PUFA (in comparison to n-6 PUFA) can reduce breast cancer risk [58]. [L1, M]
- n-3 LC PUFA are beneficial to the prevention, development and progression of breast cancer [59]. [L1, H]

3.4.2 Colorectal cancer

- Fish oil supplementation (or ≥ 2 serves fatty fish per week) reduces the risk of cancers including colon, hepatobiliary and lung cancer in adults [46]. [L2, H]
- Increasing consumption of n-3 PUFA, and seafood, while decreasing dietary n-6 PUFA and fats, reduces the incidence of colorectal tumours [60]. [L1, M]
- EPA and DHA consumption are associated with a lower risk of colorectal cancer (by approximately 11%) [61]. [L1, M]
- Fish oil has a beneficial effect on eicosanoids which are associated with colorectal cancer [62]. [L2, M]
- n-3 PUFA and fermentable dietary fibres are thought to reduce the risk of colon cancer [63]. [L2, M]

3.4.3 Lung cancer

- Fish oil supplementation in adults (those consuming ≥ 2 serves fatty fish per week) reduces the risk of hepatobiliary and lung cancer [46]. [L2, H]
- n-6:n-3 PUFA ratio is inversely associated with lung cancer risk [64]. [L1, H]
- Lung cancer patients undergoing radio or chemotherapy derive health benefits from n-3 PUFA through improved nutritional status and reduced inflammation [65].[L1, M]
- n-3 PUFA supplementation increases weight and quality of life in patients with non-small cell lung cancer and cancer cachexia (loss of muscle mass and fat) [66]. [L1, H]

3.4.4 Other cancers

- n-3 LC PUFA and non-fried fish consumption is associated with a 20% reduced risk of head and neck and oesophageal cancer [47]. [L1, M]
- Marine n-3 PUFA and DHA are associated with a reduced risk of pancreatic cancer [67]. [L1, H]
- High n-3 PUFA status is associated with reduced risk of endometrial cancer [45]. [L1, M]
- n-3 PUFA provides health benefits to post operative gastrointestinal cancer patients due to anti-inflammatory properties and improved immune function [68,69]. [L1, M-H]

3.5 Cardiovascular disease

3.5.1 Diet and seafood consumption

- A Mediterranean diet, high in fruit, vegetables, nuts and fish, improves atherothrombosis (arterial health) biomarkers in high CVD risk adults [70]. [L2, H]
- Higher dietary intake of fish, fruit and vegetables and lower salt intake are associated with a lower risk of CVD mortality [71]. [L2, M]
- Fish and marine n-3 PUFA are inversely related to the risk of CVD mortality [72-76] [L1, M-H], myocardial infarction [77] [L1, H], and stroke [78,79]. [L1, M-H]
    - Some studies report mixed results or lower levels of evidence for n-3 PUFA and stroke risk or all-cause mortality [80,81]. [L1, M-H]
    - Fish consumption reduces the risk of CHD and CHD mortality [82]. [L1, M]
    - Fatty fish consumption (but not lean fish) is inversely associated with CHD incidence and mortality [83]. [L1, H]
- The American Heart Association recommends 1 to 2 seafood meals per week to reduce the risk of congestive heart failure, CHD, ischemic stroke, and sudden cardiac death, especially where seafood replaces the consumption of less healthy foods [84]. [L1, H]
    - Two serves of fish each week reduces the risk of CVD outcomes by 10%, one serve per day reduces the risk by 30% [85]. [L1, H]
    - Some suggestion a U shape relationship where moderate consumption is more beneficial to health than high or low fish consumption [86]. [L1, M]
    - Two serves of oily fish per week reduces the risk of major CV events and mortality in populations with existing CVD [87]. [L1, M]
- Consumption of fish 6-7 times a week is associated with healthier lifestyle behaviours and lower non-HDL-C [88]. [L2, H]
- The CVD protective role is linked to consumption of fatty fish but not lean fish [83]. [L1, H]
- Fish consumption (not fried fish) is associated with a reduction in CVD events and the risk of myocardial infarction [89]. [L1, H]
- Trans fatty acid consumption (but not PUFA) is associated with a greater risk of CVD [90]. [L1, H]

3.5.2 *n-3 PUFA supplementation*

- Fish oil reduces CHD and cardiovascular events [91]. [L1, M]
- n-3 PUFA is associated with a modestly reduced incidence of fatal CHD [92] [L1, H], CVD [93,94] [L1, M-H], premature death [95] [L1, H], improved suboptimal CV health [96] [L1, H] and reduced CV risk in patients with peripheral arterial disease [97]. [L1, M]
- n-3 PUFA supplementation is associated with a non-significant reduction in CV risk factors in adults with low dietary fish consumption [53]. [L1, H]
- Higher intakes of n-3 PUFA, EPA and DHA are associated with a reduced risk of CV events and mortality [98]. [L1, H]
- Marine n-3 PUFA, EPA and DHA are associated with a lower risk of atherosclerotic CVD [99,100]. [L1, H]
- n-3 PUFA supplementation can regulate endothelial dysfunction and arterial stiffness and may slow the progression of atherosclerosis [101]. [L1, M]
- n-3 PUFA supplementation reduces blood pressure in patients with a high risk of CVD [102] [L1, H] and metabolic syndrome [103]. [L1, H]
- Daily EPA and DHA supplementation as low as 0.7 g per day can reduce blood pressure and CVD risk [104]. [L1, M]
- There is strong evidence for the cardioprotective role of EPA and DHA [105]. [L1, H]
- EPA and DHA supplementation reduce the risk of myocardial inflation and CV death [106]. [L1, M]
- EPA and DHA are protective against CVD [107] [L1, H] and major ischemic events [99] [L1, H] with higher doses being more beneficial [108]. [L1, H]
- n-3 PUFA supplementation moderately reduces the risk of myocardial infarction with EPA alone offering a significant risk reduction for CVD outcomes [109-111]. [L1, M-H]
- EPA is effective in reducing the risk of CVD events, CVD mortality and myocardial infarction [76]. [L1, H],
- High doses of n-3 PUFA supplementation (> 1 g per day) may increase the risk of atrial fibrillation and bleeding [112-114] [L1, M-H]; or stroke in patients with previous myocardial infarction [113]. [L1, M]

- Fish or n-3 PUFA consumption is recommended for prevention of adverse coronary events [73]. [L1, H]
- Fish oil slightly reduced the length of stay in ICU and hospital following coronary artery bypass surgery and slightly reduced the incidence of associated arterial fibrillation [115]. [L1, M]
- There is substantiated evidence that DHA improves heart and CV function although more research is needed to identify the pathways of DHA within the body [23]. [L1, H]
- There is strong evidence that n-3 LC PUFA supplementation (particularly DHA) reduces heart rate. When DHA or EPA is administered alone, heart rate is slowed by DHA rather than by EPA [116]. [L1, H]
- n-3 PUFA is effective for secondary CVD prevention in patients with a high risk of CVD; risk is reduced for CHD but not stroke [117]. [L1, H]
- High n-3 PUFA status is associated with a lower overall stroke and ischemic stroke risk but not haemorrhagic stroke risk [118]. [L1, H]
- Higher levels of serum ALA (alpha linoleic acid) and EPA are associated with lower adverse clinical events in patients with acute myocardial infarction [119]. [L2, H]
- Higher adipose marine n-3 PUFA is associated with a lower risk of peripheral arterial disease [120]. [L2, H]
- Higher doses of n-3 PUFA are recommended to improve clinical outcomes and reduce cardiac mortality in patients with chronic atherosclerotic disease [22]. [L1, H]

3.5.3 Heart surgery

- n-3 PUFA, particularly EPA, is associated with a substantial decrease in the risk of requiring coronary revascularizations (procedure to restore blood flow) [109-111]. [L1, M-H]
- Supplementation with n-3 PUFA and Vitamin C significantly reduces patient postoperative fatigue following coronary artery bypass graft surgery [121]. [L1, H]
- High doses of n-3 PUFA reduce adverse left ventricular remodelling following myocardial infarction, non-infarction myocardial fibrosis, and serum biomarkers of systemic inflammation in patients with acute myocardial infarction [122]. [L2, M]
- Perioperative n-3 PUFA reduces bleeding and frequency of blood infusions [123]. [L1, M]

3.5.4 *Blood lipids*

- n-3 PUFA supplementation can induce favourable changes in blood lipids including a reduction in triglyceride levels [124,125]. [L1, M-H] One study identified a slight increase HDL- and LDL-C (low density lipoprotein cholesterol) [103,126-130]. [L1, M-H]
- There is moderate evidence for improvements in blood lipids and blood pressure through intake of n-3 PUFA in people without CVD [131]. [L1, H]
- The addition of n-3 PUFA to statin treatment reduces the incidence of myocardial infarction, adverse cardiac events, unstable angina and favourable changes in blood lipids [132-135]. [L1, M-H]
- Fish oil and Vitamin E supplementation reduce total cholesterol and LDL-C in menopausal women [136]. [L1, M]
- High levels of triglycerides increase the risk of heart disease and pancreatitis. n-3 PUFA reduces blood triglycerides with effects increased with increased doses of EPA [137]. [L1, H]

3.6 Diabetes

- Consumption of fish, whole grains, fibre and n-3 PUFA is inversely associated with all-cause mortality in individuals with type 2 diabetes [24]. [L1, M]
- Insulin sensitivity markers are significantly associated with serum DHA [138]. [L2, H]
- Short term fish oil supplementation in adults with metabolic disorder increases insulin sensitivity [139]. [L1, M]
- n-3 PUFA is associated with reductions in LDL-C, VLDL-C, triglycerides, proinflammatory cytokines and Haemoglobin A1c in type 2 diabetic patients which indicates a reduced CVD risk [140] [L1, H], improved glycaemia [141] [L1, H] and modulation of peripheral nerve health [142]. [L1, H]
- Higher dietary n-3 PUFA (ALA and DPA -docosapentaenoic acid) is associated with a reduction in all-cause and CV mortality in adults with diabetes or prediabetes [143]. [L1, H]
- 6 months of fish oil supplementation improves triglyceride and HDL-C levels but not glycaemic control in patients with type 2 diabetes and abdominal obesity [144,145]. [L1, M]

- 2 g fish oil per day is recommended to reduce inflammation and promote retinal health [146]. [L2, M]
- Consumption of 500 mg of n-3 LC PUFA or two serves of oily fish per week reduces the risk of diabetic retinopathy in people with type 2 diabetes [147]. [L2, H]
- The anti-inflammatory properties of fish oil and marine n-3 PUFA may be beneficial for diabetic neural peripheral neuropathy [148,149]. [L1, M]
- Supplementation with n-3 PUFA and Vitamin D improves sleep quality, depression and anxiety in women of reproductive age with pre-diabetes and low Vitamin D status [150]. [L2, M]
- n-3 PUFA supplementation is not associated with a reduced risk of gestational diabetes [151]. [L1, H]
- n-3 PUFA is inversely associated with diabetes in overweight females but not males [152]. [L1, H]
- n-3 PUFA have clear benefits to CV health for people with diabetes mellitus or prediabetes [75]. [L1, H]
- Fish oil supplementation benefits pregnant women with type 2 diabetes; < 200 mg EPA improves HOMA -IR (insulin resistance) [153]. [L1, M]

3.7 Fertility

- Greater male and female consumption of seafood is associated with a higher frequency of sexual intercourse and fecundity in couples attempting pregnancy [154]. [L2, M]
- Men's intake of omega-3 fatty acids may improve semen quality with increase sperm count, concentration and motility [155]. [L2, M]
- n-3 PUFA supplementation of infertile men significantly improves sperm motility and concentration of DHA in seminal plasma [156]. [L1, H]

3.8 Healthy ageing

3.8.1 Healthy ageing and seafood consumption

- A Mediterranean diet featuring vegetables, fruit and fish improves cognition and reduces the risk of depression and dementia. There is emerging evidence for a further benefit from dietary components including n-3 PUFA, polyphenols, Vitamin D and B vitamins [157]. [L2, M]
- n-3 PUFA have an anti-inflammatory effect in ageing [158]. [L1, M]
- n-3 PUFA supplementation can improve executive function in middle aged and elderly people [159]. [L1, M]
- Healthy ageing is associated with higher EPA and DPA status; health ageing was assessed as the absence of chronic conditions such as CV, cancer, chronic kidney or lung disease [160]. [L1, H]
- Fish oil n-3 PUFA can benefit muscle strength, physical performance and body composition and improve serum lipid profiles in older adults plus may help prevent sarcopenia (age related, muscle loss, strength and function) [161]. [L2, M]
- Supplementation with n-3 LC PUFA may maintain or increase neuromuscular function during ageing [162]. [L2, H]

3.8.2 Dementia and Alzheimer's disease

- Two serves of fish a week is protective against cognitive decline (10% reduction in all-cause dementia and 30% reduction in Alzheimer's disease risk) [163]. [L1, M]
- One serve of seafood and n-3 LC PUFA each week is protective against multiple cognitive declines [164]. [L2, M]
- Greater fish consumption is associated with a lower risk of dementia [165] [L1, H] and rate of memory decline [166]. [L1, H]
- A healthy diet improves cognitive function in older adults; long term protective effects were identified with a higher intake of fish and tea combined [167]. [L1, M]
- A high intake of fish in mid-life may reduce the likelihood of developing dementia [168,169]. [L1-2, M-H]

- Research has found that adequate intake of-3 PUFA reduces the neuroinflammation associated with cognitive decline plus delays the onset of Alzheimer's disease and slows disease progression following onset [170-172]. [L1, M-H]

3.8.3 Age related issues including cognitive decline

- n-3 PUFA supplementation in the elderly is beneficial for mild to moderate depression [173]. [L1, H]
- Higher n-3 LC PUFA status may provide benefit to the ageing brain and reduce the rate of cognitive decline in older adults [174,175] [L1-2, M-H] and Alzheimer's disease patients [176,177]. [L1-2, M-H]
- A higher n-3 PUFA status may be protective against the influence of air pollution on the brain [178]. [L1, M]
- DHA improves brain function and slows the rate of cognitive decline [23]. [L1, H]
- The benefits to cognition derived from fish oil supplementation in older adults may be affected by: carrier status of the gene APOE-ε4 which increases the chance of developing Alzheimer's disease [179] [L1, H] and gender. Further research is needed to investigate the influence of the APOE-ε4 gene, and gender [180]. [L2, M]
- Higher consumption of oily fish (or fish oil supplements) may prevent frailty in older adults [181]. [L2, H]
- Oily fish consumption and n-3 PUFA (EPA and DHA) are inversely related to the incidence of pain in older adults [182]. [L1, H]

3.9 Hospitalisation

- The n-3 PUFA status of critically ill patients reduced the risk of infection plus shortened hospital and ICU lengths of stay [183-185]. [L1, M-H]
- n-3 PUFA reduce the risk of infection in surgical and critically ill patients [186,187]. [L2, M]
- Increased EPA and DHA emulsions improve survival rates in critically ill septic patients [188]. [L2, M]
- n-3 PUFA improves arterial blood oxygenation; and reduces ICU length of stay and duration of mechanical ventilation in patients with acute respiratory distress [186]. [L1, M]

3.10 Inflammatory conditions

- Consumption of oily fish [189] [L2, H] and n-3 PUFA mitigate inflammatory markers which indicate lower levels of inflammation [190]. [L1, M]
- n-3 PUFA may reduce bio-inflammatory markers in diabetic and CV patients [191]. [L1, M]
- Consumption of a Mediterranean diet (including two meals or a minimum of 300 g of oily fish each week) significantly reduces airway inflammation in children [192]. [L2, M]
- n-3 PUFA supplementation in patients with schizophrenia and metabolic syndrome reduces levels of inflammation [193]. [L2, M]
- n-3 PUFA and Vitamin E supplementation may improve inflammation in haemodialysis patients [194]. [L1, M]
- n-3 PUFA has an anti-inflammatory effect on ageing [158]. [L2, M]
- n-3 PUFA reduces inflammatory marker C-reactive protein in patients with HIV [195]. [L1, M]
- The anti-inflammatory properties of fish oil and marine n-3 PUFA may be beneficial for diabetic neural peripheral neuropathy [148]. [L2, M]
- n-3 PUFA reduces the leukotriene B4 proinflammatory marker in patients with rheumatoid arthritis [196]. [L1, H]
- Consumption of > 2 g of n-3 PUFA per day, may improve inflammatory rheumatic diseases such as rheumatoid arthritis [197] [L1, M], and reduce symptoms of swollen and tender joints [198]. [L1, H]
- Fish consumption can reduce rheumatoid arthritis disease activity [199]. [L2, M]
- Increasing unsaturated fats (as a proportion of total dietary fat) reduces the incidence of metabolic syndrome [200] [L1, H].
- The anti-inflammatory properties of n-3 PUFA reduce the risk of developing rheumatoid arthritis or systemic lupus and reduce the severity of symptoms [190]. [L1, M]
- n-3 PUFA can increase survival in patients with systemic inflammatory response syndrome [16]. [L1, M]
- Consumption of n-3 PUFA has a beneficial effect on gut microbiota and may help regulate gut immunity [201]. [L1, M]

3.11 Kidney health

- Higher consumption of marine n-3 PUFA is associated with a lower risk of chronic kidney disease [202,203]. [L1, H]
- Dialysis patients have lower proportions of n-3 and n-6 PUFA than healthy adults [93,94]. [L1, M]
- Marine n-3 PUFA supplementation significantly improves cardiac function in renal transplant patients [204]. [L2, H]
- n-3 PUFA supplementation reduces CV mortality in patients on haemodialysis [205]. [L1, M]
- n-3 PUFA and Vitamin E supplementation may improve inflammation in haemodialysis patients [194]. [L1, M]

3.12 Liver health

- n-3 PUFA improve metabolic indicators, liver enzymes and reduce liver fat content in patients with non-alcoholic fatty liver disease [206]. [L1, M]
- n-3 PUFA supplementation (especially DHA) is beneficial in the treatment of non-alcoholic fatty liver disease [207]. [L1, H]

3.13 Maternal and infant health

3.13.1 Maternal health

- Consumption of n-3 LC PUFA (through food or supplements) during pregnancy can reduce the incidence of preterm birth and the chance of having a low birthweight baby [208-211]. [L1, M-H]
- n-3 PUFA consumption during pregnancy can reduce the risk of preeclampsia [212-214]. [L1-2, M-H]
- n-3 PUFA and n-3 PUFA-rich foods may decrease the risk of pregnancy loss [155]. [L2, M]
- Daily supplementation of n-3 PUFA (2.4 g total DHA and EPA) prolongs pregnancy and increases birthweight; the increase in birth weight is not explained by the longer gestation [215]. [L1, M]
- n-3 PUFA supplementation is linked to DHA and DHA derived oxylipins which play a role in pregnancy duration [216]. [L2, M]

- Higher fish consumption reduces the risk of preterm birth in lean women but increases the risk in obese women [217]. [L1, M]
- n-3 PUFA supplementation of women with a low n-3 PUFA status can reduce the risk of preterm birth [218]. [L2, M]
- DHA has a potential role in mitigating the effect of prenatal alcohol exposure on the foetus [219]. [L1, M]
- Maternal n-3 PUFA intake during pregnancy and lactation reduces the risk of infant food allergy and food sensitisation and is more efficacious than consumption of n-3 PUFA during childhood [34] [L1, H].
- Higher maternal serum DHA may influence plasma markers for insulin sensitivity [138]. [L2, H]
- n-3 PUFA and iodine from fish consumption reduce maternal depression and anxiety and increase neurocognitive child development [220]. [L2, M]
- n-3 PUFA, in pregnancy or postpartum, significantly improves symptoms of depression; the greatest effect is achieved with EPA supplementation in women with mild or moderate depression [221]. [L1, M]
- Fish oil supplementation improves the health of pregnant women with type 2 diabetes; EPA doses of < 200 mg improve insulin resistance (HOMA -IR) [153]. [L1, M]
- There is a need for further studies to identify appropriate dosage [222] [L1, M], length of treatment time and the effect of interactions between different dietary fatty acids associated with maternal health [223]. [L1, H]

3.13.2 Infant health

- Higher birthweight and a higher maternal PUFA status are associated with a higher infant PUFA status at 3 months of age [224]. [L2, H]
- Consumption of fatty fish during pregnancy benefits infant cognitive function and reduces autism spectrum traits [225,226]. [L1-2, M]
- Maternal fish consumption during pregnancy may reduce the risk of neurodevelopmental delay in the domains of fine motor, problem-solving, and personal-social traits [227]. [L1, H]

- Fish oil supplementation from 24 weeks of pregnancy reduces the number of incidences of gastroenteritis in infants to 3 years [228]. [L1, M]
- Consumption of fish in the first year of life reduces the risk of eczema and allergic rhinitis [25] [L1, H].
- n-3 PUFA supplementation improves child psychomotor skills and visual development [229]. [L1, M]
- Consumption of salmon (three times a week for 16 weeks) improves cognition in children [230,231]. [L1, M]
- n-3 PUFA supplementation of ≥ 450 mg DHA and EPA per day and an omega 3 index over six percent improves child and adolescent cognition [232]. [L1, H]
- DHA is an essential component of the brain. In cases where amino acid metabolism is compromised, DHA supplementation has proven effective in improving DHA levels within brain structures [233,234]. [L1-2, H]
- Consumption of n-3 LC PUFA throughout life may have a positive effect on neurodevelopment including communication, working memory, executive function and visual attention [235]. [L1, M]

3.14 Menopause

- n-3 PUFA can reduce night sweats in menopausal women [236]. [L1, M]
- Fish oil and Vitamin E supplementation reduces total and LDL cholesterol in menopausal women [136]. [L1, M]

3.15 Mental health

3.15.1 Anxiety and depression

- n-3 PUFA may reduce the symptoms of clinical anxiety [237] [L1, M] and chilliness associated with anxiety [238]. [L2, M]
- A Mediterranean diet and supplementation with fish oil reduces depressive symptoms and improves mental health as well as quality of life, within three months of the intervention [239]. [L2, M]

- n-3 PUFA (1000 mg) and Vitamin D supplementation (50,000 IU) in women of reproductive age with pre-diabetes and low vitamin D status for eight weeks improves anxiety, depression and sleep quality [150]. [L2, M]
- Mediterranean diets reduce the risk of depression and dementia. There is evidence for the protective role of n-3 PUFA, polyphenols, folate, Vitamin D and B Vitamins [157]. [L1, H]
- A healthy or Mediterranean diet is linearly associated with a lower risk of depression over time; dietary inflammatory index and consumption of fish and vegetables are also associated with lower incidence of depression [240]. [L1, M]
- High adult fish consumption (≥ 4 serves per week) is associated with 26% lower odds of depression compared with low fish consumption (< 1 serve per week), especially in females [241]. [L1, H]
- Some researchers suggest a U-shaped relationship between n-3 PUFA and fish intake with a moderate intake reducing the odds of depression more than a high intake [242]. [L1, H]
- Higher n-3 to n-6 PUFA intake is linked to slower development of depressive symptoms especially in women [243]. [L1, H]
- n-3 PUFA supplementation with 100% or ≥ 60% EPA has clinical benefits for people with depression but not 100% DHA or ≥ 60% DHA [244]. [L1, M]
- n-3 PUFA supplementation significantly improves depressive symptoms in HIV positive patients [245]. [L1, M]
- n-3 PUFA supplementation had a significant effect on perinatal depression; mild to moderate depression in pregnant and postpartum women was significantly improved with high EPA:DHA (≥ 1.5) supplementation being the most efficacious [221]. [L1, M]
- Erythrocyte Omega 3 index is inversely associated with depressive symptoms in adults with high levels of oxidative markers [246]. [L1, H]
- n-3 PUFA (EPA and DHA) supplementation is effective in the reduction of depression symptoms [247-249]. [L1, M-H]
- High doses of n-3 PUFA (≥ 2000 mg per day) are more effective in the management of major depressive disorders than low doses (< 2000 mg per day) [250]. [L1, M]

3.15.2 Behavioural disorders

- Low intakes of marine n-3 PUFA increases the risk of attention deficit hyperactivity disorder, autism, bipolar disorder, depression and suicide ideation [251] [L1, H]; supplementation with n-3 PUFA has value as an adjunct treatment for children and adolescents with bipolar disorder [252]. [L1, H]
- Child n-3 PUFA supplementation can improve health status and quality of life in children especially where hyperactivity, inattention, problems with conduct [253] [L1, M] or aggression exist [254] [L1, H]
- Treatment including n-3 PUFA supplementation in youth with depression or sub syndromic bipolar disorder results in sustained improvements in symptoms and overall functioning [255]. [L2, M]
- n-3 PUFA supplementation improves the social and interpersonal skills of children with some personality disorders. Early intervention with dietary or supplementary n-3 PUFA, in conjunction with other known effective treatments, should be considered as these children move into adolescence [254]. [L1, M]

3.15.3 Behaviour regulation

- Marine n-3 PUFA improves borderline personality disorder especially impulsive behavioural dyscontrol and affective dysregulation [256]. [L1, M]
- Daily intake of n-3 PUFA or 100 g fish high in DHA are beneficial to cognitive and behavioural outcomes in heathy school-aged children. Fortification may be considered as an effective public health initiative [257]. [L1, H]

3.15.4 Other mental health issues

- Greater consumption of oily fish is associated with better sleep quality [258]. [L1, H]
- n-3 PUFA supplementation benefits older adults with mild to moderate depression [173] [L1, M]; higher red blood cell DHA and EPA is independently associated with 12-month psychotrophic drug use in older adults [259]. [L1, H]

- DHA associated with health benefits related to autistic spectrum disorder, Alzheimer's disease, schizophrenia, stroke and traumatic brain injury; mixed results in research is likely due to background diet heterogeneity [260]. [L1, M]
- n-3 PUFA supplementation benefits younger adults with lower n-3 PUFA status and schizophrenia in the prodromal stage of disease [261]. [L2, M]
- n-3 fatty acid supplementation has beneficial effects on triglyceride metabolism and reduces the level of inflammation in patients with both schizophrenia and metabolic syndrome [193]. [L1, M]
- n-3 fatty acid supplement of around 1500 mg per day (range 1000-2880 mg per day) has proven effective in reducing the frequency of seizures in both adults and children with epilepsy [262]. [L1, M]
- n-3 PUFA supplementation should be considered as a potential beneficial adjunct therapy in all mental health disorders [263]. [L1, M]
- n-3 PUFA supplementation for young people at high-risk of psychosis was found to be a safe, user-friendly and effective treatment with therapeutic benefits at onset and as a long-term treatment option [264]. [L1, H]

3.16 Metabolic syndrome

- Fish and n-3 LC PUFA consumption attenuates long term weight gain [265,266]. [L1, M]
- Fish intake is inversely associated with metabolic syndrome [267]. [L1, H]
- n-3 PUFA lower the risk of metabolic syndrome [268,269]. [L1, H]
- Short term fish oil supplementation of adults with metabolic disorder increased insulin sensitivity [139]. [L1, M]
- n-3 PUFA together with Vitamin E improve blood lipid profiles of patients with metabolic syndrome [270]. [L1, M]

3.17 Muscular health / performance

- Supplementation with fish oil derived n-3 PUFA can benefit muscle strength, physical performance, body composition and serum lipids in older adults and may help prevent sarcopenia (age related, muscle loss, strength and function) [161]. [L1, H]
- n-3 LC PUFA may maintain or increase neuromuscular function during ageing [162,271]. [L1, M]
- n-3 PUFA may lead to small increases in muscle strength but not muscle mass or function [272]. [L1, M]
- n-3 PUFA improve recovery from onset muscle soreness and improved muscle function but not muscle hypertrophy, muscle strength or muscular inflammatory markers [273]. [L1, M]
- n-3 LC PUFA positively associated with muscle mass and strength [274]. [L2, M]
- Fish oil is likely to preserve strength and promote recovery from physiological stress in young adults; other muscular benefits are unclear [275]. [L1, M]
- Fish oil supplementation of athletes benefits the central nervous system, CV system, skeletal muscle and reduces proinflammatory cytokines [276]. [L1, M]

3.18 Health benefits associated with eating seafood

- The benefits of fish consumption and the role of n-3 PUFA in health at all stages of life, from conception to ageing, outweigh the potential risks (with the exception of a few selected species in sensitive populations) [277]. [L2, M]
- Studies that examine seafood as a whole food integrate any adverse effect from neurotoxicants and identify benefits to cognition derived from n-3 PUFA and other essential nutrients found in seafood [278]. [L1, M]
- Health benefits of fish consumption generally counter the risk of polyfluoroalkyl substances (e.g. from packaging) [279]. [L1, M]
- Polychlorinated biphenyl (PCB) contamination (minimal in Australian caught seafood) [280] [L1, M] is linked to an increased risk of myocardial infarction.
- EPA and DHA are protective and associated with a lower risk of CV events [281]. [L1, H]

4. Conclusion

This report provides a summary of moderate to high level scientific evidence published in peer reviewed literature, from January 2015 to January 2025, around the health benefits of seafood consumption to human health. The evidence clearly supports the consumption of at least two serves of seafood per week as a part of a healthy diet. It is also evident that a variety of seafood should be consumed to gain optimal health benefit. The strongest evidence supports at least one serve of n-3 PUFA rich seafood each week.

5. References

1. Sokoła-Wysoczańska E, Wysoczański T, Wagner J, Czyż K, Bodkowski R, Lochyński S, Patkowska-Sokoła B. Polyunsaturated Fatty Acids and Their Potential Therapeutic Role in Cardiovascular System Disorders-A Review. *Nutrients*. Oct 21 2018;10(10)doi:10.3390/nu10101561
2. McManus A, Newton W. *Seafood, nutrition and human health: A synopsis of the nutritional benefits of consuming seafood*. 2011.
3. Tørris C, Småstuen MC, Molin M. Nutrients in Fish and Possible Associations with Cardiovascular Disease Risk Factors in Metabolic Syndrome. *Nutrients*. Jul 23 2018;10(7)doi:10.3390/nu10070952
4. Jayasekara C, Mendis E, Kim S-K. Seafood in the Human Diet for Better Nutrition and Health. *Encyclopedia of Marine Biotechnology*. 2020:2939-2959.
5. Bechthold A, Boeing H, Schwedhelm C, et al. Food groups and risk of coronary heart disease, stroke and heart failure: A systematic review and dose-response meta-analysis of prospective studies. *Crit Rev Food Sci Nutr*. 2019;59(7):1071-1090. doi:10.1080/10408398.2017.1392288
6. Hernáez Á, Sanllorente A, Castañer O, et al. Increased Consumption of Virgin Olive Oil, Nuts, Legumes, Whole Grains, and Fish Promotes HDL Functions in Humans. *Mol Nutr Food Res*. Mar 2019;63(6):e1800847. doi:10.1002/mnfr.201800847
7. Tong TYN, Appleby PN, Bradbury KE, Perez-Cornago A, Travis RC, Clarke R, Key TJ. Risks of ischaemic heart disease and stroke in meat eaters, fish eaters, and vegetarians over 18 years of follow-up: results from the prospective EPIC-Oxford study. Research Support, Non-U.S. Gov't. *BMJ*. 2019;366:l4897. doi:https://dx.doi.org/10.1136/bmj.l4897
8. McManus A, Howieson J, Fielder L, Cooper L. *Review of health benefit research and development relevant to the Australian seafood industry and members of the Australian Seafood CRC*. 2008. 081201.
9. McManus A, Howieson J, Nicholson C. *Industry Guidelines – Evidence around the health benefit of regular consumption of seafood as part of a healthy diet*. 2009. 090712.
10. McManus A, Howieson J, Nicholson C. *Review of literature and resources relating to the health benefit of regular consumption of seafood as part of a healthy diet (Plus separate publication – Executive Summary)*. 2009. 090101.
11. McManus A, Pohlenz-Saw J, McManus J, Hunt W. *Health benefits of seafood for the prevention and management of chronic conditions: A systematic literature review*. 2014. 310314.
12. McManus A, White J, Hunt W, Storey J, McManus J, Cuesta-Briand B, Golightly A. *Community intervention to increase seafood consumption (CIISC)*. 2011. 16092011.
13. McManus A P-SJ, McManus J. *Review of literature relating to the health benefits of regular consumption of seafood as part of a healthy diet*. 2013. 311013.
14. Christenson JK, O'Kane G, McManus A, Farmerv A. Barriers and drivers of seafood consumption in Australia: A narrative literature review. *International Journal of Consumer Studies* 2017;41:299-311. doi:doi:10.1111/ijcs.12342
15. Glasziou P, Irwig L, Bain C, Colditz G. How to review the evidence: systematic identification and review of the scientific literature. 2000;
16. Wan X, Gao X, Bi J, Tian F, Wang X. Use of n-3 PUFAs can decrease the mortality in patients with systemic inflammatory response syndrome: a systematic review and meta-analysis. *Lipids Health Dis*. Mar 31 2015;14:23. doi:10.1186/s12944-015-0022-5

17. Chen GC, Yang J, Eggersdorfer M, Zhang W, Qin LQ. N-3 long-chain polyunsaturated fatty acids and risk of all-cause mortality among general populations: a meta-analysis. *Sci Rep*. Jun 16 2016;6:28165. doi:10.1038/srep28165
18. Zhang Y, Zhuang P, He W, et al. Association of fish and long-chain omega-3 fatty acids intakes with total and cause-specific mortality: prospective analysis of 421 309 individuals. Research Support, N.I.H., Intramural
Research Support, Non-U.S. Gov't. *Journal of Internal Medicine*. 2018;284(4):399-417.
19. Bellavia A, Larsson SC, Wolk A. Fish consumption and all-cause mortality in a cohort of Swedish men and women. Research Support, Non-U.S. Gov't. *Journal of Internal Medicine*. 2016;281(1):86-95. doi:https://dx.doi.org/10.1111/joim.12545
20. Zhuang P, Wang W, Wang J, Zhang Y, Jiao J. Polyunsaturated fatty acids intake, omega-6/omega-3 ratio and mortality: Findings from two independent nationwide cohorts. Article. *Clinical Nutrition*. 2019;38(2):848-855. doi:10.1016/j.clnu.2018.02.019
21. O'Keefe EL, O'Keefe JH, Tintle NL, Westra J, Albuisson L, Harris WS. Circulating Docosahexaenoic Acid and Risk of All-Cause and Cause-Specific Mortality. *Mayo Clin Proc*. Apr 2024;99(4):534-541. doi:10.1016/j.mayocp.2023.11.026
22. Nayda NC, Thomas JM, Delaney CL, Miller MD. The effect of omega-3 polyunsaturated fatty acid intake on blood levels of omega-3s in people with chronic atherosclerotic disease: a systematic review. *Nutr Rev*. Oct 10 2023;81(11):1447-1461. doi:10.1093/nutrit/nuad020
23. Ghasemi Fard S, Wang F, Sinclair AJ, Elliott G, Turchini GM. How does high DHA fish oil affect health? A systematic review of evidence. *Crit Rev Food Sci Nutr*. 2019;59(11):1684-1727. doi:10.1080/10408398.2018.1425978
24. Barbaresko J, Lang A, Szczerba E, et al. Dietary Factors and All-Cause Mortality in Individuals With Type 2 Diabetes: A Systematic Review and Meta-analysis of Prospective Observational Studies. *Diabetes Care*. Feb 1 2023;46(2):469-477. doi:10.2337/dc22-1018
25. Zhang GQ, Liu B, Li J, et al. Fish intake during pregnancy or infancy and allergic outcomes in children: A systematic review and meta-analysis. *Pediatr Allergy Immunol*. Mar 2017;28(2):152-161. doi:10.1111/pai.12648
26. Freedman R, Hunter SK, Hoffman MC. Prenatal Primary Prevention of Mental Illness by Micronutrient Supplements in Pregnancy. Research Support, N.I.H., Extramural
Research Support, Non-U.S. Gov't
Systematic Review. *American Journal of Psychiatry*. 2018;175(7):607-619. doi:https://dx.doi.org/10.1176/appi.ajp.2018.17070836
27. Bisgaard H, Stokholm J, Chawes BL, et al. Fish Oil-Derived Fatty Acids in Pregnancy and Wheeze and Asthma in Offspring. *N Engl J Med*. Dec 29 2016;375(26):2530-9. doi:10.1056/NEJMoa1503734
28. Papamichael MM, Shrestha SK, Itsiopoulos C, Erbas B. The role of fish intake on asthma in children: A meta-analysis of observational studies. *Pediatr Allergy Immunol*. Jun 2018;29(4):350-360. doi:10.1111/pai.12889
29. Hansell AL, Bakolis I, Cowie CT, et al. Childhood fish oil supplementation modifies associations between traffic related air pollution and allergic sensitisation. *Environ Health*. Mar 27 2018;17(1):27. doi:10.1186/s12940-018-0370-5
30. Lee-Sarwar K, Kelly RS, Lasky-Su J, et al. Dietary and Plasma Polyunsaturated Fatty Acids Are Inversely Associated with Asthma and Atopy in Early Childhood. *J Allergy Clin Immunol Pract*. Feb 2019;7(2):529-538.e8. doi:10.1016/j.jaip.2018.07.039

31. Sordillo JE, Rifas-Shiman SL, Switkowski K, et al. Prenatal oxidative balance and risk of asthma and allergic disease in adolescence. *J Allergy Clin Immunol*. Dec 2019;144(6):1534-1541.e5. doi:10.1016/j.jaci.2019.07.044
32. Jia Y, Huang Y, Wang H, Jiang H. A dose-response meta-analysis of the association between the maternal omega-3 long-chain polyunsaturated fatty acids supplement and risk of asthma/wheeze in offspring. *BMC Pediatr*. Jul 16 2022;22(1):422. doi:10.1186/s12887-022-03421-z
33. Gunaratne AW, Makrides M, Collins CT. Maternal prenatal and/or postnatal n-3 long chain polyunsaturated fatty acids (LCPUFA) supplementation for preventing allergies in early childhood. *Cochrane Database Syst Rev*. Jul 22 2015;2015(7):CD010085. doi:10.1002/14651858.CD010085.pub2
34. Huynh LBP, Nguyen NN, Fan HY, Huang SY, Huang CH, Chen YC. Maternal Omega-3 Supplementation During Pregnancy, but Not Childhood Supplementation, Reduces the Risk of Food Allergy Diseases in Offspring. *J Allergy Clin Immunol Pract*. Sep 2023;11(9):2862-2871.e8. doi:10.1016/j.jaip.2023.06.005
35. Miles EA, Childs CE, Calder PC. Long-Chain Polyunsaturated Fatty Acids (LCPUFAs) and the Developing Immune System: A Narrative Review. *Nutrients*. Jan 16 2021;13(1)doi:10.3390/nu13010247
36. Sadeghi O, Djafarian K, Ghorabi S, Khodadost M, Nasiri M, Shab-Bidar S. Dietary intake of fish, n-3 polyunsaturated fatty acids and risk of hip fracture: A systematic review and meta-analysis on observational studies. *Crit Rev Food Sci Nutr*. 2019;59(8):1320-1333. doi:10.1080/10408398.2017.1405908
37. Del Brutto OH, Mera RM, Rumbea DA, Arias EE, Guzmán EJ, Sedler MJ. On the association between dietary oily fish intake and bone mineral density in frequent fish consumers of Amerindian ancestry. The three villages study. Article. *Archives of Osteoporosis*. 2024;19(1)31. doi:10.1007/s11657-024-01391-6
38. Feehan O, Magee PJ, Pourshahidi LK, et al. Associations of long chain polyunsaturated fatty acids with bone mineral density and bone turnover in postmenopausal women. Article. *European Journal of Nutrition*. 2023;62(1):95-104. doi:10.1007/s00394-022-02933-9
39. Longo AB, Ward WE. PUFAs, Bone Mineral Density, and Fragility Fracture: Findings from Human Studies. *Adv Nutr*. Mar 2016;7(2):299-312. doi:10.3945/an.115.009472
40. Harris TB, Song X, Reinders I, et al. Plasma phospholipid fatty acids and fish-oil consumption in relation to osteoporotic fracture risk in older adults: the Age, Gene/Environment Susceptibility Study. Article. *Am J Clin Nutr*. May 2015;101(5):947-55. doi:10.3945/ajcn.114.087502
41. Sharma T, Mandal CC. Omega-3 fatty acids in pathological calcification and bone health. *J Food Biochem*. Aug 2020;44(8):e13333. doi:10.1111/jfbc.13333
42. Nindrea RD, Aryandono T, Lazuardi L, Dwiprahasto I. Protective Effect of Omega-3 Fatty Acids in Fish Consumption Against Breast Cancer in Asian Patients: A Meta-Analysis. *Asian Pac J Cancer Prev*. Feb 26 2019;20(2):327-332. doi:10.31557/apjcp.2019.20.2.327
43. Aglago EK, Huybrechts I, Murphy N, et al. Consumption of Fish and Long-chain n-3 Polyunsaturated Fatty Acids Is Associated With Reduced Risk of Colorectal Cancer in a Large European Cohort. Research Support, Non-U.S. Gov't. *Clinical Gastroenterology & Hepatology*. 2019;18(3):654-666.e6. doi:https://dx.doi.org/10.1016/j.cgh.2019.06.031

44. Wang J, Zhang Y, Zhao L. Omega-3 PUFA intake and the risk of digestive system cancers: A meta-analysis of observational studies. Meta-Analysis. *Medicine*. 2020;99(19):e20119.
45. Brasky TM, Rodabough RJ, Liu J, et al. Long-chain omega-3 fatty acid intake and endometrial cancer risk in the Women's Health Initiative. Article. *Am J Clin Nutr*. Apr 2015;101(4):824-34. doi:10.3945/ajcn.114.098988
46. Liu Z, Luo Y, Ren J, et al. Association between fish oil supplementation and cancer risk according to fatty fish consumption: A large prospective population-based cohort study using UK Biobank. Research Support, Non-U.S. Gov't. *International Journal of Cancer*. 2021;150(4):562-571. doi:https://dx.doi.org/10.1002/ijc.33819
47. Zamani SA, McClain KM, Graubard BI, Liao LM, Abnet CC, Cook MB, Petrick JL. Dietary Polyunsaturated Fat Intake in Relation to Head and Neck, Esophageal, and Gastric Cancer Incidence in the National Institutes of Health-AARP Diet and Health Study. Research Support, N.I.H., Intramural
Research Support, Non-U.S. Gov't. *American Journal of Epidemiology*. 2020;189(10):1096-1113. doi:https://dx.doi.org/10.1093/aje/kwaa024
48. Jiang W, Wang M, Jiang HZ, Chen GC, Hua YF. Meta-analysis of fish consumption and risk of pancreatic cancer in 13 prospective studies with 1.8 million participants. *PLoS One*. 2019;14(9):e0222139. doi:10.1371/journal.pone.0222139
49. Kleckner AS, Culakova E, Kleckner IR, et al. Nutritional Status Predicts Fatty Acid Uptake from Fish and Soybean Oil Supplements for Treatment of Cancer-Related Fatigue: Results from a Phase II Nationwide Study. *Nutrients*. Dec 31 2021;14(1)doi:10.3390/nu14010184
50. Ukovic B, Porter J. Nutrition interventions to improve the appetite of adults undergoing cancer treatment: a systematic review. *Support Care Cancer*. Oct 2020;28(10):4575-4583. doi:10.1007/s00520-020-05475-0
51. D'Archivio M, Scazzocchio B, Vari R, Santangelo C, Giovannini C, Masella R. Recent Evidence on the Role of Dietary PUFAs in Cancer Development and Prevention. *Curr Med Chem*. 2018;25(16):1818-1836. doi:10.2174/0929867325666171204160231
52. Nabavi SF, Bilotto S, Russo GL, et al. Omega-3 polyunsaturated fatty acids and cancer: lessons learned from clinical trials. *Cancer Metastasis Rev*. Sep 2015;34(3):359-80. doi:10.1007/s10555-015-9572-2
53. Manson JE, Cook NR, Lee IM, et al. Marine n-3 Fatty Acids and Prevention of Cardiovascular Disease and Cancer. *N Engl J Med*. Jan 3 2019;380(1):23-32. doi:10.1056/NEJMoa1811403
54. Khankari NK, Bradshaw PT, Steck SE, et al. Dietary intake of fish, polyunsaturated fatty acids, and survival after breast cancer: A population-based follow-up study on Long Island, New York. Research Support, N.I.H., Extramural
Research Support, Non-U.S. Gov't
Research Support, U.S. Gov't, Non-P.H.S. *Cancer*. Jul 1 2015;121(13):2244-52. doi:10.1002/cncr.29329
55. Darwito D, Dharmana E, Riwanto I, et al. Effects of Omega-3 Supplementation on Ki-67 and VEGF Expression Levels and Clinical Outcomes of Locally Advanced Breast Cancer Patients Treated with Neoadjuvant CAF Chemotherapy: A Randomized Controlled Trial Report. *Asian Pac J Cancer Prev*. Mar 26 2019;20(3):911-916. doi:10.31557/apjcp.2019.20.3.911

56. Yang B, Ren XL, Wang ZY, Wang L, Zhao F, Guo XJ, Li D. Biomarker of long-chain n-3 fatty acid intake and breast cancer: Accumulative evidence from an updated meta-analysis of epidemiological studies. *Crit Rev Food Sci Nutr*. 2019;59(19):3152-3164. doi:10.1080/10408398.2018.1485133
57. Kiyabu GY, Inoue M, Saito E, et al. Fish, n - 3 polyunsaturated fatty acids and n - 6 polyunsaturated fatty acids intake and breast cancer risk: The Japan Public Health Center-based prospective study. Research Support, Non-U.S. Gov't. *Int J Cancer*. Dec 15 2015;137(12):2915-26. doi:10.1002/ijc.29672
58. Nindrea RD, Aryandono T, Lazuardi L, Dwiprahasto I. Association of Dietary Intake Ratio of n-3/n-6 Polyunsaturated Fatty Acids with Breast Cancer Risk in Western and Asian Countries: A Meta-Analysis. *Asian Pac J Cancer Prev*. May 25 2019;20(5):1321-1327. doi:10.31557/apjcp.2019.20.5.1321
59. Fodil M, Blanckaert V, Ulmann L, Mimouni V, Chénais B. Contribution of n-3 Long-Chain Polyunsaturated Fatty Acids to the Prevention of Breast Cancer Risk Factors. *Int J Environ Res Public Health*. Jun 28 2022;19(13)doi:10.3390/ijerph19137936
60. Tokudome S, Kuriki K, Yokoyama Y, et al. Dietary n-3/long-chain n-3 polyunsaturated fatty acids for prevention of sporadic colorectal tumors: a randomized controlled trial in polypectomized participants. *Prostaglandins Leukot Essent Fatty Acids*. Mar 2015;94:1-11. doi:10.1016/j.plefa.2014.09.001
61. Nguyen S, Li H, Yu D, et al. Dietary fatty acids and colorectal cancer risk in men: A report from the Shanghai Men's Health Study and a meta-analysis. Article. *International Journal of Cancer*. 2021;148(1):77-89. doi:10.1002/ijc.33196
62. White MN, Shrubsole MJ, Cai Q, et al. Effects of fish oil supplementation on eicosanoid production in patients at higher risk for colorectal cancer. *Eur J Cancer Prev*. May 2019;28(3):188-195. doi:10.1097/cej.0000000000000455
63. Chapkin RS, Navarro SL, Hullar MAJ, Lampe JW. Diet and Gut Microbes Act Coordinately to Enhance Programmed Cell Death and Reduce Colorectal Cancer Risk. *Dig Dis Sci*. Mar 2020;65(3):840-851. doi:10.1007/s10620-020-06106-8
64. Luu HN, Cai H, Murff HJ, et al. A prospective study of dietary polyunsaturated fatty acids intake and lung cancer risk. Article. *International Journal of Cancer*. 2018;143(9):2225-2237. doi:10.1002/ijc.31608
65. Tao X, Zhou Q, Rao Z. Efficacy of omega-3 Polyunsaturated Fatty Acids in Patients with Lung Cancer Undergoing Radiotherapy and Chemotherapy: A Meta-Analysis. Meta-Analysis
Review
Systematic Review. *International Journal of Clinical Practice*. 2022;2022:6564466.
66. Chua AV, Jr., Hernandez ARB, Mendoza MJL, San Juan MD. Omega-3 Fatty Acids Increase Weight and Quality of Life Scores in Patients With Advanced Non-Small Cell Lung Cancer and Cancer Cachexia: A Meta-Analysis. *Integr Cancer Ther*. Jan-Dec 2024;23:15347354241275052. doi:10.1177/15347354241275052
67. Hidaka A, Shimazu T, Sawada N, et al. Fish, n-3 PUFA consumption, and pancreatic cancer risk in Japanese: a large, population-based, prospective cohort study. Article. *Am J Clin Nutr*. Dec 2015;102(6):1490-7. doi:10.3945/ajcn.115.113597
68. Zhao Y, Wang C. Effect of omega-3 polyunsaturated fatty acid-supplemented parenteral nutrition on inflammatory and immune function in postoperative patients with gastrointestinal malignancy: A meta-analysis of randomized control trials in China. Meta-Analysis. *Medicine*. 2018;97(16):e0472.

69. Bai H, Li Z, Meng Y, Yu Y, Zhang H, Shen D, Chen L. Effects of parenteral ω-3 fatty acid supplementation in postoperative gastrointestinal cancer on immune function and length of hospital stay: a systematic review and meta-analysis. *Asia Pac J Clin Nutr*. 2018;27(1):121-128. doi:10.6133/apjcn.022017.19
70. Hernáez Á, Castañer O, Tresserra-Rimbau A, et al. Mediterranean Diet and Atherothrombosis Biomarkers: A Randomized Controlled Trial. *Mol Nutr Food Res*. Oct 2020;64(20):e2000350. doi:10.1002/mnfr.202000350
71. Kondo K, Miura K, Tanaka-Mizuno S, et al. Cardiovascular Risk Assessment Chart by Dietary Factors in Japan - NIPPON DATA80. *Circ J*. May 24 2019;83(6):1254-1260. doi:10.1253/circj.CJ-18-1002
72. Jiang L, Wang J, Xiong K, Xu L, Zhang B, Ma A. Intake of Fish and Marine n-3 Polyunsaturated Fatty Acids and Risk of Cardiovascular Disease Mortality: A Meta-Analysis of Prospective Cohort Studies. *Nutrients*. Jul 9 2021;13(7)doi:10.3390/nu13072342
73. Qian F, Tintle N, Jensen PN, et al. Omega-3 Fatty Acid Biomarkers and Incident Atrial Fibrillation. *J Am Coll Cardiol*. Jul 25 2023;82(4):336-349. doi:10.1016/j.jacc.2023.05.024
74. Maki KC, Dicklin MR. Omega-3 Fatty Acid Supplementation and Cardiovascular Disease Risk: Glass Half Full or Time to Nail the Coffin Shut? *Nutrients*. Jul 4 2018;10(7)doi:10.3390/nu10070864
75. Siscovick DS, Barringer TA, Fretts AM, et al. Omega-3 Polyunsaturated Fatty Acid (Fish Oil) Supplementation and the Prevention of Clinical Cardiovascular Disease: A Science Advisory From the American Heart Association. Review. *Circulation*. 2017;135(15):e867-e884. doi:https://dx.doi.org/10.1161/CIR.0000000000000482
76. Hu Y, Hu FB, Manson JE. Marine Omega-3 Supplementation and Cardiovascular Disease: An Updated Meta-Analysis of 13 Randomized Controlled Trials Involving 127 477 Participants. *J Am Heart Assoc*. Oct 2019;8(19):e013543. doi:10.1161/jaha.119.013543
77. Rodriguez D, Lavie CJ, Elagizi A, Milani RV. Update on Omega-3 Polyunsaturated Fatty Acids on Cardiovascular Health. *Nutrients*. Dec 3 2022;14(23)doi:10.3390/nu14235146
78. Nestel P, Clifton P, Colquhoun D, Noakes M, Mori TA, Sullivan D, Thomas B. Indications for Omega-3 Long Chain Polyunsaturated Fatty Acid in the Prevention and Treatment of Cardiovascular Disease. *Heart Lung Circ*. Aug 2015;24(8):769-79. doi:10.1016/j.hlc.2015.03.020
79. Critselis E, Tsiampalis T, Damigou E, et al. High fish intake rich in n-3 polyunsaturated fatty acids reduces cardiovascular disease incidence in healthy adults: The ATTICA cohort study (2002-2022). Article. *Frontiers in Physiology*. 2023;141158140. doi:10.3389/fphys.2023.1158140
80. Abdelhamid AS, Martin N, Bridges C, et al. Polyunsaturated fatty acids for the primary and secondary prevention of cardiovascular disease. *Cochrane Database Syst Rev*. Jul 18 2018;7(7):Cd012345. doi:10.1002/14651858.CD012345.pub2
81. Yu F, Qi S, Ji Y, Wang X, Fang S, Cao R. Effects of omega-3 fatty acid on major cardiovascular outcomes: A systematic review and meta-analysis. Meta-Analysis Systematic Review. *Medicine*. 2022;101(30):e29556.
82. Zhang B, Xiong K, Cai J, Ma A. Fish Consumption and Coronary Heart Disease: A Meta-Analysis. *Nutrients*. Jul 29 2020;12(8)doi:10.3390/nu12082278
83. Giosuè A, Calabrese I, Lupoli R, Riccardi G, Vaccaro O, Vitale M. Relations between the Consumption of Fatty or Lean Fish and Risk of Cardiovascular Disease and All-Cause Mortality: A Systematic Review and Meta-Analysis. *Adv Nutr*. Oct 2 2022;13(5):1554-1565. doi:10.1093/advances/nmac006

84. Rimm EB, Appel LJ, Chiuve SE, et al. Seafood Long-Chain n-3 Polyunsaturated Fatty Acids and Cardiovascular Disease: A Science Advisory From the American Heart Association. *Circulation*. Jul 3 2018;138(1):e35-e47. doi:10.1161/cir.0000000000000574
85. Ricci H, Gaeta M, Franchi C, et al. Fish Intake in Relation to Fatal and Non-Fatal Cardiovascular Risk: A Systematic Review and Meta-Analysis of Cohort Studies. *Nutrients*. Oct 26 2023;15(21)doi:10.3390/nu15214539
86. Jayedi A, Shab-Bidar S, Eimeri S, Djafarian K. Fish consumption and risk of all-cause and cardiovascular mortality: a dose-response meta-analysis of prospective observational studies. *Public Health Nutr*. May 2018;21(7):1297-1306. doi:10.1017/s1368980017003834
87. Mohan D, Mente A, Dehghan M, et al. Associations of Fish Consumption With Risk of Cardiovascular Disease and Mortality Among Individuals With or Without Vascular Disease From 58 Countries. Research Support, Non-U.S. Gov't. *JAMA Internal Medicine*. 2021;181(5):631-649.
88. Tani S, Matsuo R, Imatake K, Suzuki Y, Takahashi A, Matsumoto N. Association of daily fish intake with serum non-high-density lipoprotein cholesterol levels and healthy lifestyle behaviours in apparently healthy males over the age of 50 years in Japanese: Implication for the anti-atherosclerotic effect of fish consumption. Article. *Nutrition, Metabolism and Cardiovascular Diseases*. 2020;30(2):190-200. doi:10.1016/j.numecd.2019.09.019
89. Krittanawong C, Isath A, Hahn J, et al. Fish Consumption and Cardiovascular Health: A Systematic Review. *Am J Med*. Jun 2021;134(6):713-720. doi:10.1016/j.amjmed.2020.12.017
90. Zhu Y, Bo Y, Liu Y. Dietary total fat, fatty acids intake, and risk of cardiovascular disease: a dose-response meta-analysis of cohort studies. *Lipids Health Dis*. Apr 6 2019;18(1):91. doi:10.1186/s12944-019-1035-2
91. Wu G, Ji Q, Huang H, Zhu X. The efficacy of fish oil in preventing coronary heart disease: A systematic review and meta-analysis. *Medicine (Baltimore)*. Sep 17 2021;100(37):e27253. doi:10.1097/md.0000000000027253
92. Del Gobbo LC, Imamura F, Aslibekyan S, et al. omega-3 Polyunsaturated Fatty Acid Biomarkers and Coronary Heart Disease: Pooling Project of 19 Cohort Studies. Research Support, N.I.H., Extramural
Research Support, N.I.H., Intramural
Research Support, Non-U.S. Gov't. *JAMA Intern Med*. Aug 1 2016;176(8):1155-66. doi:10.1001/jamainternmed.2016.2925
93. Khor BH, Narayanan SS, Chinna K, et al. Blood Fatty Acid Status and Clinical Outcomes in Dialysis Patients: A Systematic Review. *Nutrients*. Sep 21 2018;10(10)doi:10.3390/nu10101353
94. Chareonrungrueangchai K, Wongkawinwoot K, Anothaisintawee T, Reutrakul S. Dietary Factors and Risks of Cardiovascular Diseases: An Umbrella Review. *Nutrients*. Apr 15 2020;12(4)doi:10.3390/nu12041088
95. Jiang H, Wang L, Wang D, et al. Omega-3 polyunsaturated fatty acid biomarkers and risk of type 2 diabetes, cardiovascular disease, cancer, and mortality. *Clin Nutr*. Aug 2022;41(8):1798-1807. doi:10.1016/j.clnu.2022.06.034
96. Zeng Q, Dong SY, Liu YP, Fu J, Shuai P, Zhao ZM, Li TX. Effects of fish oil-derived fatty acids on suboptimal cardiovascular health: A multicenter, randomized, double-blind, placebo-controlled trial. *Nutr Metab Cardiovasc Dis*. Nov 2017;27(11):964-970. doi:10.1016/j.numecd.2017.09.004

97. Hammer A, Moertl D, Schlager O, Matschuck M, Seidinger D, Koppensteiner R, Steiner S. Effects of n-3 PUFA on endothelial function in patients with peripheral arterial disease: a randomised, placebo-controlled, double-blind trial. *Br J Nutr*. Sep 28 2019;122(6):698-706. doi:10.1017/s0007114519001582
98. Koh AS, Pan A, Wang R, Odegaard AO, Pereira MA, Yuan JM, Koh WP. The association between dietary omega-3 fatty acids and cardiovascular death: the Singapore Chinese Health Study. Article. *Eur J Prev Cardiol*. Mar 2015;22(3):364-72. doi:10.1177/2047487313517576
99. Bork CS, Lundbye-Christensen S, Venø SK, Lasota AN, Tjønneland A, Schmidt EB, Overvad K. Intake of marine and plant-derived n-3 fatty acids and development of atherosclerotic cardiovascular disease in the Danish Diet, Cancer and Health cohort. Article. *European Journal of Nutrition*. 2023;62(3):1389-1401. doi:10.1007/s00394-022-03081-w
100. Watanabe Y, Tatsuno I. Omega-3 polyunsaturated fatty acids for cardiovascular diseases: present, past and future. *Expert Rev Clin Pharmacol*. Aug 2017;10(8):865-873. doi:10.1080/17512433.2017.1333902
101. Ververiotis A, Siasos G, Oikonomou E, et al. The Impact of Omega 3 Fatty Acids in Atherosclerosis and Arterial Stiffness: An Overview of their Actions. *Curr Pharm Des*. 2018;24(17):1865-1872. doi:10.2174/1381612824666180321095022
102. Zhang X, Ritonja JA, Zhou N, Chen BE, Li X. Omega-3 Polyunsaturated Fatty Acids Intake and Blood Pressure: A Dose-Response Meta-Analysis of Randomized Controlled Trials. *J Am Heart Assoc*. Jun 7 2022;11(11):e025071. doi:10.1161/jaha.121.025071
103. Wang Y, Wang Y, Shehzad Q, et al. Does omega-3 PUFAs supplementation improve metabolic syndrome and related cardiovascular diseases? A systematic review and meta-analysis of randomized controlled trials. *Crit Rev Food Sci Nutr*. Sep 2024;64(26):9455-9482. doi:10.1080/10408398.2023.2212817
104. Minihane AM, Armah CK, Miles EA, et al. Consumption of Fish Oil Providing Amounts of Eicosapentaenoic Acid and Docosahexaenoic Acid That Can Be Obtained from the Diet Reduces Blood Pressure in Adults with Systolic Hypertension: A Retrospective Analysis. *J Nutr*. Mar 2016;146(3):516-23. doi:10.3945/jn.115.220475
105. Harris WS, Zotor FB. n-3 Fatty acids and risk for fatal coronary disease. *Proc Nutr Soc*. Nov 2019;78(4):526-531. doi:10.1017/s0029665118002902
106. Manson JE, Bassuk SS, Cook NR, Lee IM, Mora S, Albert CM, Buring JE. Vitamin D, Marine n-3 Fatty Acids, and Primary Prevention of Cardiovascular Disease Current Evidence. *Circ Res*. Jan 3 2020;126(1):112-128. doi:10.1161/circresaha.119.314541
107. Innes JK, Calder PC. Marine Omega-3 (N-3) Fatty Acids for Cardiovascular Health: An Update for 2020. *Int J Mol Sci*. Feb 18 2020;21(4)doi:10.3390/ijms21041362
108. Bernasconi AA, Wiest MM, Lavie CJ, Milani RV, Laukkanen JA. Effect of Omega-3 Dosage on Cardiovascular Outcomes: An Updated Meta-Analysis and Meta-Regression of Interventional Trials. *Mayo Clin Proc*. Feb 2021;96(2):304-313. doi:10.1016/j.mayocp.2020.08.034
109. Dinu M, Sofi F, Lotti S, et al. Effects of omega-3 fatty acids on coronary revascularization and cardiovascular events: a meta-analysis. *Eur J Prev Cardiol*. Nov 11 2024;31(15):1863-1875. doi:10.1093/eurjpc/zwae184
110. Ruscica M, Sirtori CR, Carugo S, Calder PC, Corsini A. Omega-3 and cardiovascular prevention - Is this still a choice? *Pharmacol Res*. Aug 2022;182:106342. doi:10.1016/j.phrs.2022.106342

111. Jia X, Kohli P, Virani SS. Omega-3 Fatty Acid and Cardiovascular Outcomes: Insights From Recent Clinical Trials. *Curr Atheroscler Rep*. Jan 10 2019;21(1):1. doi:10.1007/s11883-019-0763-0
112. Lombardi M, Chiabrando JG, Vescovo GM, et al. Impact of Different Doses of Omega-3 Fatty Acids on Cardiovascular Outcomes: a Pairwise and Network Meta-analysis. *Curr Atheroscler Rep*. Jul 16 2020;22(9):45. doi:10.1007/s11883-020-00865-5
113. Yan J, Liu M, Yang D, Zhang Y, An F. Efficacy and Safety of Omega-3 Fatty Acids in the Prevention of Cardiovascular Disease: A Systematic Review and Meta-analysis. *Cardiovasc Drugs Ther*. Aug 2024;38(4):799-817. doi:10.1007/s10557-022-07379-z
114. Gencer B, Djousse L, Al-Ramady OT, Cook NR, Manson JE, Albert CM. Effect of Long-Term Marine ω-3 Fatty Acids Supplementation on the Risk of Atrial Fibrillation in Randomized Controlled Trials of Cardiovascular Outcomes: A Systematic Review and Meta-Analysis. *Circulation*. Dec 21 2021;144(25):1981-1990. doi:10.1161/circulationaha.121.055654
115. Vasheghani Farahani A, Yousefi Azar A, Goodarzynejad HR, et al. Fish oil supplementation for primary prevention of atrial fibrillation after coronary artery bypass graft surgery: A randomized clinical trial. *Int J Surg*. Jun 2017;42:41-48. doi:10.1016/j.ijsu.2017.04.025
116. Hidayat K, Yang J, Zhang Z, Chen GC, Qin LQ, Eggersdorfer M, Zhang W. Effect of omega-3 long-chain polyunsaturated fatty acid supplementation on heart rate: a meta-analysis of randomized controlled trials. *Eur J Clin Nutr*. Jun 2018;72(6):805-817. doi:10.1038/s41430-017-0052-3
117. Bassuk SS, Manson JE. Marine omega-3 fatty acid supplementation and prevention of cardiovascular disease: update on the randomized trial evidence. *Cardiovasc Res*. Jun 13 2023;119(6):1297-1309. doi:10.1093/cvr/cvac172
118. O'Keefe JH, Tintle NL, Harris WS, et al. Omega-3 Blood Levels and Stroke Risk: A Pooled and Harmonized Analysis of 183 291 Participants From 29 Prospective Studies. *Stroke*. 2024;55(1):50-58.
119. Lazaro I, Rueda F, Cediel G, Ortega E, Garcia-Garcia C, Sala-Vila A, Bayes-Genis A. Circulating Omega-3 Fatty Acids and Incident Adverse Events in Patients With Acute Myocardial Infarction. Observational Study
Research Support, Non-U.S. Gov't. *Journal of the American College of Cardiology*. 2020;76(18):2089-2097.
120. Lasota AN, Gronholdt MM, Bork CS, Lundbye-Christensen S, Overvad K, Schmidt EB. Marine n-3 Fatty Acids and the Risk of Peripheral Arterial Disease. Research Support, Non-U.S. Gov't. *Journal of the American College of Cardiology*. 2018;72(14):1576-1584. doi:https://dx.doi.org/10.1016/j.jacc.2018.07.045
121. Gholami M, Najafizadeh H, Teimouri H, Ardalan A, Pooria A, Tarrahi MJ. The combined effect of vitamin C and omega-3 polyunsaturated fatty acids on fatigue following coronary artery bypass graft surgery: a triple-blind clinical trial. *J Complement Integr Med*. Aug 21 2019;16(4)doi:10.1515/jcim-2018-0113
122. Heydari B, Abdullah S, Pottala JV, et al. Effect of Omega-3 Acid Ethyl Esters on Left Ventricular Remodeling After Acute Myocardial Infarction: The OMEGA-REMODEL Randomized Clinical Trial. Comparative Study
Multicenter Study
Randomized Controlled Trial

Research Support, N.I.H., Extramural. *Circulation*. Aug 2 2016;134(5):378-91. doi:10.1161/CIRCULATIONAHA.115.019949
123. Akintoye E, Sethi P, Harris WS, et al. Fish Oil and Perioperative Bleeding. *Circ Cardiovasc Qual Outcomes*. Nov 2018;11(11):e004584. doi:10.1161/circoutcomes.118.004584
124. Barkas F, Nomikos T, Liberopoulos E, Panagiotakos D. Diet and Cardiovascular Disease Risk Among Individuals with Familial Hypercholesterolemia: Systematic Review and Meta-Analysis. *Nutrients*. Aug 13 2020;12(8)doi:10.3390/nu12082436
125. Leslie MA, Cohen DJ, Liddle DM, Robinson LE, Ma DW. A review of the effect of omega-3 polyunsaturated fatty acids on blood triacylglycerol levels in normolipidemic and borderline hyperlipidemic individuals. *Lipids Health Dis*. Jun 6 2015;14:53. doi:10.1186/s12944-015-0049-7
126. Wang J, Gaman MA, Albadawi NI, et al. Does Omega-3 Fatty Acid Supplementation Have Favorable Effects on the Lipid Profile in Postmenopausal Women? A Systematic Review and Dose-response Meta-analysis of Randomized Controlled Trials. Systematic Review
Meta-Analysis
Review. *Clinical Therapeutics*. 2023;45(1):e74-e87.
127. Song J, Hu M, Li C, Yang B, Ding Q, Wang C, Mao L. Dose-dependent effects of fish oil on cardio-metabolic biomarkers in healthy middle-aged and elderly Chinese people: a double-blind randomized controlled trial. *Food Funct*. Jun 20 2018;9(6):3235-3243. doi:10.1039/c7fo01566f
128. Chen H, Deng G, Zhou Q, et al. Effects of eicosapentaenoic acid and docosahexaenoic acid versus α-linolenic acid supplementation on cardiometabolic risk factors: a meta-analysis of randomized controlled trials. *Food Funct*. Mar 26 2020;11(3):1919-1932. doi:10.1039/c9fo03052b
129. Ferguson JJ, Veysey M, Lucock M, Niblett S, King K, MacDonald-Wicks L, Garg ML. Association between omega-3 index and blood lipids in older Australians. Article. *J Nutr Biochem*. Jan 2016;27:233-40. doi:10.1016/j.jnutbio.2015.09.010
130. Li N, Jia M, Deng Q, Wang Z, Huang F, Hou H, Xu T. Effect of low-ratio n-6/n-3 PUFA on blood lipid level: a meta-analysis. *Hormones (Athens)*. Dec 2021;20(4):697-706. doi:10.1007/s42000-020-00248-0
131. Rees K, Takeda A, Martin N, et al. Mediterranean-style diet for the primary and secondary prevention of cardiovascular disease. *Cochrane Database of Systematic Reviews*. 2019;(3)doi:10.1002/14651858.CD009825.pub3
132. Irfan A, Haider SH, Nasir A, Larik MO, Naz T. Assessing the Efficacy of Omega-3 Fatty Acids + Statins vs. Statins Only on Cardiovascular Outcomes: A Systematic Review and Meta-Analysis of 40,991 Patients. *Curr Probl Cardiol*. Feb 2024;49(2):102245. doi:10.1016/j.cpcardiol.2023.102245
133. Choi HD, Chae SM. Comparison of efficacy and safety of combination therapy with statins and omega-3 fatty acids versus statin monotherapy in patients with dyslipidemia: A systematic review and meta-analysis. Meta-Analysis
Systematic Review. *Medicine*. 2018;97(50):e13593.
134. Kim CH, Han KA, Yu J, et al. Efficacy and Safety of Adding Omega-3 Fatty Acids in Statin-treated Patients with Residual Hypertriglyceridemia: ROMANTIC (Rosuvastatin-OMAcor iN residual hyperTrIglyCeridemia), a Randomized, Double-blind, and Placebo-controlled Trial. Randomized Controlled Trial

Research Support, Non-U.S. Gov't. *Clinical Therapeutics*. 2018;40(1):83-94.
135. O'Keefe EL, Harris WS, DiNicolantonio JJ, Elagizi A, Milani RV, Lavie CJ, O'Keefe JH. Sea Change for Marine Omega-3s: Randomized Trials Show Fish Oil Reduces Cardiovascular Events. *Mayo Clin Proc*. Dec 2019;94(12):2524-2533. doi:10.1016/j.mayocp.2019.04.027
136. Alves Luzia L, Mendes Aldrighi J, Teixeira Damasceno NR, et al. Fish Oil and Vitamin E Change Lipid Profiles and Anti-Ldl-Antibodies in Two Different Ethnic Groups of Women Transitioning through Menopause. *Nutr Hosp*. Jul 1 2015;32(1):165-74. doi:10.3305/nh.2015.32.1.9079
137. Su MI, Cheng YC, Huang YC, Liu CW. Omega-3 Polyunsaturated Fatty Acid Supplementation in Patients with Lower Extremity Arterial Disease. *J Am Nutr Assoc*. May-Jun 2022;41(4):383-391. doi:10.1080/07315724.2021.1891155
138. England JA, Jain J, Holbrook BD, Schrader R, Qualls C, Mozurkewich E. Effect of prenatal EPA and DHA on maternal and cord blood insulin sensitivity: a secondary analysis of the mothers, omega 3, and mental health study. *BMC Pregnancy Childbirth*. Nov 29 2019;19(1):452. doi:10.1186/s12884-019-2599-6
139. Gao H, Geng T, Huang T, Zhao Q. Fish oil supplementation and insulin sensitivity: a systematic review and meta-analysis. *Lipids Health Dis*. Jul 3 2017;16(1):131. doi:10.1186/s12944-017-0528-0
140. Xiao Y, Zhang Q, Liao X, Elbelt U, Weylandt KH. The effects of omega-3 fatty acids in type 2 diabetes: A systematic review and meta-analysis. *Prostaglandins Leukot Essent Fatty Acids*. Jul 2022;182:102456. doi:10.1016/j.plefa.2022.102456
141. O'Mahoney LL, Matu J, Price OJ, et al. Omega-3 polyunsaturated fatty acids favourably modulate cardiometabolic biomarkers in type 2 diabetes: a meta-analysis and meta-regression of randomized controlled trials. *Cardiovasc Diabetol*. Jul 7 2018;17(1):98. doi:10.1186/s12933-018-0740-x
142. Britten-Jones AC, Kamel JT, Roberts LJ, Braat S, Craig JP, MacIsaac RJ, Downie LE. Investigating the Neuroprotective Effect of Oral Omega-3 Fatty Acid Supplementation in Type 1 Diabetes (nPROOFS1): A Randomized Placebo-Controlled Trial. *Diabetes*. Aug 2021;70(8):1794-1806. doi:10.2337/db21-0136
143. Che J, He N, Kuang X, Zheng C, Zhou R, Zhan X, Liu Z. Dietary n-3 Fatty Acids Intake and All-Cause and Cardiovascular Mortality in Patients With Prediabetes and Diabetes. Article. *Journal of Clinical Endocrinology and Metabolism*. 2024;109(11):2847-2856. doi:10.1210/clinem/dgae265
144. Wang F, Wang Y, Zhu Y, Liu X, Xia H, Yang X, Sun G. Treatment for 6 months with fish oil-derived n-3 polyunsaturated fatty acids has neutral effects on glycemic control but improves dyslipidemia in type 2 diabetic patients with abdominal obesity: a randomized, double-blind, placebo-controlled trial. *Eur J Nutr*. Oct 2017;56(7):2415-2422. doi:10.1007/s00394-016-1352-4
145. Gao C, Liu Y, Gan Y, et al. Effects of fish oil supplementation on glucose control and lipid levels among patients with type 2 diabetes mellitus: a Meta-analysis of randomized controlled trials. *Lipids Health Dis*. May 8 2020;19(1):87. doi:10.1186/s12944-020-01214-w
146. Eynard AR, Repossi G. Role of ω3 polyunsaturated fatty acids in diabetic retinopathy: a morphological and metabolically cross talk among blood retina barriers damage, autoimmunity and chronic inflammation. *Lipids Health Dis*. May 15 2019;18(1):114. doi:10.1186/s12944-019-1049-9

147. Sala-Vila A, Diaz-Lopez A, Valls-Pedret C, et al. Dietary Marine omega-3 Fatty Acids and Incident Sight-Threatening Retinopathy in Middle-Aged and Older Individuals With Type 2 Diabetes: Prospective Investigation From the PREDIMED Trial. Multicenter Study Randomized Controlled Trial. *JAMA Ophthalmol*. Oct 1 2016;134(10):1142-1149. doi:10.1001/jamaophthalmol.2016.2906
148. Yorek MA. The Potential Role of Fatty Acids in Treating Diabetic Neuropathy. *Curr Diab Rep*. Aug 25 2018;18(10):86. doi:10.1007/s11892-018-1046-9
149. Zeppieri M, Gagliano C, D'Esposito F, et al. Eicosapentaenoic Acid (EPA) and Docosahexaenoic Acid (DHA): A Targeted Antioxidant Strategy to Counter Oxidative Stress in Retinopathy. *Antioxidants (Basel)*. Dec 24 2024;14(1)doi:10.3390/antiox14010006
150. Rajabi-Naeeni M, Dolatian M, Qorbani M, Vaezi AA. Effect of omega-3 and vitamin D co-supplementation on psychological distress in reproductive-aged women with pre-diabetes and hypovitaminosis D: A randomized controlled trial. *Brain Behav*. Nov 2021;11(11):e2342. doi:10.1002/brb3.2342
151. Griffith RJ, Alsweiler J, Moore AE, Brown S, Middleton P, Shepherd E, Crowther CA. Interventions to prevent women from developing gestational diabetes mellitus: an overview of Cochrane Reviews. *Cochrane Database Syst Rev*. Jun 11 2020;6(6):Cd012394. doi:10.1002/14651858.CD012394.pub3
152. Abbott KA, Burrows TL, Thota RN, et al. Association between plasma phospholipid omega-3 polyunsaturated fatty acids and type 2 diabetes is sex dependent: The Hunter Community Study. Article. *Clinical Nutrition*. 2020;39(4):1059-1066. doi:10.1016/j.clnu.2019.04.007
153. Silveira JM, Ribeiro TS, Guilarducci MJ, Reis MG, Vieira RAL, Guimarães NS, Gomes JMG. Effect of fish-oil supplementation on the glycemic and lipidemic profiles of pregnant women: a systematic review and meta-analysis. *Nutr Rev*. Dec 1 2024;82(12):1756-1770. doi:10.1093/nutrit/nuad158
154. Gaskins AJ, Sundaram R, Buck Louis GM, Chavarro JE. Seafood Intake, Sexual Activity, and Time to Pregnancy. Research Support, N.I.H., Extramural
Research Support, N.I.H., Intramural. *Journal of Clinical Endocrinology & Metabolism*. 2018;103(7):2680-2688.
155. Salas-Huetos A, Arvizu M, Minguez-Alarcon L, et al. Women's and men's intake of omega-3 fatty acids and their food sources and assisted reproductive technology outcomes. Research Support, Non-U.S. Gov't
Research Support, N.I.H., Extramural. *American Journal of Obstetrics & Gynecology*. 2022;227(2):246.e1-246.e11.
156. Hosseini B, Nourmohamadi M, Hajipour S, Taghizadeh M, Asemi Z, Keshavarz SA, Jafarnejad S. The Effect of Omega-3 Fatty Acids, EPA, and/or DHA on Male Infertility: A Systematic Review and Meta-analysis. *J Diet Suppl*. 2019;16(2):245-256. doi:10.1080/19390211.2018.1431753
157. Moore K, Hughes CF, Ward M, Hoey L, McNulty H. Diet, nutrition and the ageing brain: current evidence and new directions. *Proc Nutr Soc*. May 2018;77(2):152-163. doi:10.1017/s0029665117004177
158. Ticinesi A, Meschi T, Lauretani F, et al. Nutrition and Inflammation in Older Individuals: Focus on Vitamin D, n-3 Polyunsaturated Fatty Acids and Whey Proteins. *Nutrients*. Mar 29 2016;8(4):186. doi:10.3390/nu8040186
159. Suh SW, Lim E, Burm SY, Lee H, Bae JB, Han JW, Kim KW. The influence of n-3 polyunsaturated fatty acids on cognitive function in individuals without dementia: a

systematic review and dose-response meta-analysis. *BMC Med*. Mar 12 2024;22(1):109. doi:10.1186/s12916-024-03296-0
160. Lai HT, de Oliveira Otto MC, Lemaitre RN, et al. Serial circulating omega 3 polyunsaturated fatty acids and healthy ageing among older adults in the Cardiovascular Health Study: prospective cohort study. Research Support, N.I.H., Extramural
Research Support, Non-U.S. Gov't. *BMJ*. 2018;363:k4067.
161. Xu D, Lu Y, Yang X, et al. Effects of fish oil-derived n-3 polyunsaturated fatty acid on body composition, muscle strength and physical performance in older people: a secondary analysis of a randomised, double-blind, placebo-controlled trial. Randomized Controlled Trial
Research Support, Non-U.S. Gov't. *Age & Ageing*. 2022;51(12):05.
162. Hayman O, Combet E, Witard OC, Gray SR. Long-chain n-3 polyunsaturated fatty acid supplementation and neuromuscular function in older adults. *Curr Opin Clin Nutr Metab Care*. Nov 1 2024;27(6):486-491. doi:10.1097/mco.0000000000001065
163. Kosti RI, Kasdagli MI, Kyrozis A, Orsini N, Lagiou P, Taiganidou F, Naska A. Fish intake, n-3 fatty acid body status, and risk of cognitive decline: a systematic review and a dose-response meta-analysis of observational and experimental studies. *Nutr Rev*. May 9 2022;80(6):1445-1458. doi:10.1093/nutrit/nuab078
164. van de Rest O, Wang Y, Barnes LL, Tangney C, Bennett DA, Morris MC. APOE epsilon4 and the associations of seafood and long-chain omega-3 fatty acids with cognitive decline. Research Support, N.I.H., Extramural
Research Support, Non-U.S. Gov't. *Neurology*. May 31 2016;86(22):2063-70. doi:10.1212/WNL.0000000000002719
165. Bakre AT, Chen R, Khutan R, et al. Association between fish consumption and risk of dementia: a new study from China and a systematic literature review and meta-analysis. *Public Health Nutr*. Jul 2018;21(10):1921-1932. doi:10.1017/s136898001800037x
166. Samieri C, Morris MC, Bennett DA, et al. Fish Intake, Genetic Predisposition to Alzheimer Disease, and Decline in Global Cognition and Memory in 5 Cohorts of Older Persons. Research Support, N.I.H., Extramural
Research Support, Non-U.S. Gov't. *American Journal of Epidemiology*. 2017;187(5):933-940. doi:https://dx.doi.org/10.1093/aje/kwx330
167. Chuang SY, Lo YL, Wu SY, Wang PN, Pan WH. Dietary Patterns and Foods Associated With Cognitive Function in Taiwanese Older Adults: The Cross-sectional and Longitudinal Studies. Research Support, Non-U.S. Gov't. *Journal of the American Medical Directors Association*. 2019;20(5):544-550.e4. doi:https://dx.doi.org/10.1016/j.jamda.2018.10.017
168. Nozaki S, Sawada N, Matsuoka YJ, Shikimoto R, Mimura M, Tsugane S. Association between dietary fish and PUFA intake in midlife and dementia in later life: The JPHC Saku mental health study. Article. *Journal of Alzheimer's Disease*. 2021;79(3):1091-1104. doi:10.3233/JAD-191313
169. Canhada S, Castro K, Perry IS, Luft VC. Omega-3 fatty acids' supplementation in Alzheimer's disease: A systematic review. *Nutr Neurosci*. Oct 2018;21(8):529-538. doi:10.1080/1028415x.2017.1321813
170. Creegan R, Hunt W, McManus A, Rainey-Smith SR. Diet, nutrients and metabolism: cogs in the wheel driving Alzheimer's disease pathology? *Br J Nutr*. May 28 2015;113(10):1499-517. doi:10.1017/s0007114515000926

171. Devassy JG, Leng S, Gabbs M, Monirujjaman M, Aukema HM. Omega-3 Polyunsaturated Fatty Acids and Oxylipins in Neuroinflammation and Management of Alzheimer Disease. *Adv Nutr*. Sep 2016;7(5):905-16. doi:10.3945/an.116.012187
172. Derbyshire E. Brain Health across the Lifespan: A Systematic Review on the Role of Omega-3 Fatty Acid Supplements. *Nutrients*. Aug 15 2018;10(8)doi:10.3390/nu10081094
173. Bae JH, Kim G. Systematic review and meta-analysis of omega-3-fatty acids in elderly patients with depression. *Nutr Res*. Feb 2018;50:1-9. doi:10.1016/j.nutres.2017.10.013
174. Chhetri JK, de Souto Barreto P, Cantet C, et al. Effects of a 3-Year Multi-Domain Intervention with or without Omega-3 Supplementation on Cognitive Functions in Older Subjects with Increased CAIDE Dementia Scores. *J Alzheimers Dis*. 2018;64(1):71-78. doi:10.3233/jad-180209
175. Godos J, Micek A, Currenti W, et al. Fish consumption, cognitive impairment and dementia: an updated dose-response meta-analysis of observational studies. *Aging Clin Exp Res*. Aug 20 2024;36(1):171. doi:10.1007/s40520-024-02823-6
176. Eriksdotter M, Vedin I, Falahati F, et al. Plasma Fatty Acid Profiles in Relation to Cognition and Gender in Alzheimer's Disease Patients During Oral Omega-3 Fatty Acid Supplementation: The OmegAD Study. Article. *J Alzheimers Dis*. 2015;48(3):805-12. doi:10.3233/JAD-150102
177. Calderon Martinez E, Zachariah Saji S, Salazar Ore JV, et al. The effects of omega-3, DHA, EPA, Souvenaid® in Alzheimer's disease: A systematic review and meta-analysis. *Neuropsychopharmacol Rep*. Sep 2024;44(3):545-556. doi:10.1002/npr2.12455
178. Chen C, Xun P, Kaufman JD, et al. Erythrocyte omega-3 index, ambient fine particle exposure, and brain aging. Observational Study
Research Support, N.I.H., Extramural
Research Support, Non-U.S. Gov't. *Neurology*. 2020;95(8):e995-e1007.
179. Daiello LA, Gongvatana A, Dunsiger S, Cohen RA, Ott BR. Association of fish oil supplement use with preservation of brain volume and cognitive function. Article. *Alzheimer's and Dementia*. 2015;11(2):226-235. doi:10.1016/j.jalz.2014.02.005
180. Danthiir V, Hosking DE, Nettelbeck T, et al. An 18-mo randomized, double-blind, placebo-controlled trial of DHA-rich fish oil to prevent age-related cognitive decline in cognitively normal older adults. *Am J Clin Nutr*. May 1 2018;107(5):754-762. doi:10.1093/ajcn/nqx077
181. Kim J, Westra J, Tintle N, Harris WS, Park Y. Association of Plasma n-3 Polyunsaturated Fatty Acid Levels and the Prevalence of Frailty in Older Adults: A Cross-Sectional Analysis of UK Biobank. Article. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences*. 2024;79(5)glae085. doi:10.1093/gerona/glae085
182. Carballo-Casla A, García-Esquinas E, Banegas JR, Rodríguez-Artalejo F, Ortolá R. Fish consumption, omega-3 fatty acid intake, and risk of pain: the Seniors-ENRICA-1 cohort. Article. *Clinical Nutrition*. 2022;41(11):2587-2595. doi:10.1016/j.clnu.2022.09.007
183. Pradelli L, Mayer K, Klek S, et al. ω-3 Fatty-Acid Enriched Parenteral Nutrition in Hospitalized Patients: Systematic Review With Meta-Analysis and Trial Sequential Analysis. *JPEN J Parenter Enteral Nutr*. Jan 2020;44(1):44-57. doi:10.1002/jpen.1672
184. Pradelli L, Klek S, Mayer K, Omar Alsaleh AJ, Rosenthal MD, Heller AR, Muscaritoli M. Omega-3 fatty acid-containing parenteral nutrition in ICU patients: systematic review with meta-analysis and cost-effectiveness analysis. *Crit Care*. Nov 3 2020;24(1):634. doi:10.1186/s13054-020-03356-w

185. Pradelli L, Muscaritoli M, Klek S, Martindale RG. Pharmacoeconomics of Parenteral Nutrition with omega-3 Fatty Acids in Hospitalized Adults. Research Support, Non-U.S. Gov't Review. *Jpen: Journal of Parenteral & Enteral Nutrition*. 2020;44 Suppl 1:S68-S73. doi:https://dx.doi.org/10.1002/jpen.1775
186. Langlois PL, D'Aragon F, Hardy G, Manzanares W. Omega-3 polyunsaturated fatty acids in critically ill patients with acute respiratory distress syndrome: A systematic review and meta-analysis. *Nutrition*. May 2019;61:84-92. doi:10.1016/j.nut.2018.10.026
187. Grau-Carmona T, Bonet-Saris A, Garcia-de-Lorenzo A, et al. Influence of n-3 polyunsaturated fatty acids enriched lipid emulsions on nosocomial infections and clinical outcomes in critically ill patients: ICU lipids study. Article. *Crit Care Med*. Jan 2015;43(1):31-9. doi:10.1097/CCM.0000000000000612
188. Hall TC, Bilku DK, Neal CP, Cooke J, Fisk HL, Calder PC, Dennison AR. The impact of an omega-3 fatty acid rich lipid emulsion on fatty acid profiles in critically ill septic patients. *Prostaglandins Leukot Essent Fatty Acids*. Sep 2016;112:1-11. doi:10.1016/j.plefa.2016.07.001
189. Boyer BB, Hopkins SE, Wiener HW, et al. Habitual Intake of Marine-Derived n-3 PUFAs is Inversely Associated with a Cardiometabolic Inflammatory Profile in Yup'ik Alaska Native People. Article. *Journal of Nutrition*. 2022;152(3):844-855. doi:10.1093/jn/nxab412
190. Hong K, Hun M, Wu F, et al. Association between Omega-3 fatty acids and autoimmune disease: Evidence from the umbrella review and Mendelian randomization analysis. Review. *Autoimmunity Reviews*. 2024;23(11):103651.
191. Natto ZS, Yaghmoor W, Alshaeri HK, Van Dyke TE. Omega-3 Fatty Acids Effects on Inflammatory Biomarkers and Lipid Profiles among Diabetic and Cardiovascular Disease Patients: A Systematic Review and Meta-Analysis. *Sci Rep*. Dec 11 2019;9(1):18867. doi:10.1038/s41598-019-54535-x
192. Papamichael MM, Katsardis C, Lambert K, Tsoukalas D, Koutsilieris M, Erbas B, Itsiopoulos C. Efficacy of a Mediterranean diet supplemented with fatty fish in ameliorating inflammation in paediatric asthma: a randomised controlled trial. *J Hum Nutr Diet*. Apr 2019;32(2):185-197. doi:10.1111/jhn.12609
193. Xu F, Fan W, Wang W, et al. Effects of omega-3 fatty acids on metabolic syndrome in patients with schizophrenia: a 12-week randomized placebo-controlled trial. *Psychopharmacology (Berl)*. Apr 2019;236(4):1273-1279. doi:10.1007/s00213-018-5136-9
194. Khor BH, Narayanan SS, Sahathevan S, et al. Efficacy of Nutritional Interventions on Inflammatory Markers in Haemodialysis Patients: A Systematic Review and Limited Meta-Analysis. *Nutrients*. Mar 23 2018;10(4)doi:10.3390/nu10040397
195. Morvaridzadeh M, Sepidarkish M, Yavari M, et al. The effects of omega-3 fatty acid supplementation on inflammatory factors in HIV-infected patients: A systematic review and meta-analysis of randomized clinical trials. *Cytokine*. Dec 2020;136:155298. doi:10.1016/j.cyto.2020.155298
196. Gioxari A, Kaliora AC, Marantidou F, Panagiotakos DP. Intake of ω-3 polyunsaturated fatty acids in patients with rheumatoid arthritis: A systematic review and meta-analysis. *Nutrition*. Jan 2018;45:114-124.e4. doi:10.1016/j.nut.2017.06.023
197. Sigaux J, Mathieu S, Nguyen Y, et al. Impact of type and dose of oral polyunsaturated fatty acid supplementation on disease activity in inflammatory rheumatic diseases: a systematic literature review and meta-analysis. *Arthritis Res Ther*. May 7 2022;24(1):100. doi:10.1186/s13075-022-02781-2

198. Kostoglou-Athanassiou I, Athanassiou L, Athanassiou P. The effect of omega-3 fatty acids on rheumatoid arthritis. Article. *Mediterranean Journal of Rheumatology*. 2020;31(2):190-194. doi:10.31138/mjr.31.2.190
199. Tedeschi SK, Bathon JM, Giles JT, Lin TC, Yoshida K, Solomon DH. Relationship Between Fish Consumption and Disease Activity in Rheumatoid Arthritis. Research Support, N.I.H., Extramural. *Arthritis care & research*. 2018;70(3):327-332. doi:https://dx.doi.org/10.1002/acr.23295
200. Julibert A, Bibiloni MDM, Tur JA. Dietary fat intake and metabolic syndrome in adults: A systematic review. *Nutr Metab Cardiovasc Dis*. Sep 2019;29(9):887-905. doi:10.1016/j.numecd.2019.05.055
201. Fu Y, Wang Y, Gao H, et al. Associations among Dietary Omega-3 Polyunsaturated Fatty Acids, the Gut Microbiota, and Intestinal Immunity. *Mediators Inflamm*. 2021;2021:8879227. doi:10.1155/2021/8879227
202. Ong KL, Marklund M, Huang L, et al. Association of omega 3 polyunsaturated fatty acids with incident chronic kidney disease: pooled analysis of 19 cohorts. Meta-Analysis. *BMJ*. 2023;380:e072909.
203. Park I, Xun P, Tsinovoi CL, Klemmer P, Liu K, He K. Intakes of long-chain omega-3 polyunsaturated fatty acids and non-fried fish in relation to incidence of chronic kidney disease in young adults: a 25-year follow-up. Article. *European Journal of Nutrition*. 2020;59(1):399-407. doi:10.1007/s00394-019-02022-4
204. Lilleberg HS, Cichosz SL, Svensson M, Christensen JH, Fleischer J, Eide I, Jenssen T. The Effect of Marine n-3 Polyunsaturated Fatty Acids on Heart Rate Variability in Renal Transplant Recipients: A Randomized Controlled Trial. *Nutrients*. Nov 20 2019;11(12)doi:10.3390/nu11122847
205. Saglimbene VM, Wong G, van Zwieten A, et al. Effects of omega-3 polyunsaturated fatty acid intake in patients with chronic kidney disease: Systematic review and meta-analysis of randomized controlled trials. *Clin Nutr*. Feb 2020;39(2):358-368. doi:10.1016/j.clnu.2019.02.041
206. Musa-Veloso K, Venditti C, Lee HY, Darch M, Floyd S, West S, Simon R. Systematic review and meta-analysis of controlled intervention studies on the effectiveness of long-chain omega-3 fatty acids in patients with nonalcoholic fatty liver disease. *Nutr Rev*. Aug 1 2018;76(8):581-602. doi:10.1093/nutrit/nuy022
207. Guo XF, Yang B, Tang J, Li D. Fatty acid and non-alcoholic fatty liver disease: Meta-analyses of case-control and randomized controlled trials. *Clin Nutr*. Feb 2018;37(1):113-122. doi:10.1016/j.clnu.2017.01.003
208. Middleton P, Gomersall JC, Gould JF, Shepherd E, Olsen SF, Makrides M. Omega-3 fatty acid addition during pregnancy. *Cochrane Database of Systematic Reviews*. 2018;(11)doi:10.1002/14651858.CD003402.pub3
209. Masina M, Medithi S, Muley A. Impact of Maternal Essential Fatty Acid Intake on the Birth Weight of Infants. *J Mother Child*. Jun 1 2023;27(1):147-157. doi:10.34763/jmotherandchild.20232701.d-22-00052
210. Collins CT, Gibson RA, McPhee AJ, Makrides M. The role of long chain polyunsaturated fatty acids in perinatal nutrition. *Semin Perinatol*. Nov 2019;43(7):151156. doi:10.1053/j.semperi.2019.06.004
211. Kar S, Wong M, Rogozinska E, Thangaratinam S. Effects of omega-3 fatty acids in prevention of early preterm delivery: a systematic review and meta-analysis of randomized

studies. *Eur J Obstet Gynecol Reprod Biol*. Mar 2016;198:40-46. doi:10.1016/j.ejogrb.2015.11.033
212. Bakouei F, Delavar MA, Mashayekh-Amiri S, Esmailzadeh S, Taheri Z. Efficacy of n-3 fatty acids supplementation on the prevention of pregnancy induced-hypertension or preeclampsia: A systematic review and meta-analysis. *Taiwan J Obstet Gynecol*. Jan 2020;59(1):8-15. doi:10.1016/j.tjog.2019.11.002
213. Abdelrahman MA, Osama H, Saeed H, Madney YM, Harb HS, Abdelrahim MEA. Impact of n-3 polyunsaturated fatty acid intake in pregnancy on maternal health and birth outcomes: systematic review and meta-analysis from randomized controlled trails. *Arch Gynecol Obstet*. Jan 2023;307(1):249-262. doi:10.1007/s00404-022-06533-0
214. Rajati M, Rajati F, Chegeni M, Rasulehvandi R, Rezaei M, Ganjabi M, Kazeminia M. The effect of Omega-3 supplementation and fish oil on preeclampsia: A systematic review and meta-analysis. *Clin Nutr ESPEN*. Dec 2024;64:274-283. doi:10.1016/j.clnesp.2024.10.146
215. Vinding RK, Stokholm J, Sevelsted A, et al. Fish Oil Supplementation in Pregnancy Increases Gestational Age, Size for Gestational Age, and Birth Weight in Infants: A Randomized Controlled Trial. *J Nutr*. Apr 1 2019;149(4):628-634. doi:10.1093/jn/nxy204
216. Best KP, Gibson RA, Yelland LN, Leemaqz S, Gomersall J, Liu G, Makrides M. Effect of omega-3 lcpufa supplementation on maternal fatty acid and oxylipin concentrations during pregnancy. *Prostaglandins Leukot Essent Fatty Acids*. Nov 2020;162:102181. doi:10.1016/j.plefa.2020.102181
217. Smid MC, Stuebe AM, Manuck TA, Sen S. Maternal obesity, fish intake, and recurrent spontaneous preterm birth. *J Matern Fetal Neonatal Med*. Aug 2019;32(15):2486-2492. doi:10.1080/14767058.2018.1439008
218. Simmonds LA, Sullivan TR, Skubisz M, et al. Omega-3 fatty acid supplementation in pregnancy-baseline omega-3 status and early preterm birth: exploratory analysis of a randomised controlled trial. Multicenter Study
Observational Study. *BJOG: An International Journal of Obstetrics & Gynaecology*. 2020;127(8):975-981.
219. Feltham BA, Louis XL, Eskin MNA, Suh M. Docosahexaenoic Acid: Outlining the Therapeutic Nutrient Potential to Combat the Prenatal Alcohol-Induced Insults on Brain Development. *Adv Nutr*. May 1 2020;11(3):724-735. doi:10.1093/advances/nmz135
220. Emmett PM, Jones LR, Golding J. Pregnancy diet and associated outcomes in the Avon Longitudinal Study of Parents and Children. *Nutr Rev*. Oct 2015;73 Suppl 3(Suppl 3):154-74. doi:10.1093/nutrit/nuv053
221. Zhang MM, Zou Y, Li SM, et al. The efficacy and safety of omega-3 fatty acids on depressive symptoms in perinatal women: a meta-analysis of randomized placebo-controlled trials. *Transl Psychiatry*. Jun 17 2020;10(1):193. doi:10.1038/s41398-020-00886-3
222. Elagizi A, Lavie CJ, O'Keefe E, Marshall K, O'Keefe JH, Milani RV. An Update on Omega-3 Polyunsaturated Fatty Acids and Cardiovascular Health. *Nutrients*. Jan 12 2021;13(1)doi:10.3390/nu13010204
223. Phang M, Skilton MR. Marine Omega-3 Fatty Acids, Complications of Pregnancy and Maternal Risk Factors for Offspring Cardio-Metabolic Disease. *Mar Drugs*. Apr 24 2018;16(5)doi:10.3390/md16050138
224. Kamenju P, Hertzmark E, Kabagambe EK, et al. Factors associated with plasma n-3 and n-6 polyunsaturated fatty acid levels in Tanzanian infants. *Eur J Clin Nutr*. Jan 2020;74(1):97-105. doi:10.1038/s41430-019-0428-7

225. Steenweg-de Graaff J, Tiemeier H, Ghassabian A, Rijlaarsdam J, Jaddoe VW, Verhulst FC, Roza SJ. Maternal Fatty Acid Status During Pregnancy and Child Autistic Traits: The Generation R Study. Research Support, Non-U.S. Gov't. *Am J Epidemiol*. May 1 2016;183(9):792-9. doi:10.1093/aje/kwv263
226. Julvez J, Mendez M, Fernandez-Barres S, et al. Maternal Consumption of Seafood in Pregnancy and Child Neuropsychological Development: A Longitudinal Study Based on a Population With High Consumption Levels. Multicenter Study
Research Support, Non-U.S. Gov't. *American Journal of Epidemiology*. 2016;183(3):169-82. doi:https://dx.doi.org/10.1093/aje/kwv195
227. Inoue M, Matsumura K, Hamazaki K, Tsuchida A, Inadera H. Maternal dietary intake of fish and child neurodevelopment at 3 years: a nationwide birth cohort—The Japan Environment and Children's Study. Article. *Frontiers in Public Health*. 2023;111267088. doi:10.3389/fpubh.2023.1267088
228. Horner D, Hjelmso MH, Thorsen J, et al. Supplementation With Fish Oil in Pregnancy Reduces Gastroenteritis in Early Childhood. Randomized Controlled Trial
Research Support, Non-U.S. Gov't. *Journal of Infectious Diseases*. 2021;227(3):448-456. doi:https://dx.doi.org/10.1093/infdis/jiab607
229. Shulkin M, Pimpin L, Bellinger D, Kranz S, Fawzi W, Duggan C, Mozaffarian D. n-3 Fatty Acid Supplementation in Mothers, Preterm Infants, and Term Infants and Childhood Psychomotor and Visual Development: A Systematic Review and Meta-Analysis. *J Nutr*. Mar 1 2018;148(3):409-418. doi:10.1093/jn/nxx031
230. Demmelmair H, Øyen J, Pickert T, et al. The effect of Atlantic salmon consumption on the cognitive performance of preschool children - A randomized controlled trial. *Clin Nutr*. Dec 2019;38(6):2558-2568. doi:10.1016/j.clnu.2018.11.031
231. Øyen J, Kvestad I, Midtbø LK, et al. Fatty fish intake and cognitive function: FINS-KIDS, a randomized controlled trial in preschool children. *BMC Med*. Mar 12 2018;16(1):41. doi:10.1186/s12916-018-1020-z
232. van der Wurff ISM, Meyer BJ, de Groot RHM. Effect of Omega-3 Long Chain Polyunsaturated Fatty Acids (n-3 LCPUFA) Supplementation on Cognition in Children and Adolescents: A Systematic Literature Review with a Focus on n-3 LCPUFA Blood Values and Dose of DHA and EPA. *Nutrients*. Oct 12 2020;12(10)doi:10.3390/nu12103115
233. Chappus-McCendie H, Chevalier L, Roberge C, Plourde M. Omega-3 PUFA metabolism and brain modifications during aging. *Prog Neuropsychopharmacol Biol Psychiatry*. Aug 30 2019;94:109662. doi:10.1016/j.pnpbp.2019.109662
234. Couce ML, de Castro MJ, de Lamas C, Leis R. Effects of LC-PUFA Supplementation in Patients with Phenylketonuria: A Systematic Review of Controlled Trials. *Nutrients*. Jul 6 2019;11(7)doi:10.3390/nu11071537
235. Sherzai D, Moness R, Sherzai S, Sherzai A. A Systematic Review of Omega-3 Fatty Acid Consumption and Cognitive Outcomes in Neurodevelopment. *Am J Lifestyle Med*. Sep-Oct 2023;17(5):649-685. doi:10.1177/15598276221116052
236. Mohammady M, Janani L, Jahanfar S, Mousavi MS. Effect of omega-3 supplements on vasomotor symptoms in menopausal women: A systematic review and meta-analysis. *Eur J Obstet Gynecol Reprod Biol*. Sep 2018;228:295-302. doi:10.1016/j.ejogrb.2018.07.008
237. Su KP, Tseng PT, Lin PY, Okubo R, Chen TY, Chen YW, Matsuoka YJ. Association of Use of Omega-3 Polyunsaturated Fatty Acids With Changes in Severity of Anxiety Symptoms: A Systematic Review and Meta-analysis. *JAMA Netw Open*. Sep 7 2018;1(5):e182327. doi:10.1001/jamanetworkopen.2018.2327

238. Terauchi M, Odai T, Hirose A, Kato K, Miyasaka N. Chilliness in Japanese middle-aged women is associated with anxiety and low n-3 fatty acid intake. Article. *Climacteric*. 2020;23(2):178-183. doi:10.1080/13697137.2019.1653841
239. Parletta N, Zarnowiecki D, Cho J, et al. A Mediterranean-style dietary intervention supplemented with fish oil improves diet quality and mental health in people with depression: A randomized controlled trial (HELFIMED). *Nutr Neurosci*. Jul 2019;22(7):474-487. doi:10.1080/1028415x.2017.1411320
240. Molendijk M, Molero P, Ortuño Sánchez-Pedreño F, Van der Does W, Angel Martínez-González M. Diet quality and depression risk: A systematic review and dose-response meta-analysis of prospective studies. *J Affect Disord*. Jan 15 2018;226:346-354. doi:10.1016/j.jad.2017.09.022
241. Kim E, Je Y. Fish consumption and depression in Korean population: The Korea National Health and Nutrition Examination Survey, 2013–2021. Article. *Journal of Affective Disorders*. 2024;359:255-261. doi:10.1016/j.jad.2024.05.103
242. Sánchez-Villegas A, Álvarez-Pérez J, Toledo E, et al. Seafood Consumption, Omega-3 Fatty Acids Intake, and Life-Time Prevalence of Depression in the PREDIMED-Plus Trial. *Nutrients*. Dec 18 2018;10(12)doi:10.3390/nu10122000
243. Beydoun MA, Fanelli Kuczmarski MT, Beydoun HA, Rostant OS, Evans MK, Zonderman AB. Associations of the Ratios of n-3 to n-6 Dietary Fatty Acids With Longitudinal Changes in Depressive Symptoms Among US Women. Article. *Am J Epidemiol*. May 1 2015;181(9):691-705. doi:10.1093/aje/kwu334
244. Liao Y, Xie B, Zhang H, et al. Efficacy of omega-3 PUFAs in depression: A meta-analysis. *Transl Psychiatry*. Aug 5 2019;9(1):190. doi:10.1038/s41398-019-0515-5
245. Ravi S, Khalili H, Abbasian L, Arbabi M, Ghaeli P. Effect of Omega-3 Fatty Acids on Depressive Symptoms in HIV-Positive Individuals: A Randomized, Placebo-Controlled Clinical Trial. Randomized Controlled Trial. *Ann Pharmacother*. Oct 2016;50(10):797-807. doi:10.1177/1060028016656017
246. Bigornia SJ, Harris WS, Falcon LM, Ordovas JM, Lai CQ, Tucker KL. The Omega-3 Index Is Inversely Associated with Depressive Symptoms among Individuals with Elevated Oxidative Stress Biomarkers. Article. *J Nutr*. Apr 2016;146(4):758-66. doi:10.3945/jn.115.222562
247. Lu Y, Qiao D, Mi G. Clinical impacts of n-3 fatty acids supplementation on depression symptoms: an umbrella review of meta-analyses. *Br J Nutr*. Mar 14 2024;131(5):841-850. doi:10.1017/s000711452300226x
248. van der Burg KP, Cribb L, Firth J, et al. EPA and DHA as markers of nutraceutical treatment response in major depressive disorder. *Eur J Nutr*. Sep 2020;59(6):2439-2447. doi:10.1007/s00394-019-02090-6
249. Appleton KM, Voyias PD, Sallis HM, Dawson S, Ness AR, Churchill R, Perry R. Omega-3 fatty acids for depression in adults. *Cochrane Database of Systematic Reviews*. 2021;(11)doi:10.1002/14651858.CD004692.pub5
250. Luo XD, Feng JS, Yang Z, et al. High-dose omega-3 polyunsaturated fatty acid supplementation might be more superior than low-dose for major depressive disorder in early therapy period: a network meta-analysis. *BMC Psychiatry*. May 20 2020;20(1):248. doi:10.1186/s12888-020-02656-3
251. DiNicolantonio JJ, O'Keefe JH. The Importance of Marine Omega-3s for Brain Development and the Prevention and Treatment of Behavior, Mood, and Other Brain Disorders. *Nutrients*. Aug 4 2020;12(8)doi:10.3390/nu12082333

252. Vesco AT, Lehmann J, Gracious BL, Arnold LE, Young AS, Fristad MA. Omega-3 Supplementation for Psychotic Mania and Comorbid Anxiety in Children. *J Child Adolesc Psychopharmacol*. Sep 2015;25(7):526-34. doi:10.1089/cap.2013.0141
253. Rodríguez-Hernández PJ, Canals-Baeza A, Santamaria-Orleans A, Cachadiña-Domenech F. Impact of Omega-3 Fatty Acids Among Other Nonpharmacological Interventions on Behavior and Quality of Life in Children with Compromised Conduct in Spain. Article. *Journal of Dietary Supplements*. 2020;17(1):1-12. doi:10.1080/19390211.2018.1481165
254. Raine A, Ang RP, Choy O, et al. Omega-3 (ω-3) and social skills interventions for reactive aggression and childhood externalizing behavior problems: a randomized, stratified, double-blind, placebo-controlled, factorial trial. *Psychol Med*. Jan 2019;49(2):335-344. doi:10.1017/s0033291718000983
255. Fristad MA, Roley-Roberts ME, Black SR, Arnold LE. Moody kids years later: Long-term outcomes of youth from the Omega-3 and therapy (OATS) studies. *J Affect Disord*. Feb 15 2021;281:24-32. doi:10.1016/j.jad.2020.11.115
256. Karaszewska DM, Ingenhoven T, Mocking RJT. Marine Omega-3 Fatty Acid Supplementation for Borderline Personality Disorder: A Meta-Analysis. *J Clin Psychiatry*. May 4 2021;82(3)doi:10.4088/JCP.20r13613
257. Al-Ghannami SS, Al-Adawi S, Ghebremeskel K, et al. Randomized open-label trial of docosahexaenoic acid-enriched fish oil and fish meal on cognitive and behavioral functioning in Omani children. *Nutrition*. Jan 2019;57:167-172. doi:10.1016/j.nut.2018.04.008
258. Del Brutto OH, Mera RM, Ha JE, Gillman J, Zambrano M, Castillo PR. Dietary fish intake and sleep quality: A population-based study. Article. *Sleep Medicine*. 2016;17:126-128. doi:10.1016/j.sleep.2015.09.021
259. Gallini A, Yrondi A, Cantet C, Poncet M, Vellas B, Schmitt L, Andrieu S. Red Blood Cell Omega-3 Fatty Acid Composition and Psychotropic Drug Use in Older Adults: Results from the MAPT Study. *J Nutr Health Aging*. 2019;23(9):805-812. doi:10.1007/s12603-019-1252-4
260. Sun GY, Simonyi A, Fritsche KL, et al. Docosahexaenoic acid (DHA): An essential nutrient and a nutraceutical for brain health and diseases. *Prostaglandins Leukot Essent Fatty Acids*. Sep 2018;136:3-13. doi:10.1016/j.plefa.2017.03.006
261. Hsu MC, Huang YS, Ouyang WC. Beneficial effects of omega-3 fatty acid supplementation in schizophrenia: possible mechanisms. *Lipids Health Dis*. Jul 3 2020;19(1):159. doi:10.1186/s12944-020-01337-0
262. Sohouli MH, Razmpoosh E, Zarrati M, Jaberzadeh S. The effect of omega-3 fatty acid supplementation on seizure frequency in individuals with epilepsy: a systematic review and meta-analysis. *Nutr Neurosci*. Nov 2022;25(11):2421-2430. doi:10.1080/1028415x.2021.1959100
263. Boronin L, Spinei L, Nastas I. OMEGA-3 FATTY ACIDS AS ADJUVANT THERAPY IN MENTAL DISORDERS. Article. *Archives of the Balkan Medical Union*. 2024;59(2):11-20. doi:10.31688/ABMU.2024.59.2.07
264. Amminger GP, Nelson B, Markulev C, et al. The NEURAPRO Biomarker Analysis: Long-Chain Omega-3 Fatty Acids Improve 6-Month and 12-Month Outcomes in Youths at Ultra-High Risk for Psychosis. Multicenter Study
Research Support, Non-U.S. Gov't. *Biological Psychiatry*. 2019;87(3):243-252. doi:https://dx.doi.org/10.1016/j.biopsych.2019.08.030

265. Huang T, Wang T, Heianza Y, et al. Habitual consumption of long-chain n-3 PUFAs and fish attenuates genetically associated long-term weight gain. *Am J Clin Nutr*. Mar 1 2019;109(3):665-673. doi:10.1093/ajcn/nqy238
266. de la Iglesia R, Loria-Kohen V, Zulet MA, Martinez JA, Reglero G, Ramirez de Molina A. Dietary Strategies Implicated in the Prevention and Treatment of Metabolic Syndrome. *Int J Mol Sci*. Nov 10 2016;17(11)doi:10.3390/ijms17111877
267. Karimi G, Heidari Z, Firouzi S, Haghighatdoost F. A systematic review and meta-analysis of the association between fish consumption and risk of metabolic syndrome. *Nutr Metab Cardiovasc Dis*. May 7 2020;30(5):717-729. doi:10.1016/j.numecd.2020.02.001
268. Jang H, Park K. Omega-3 and omega-6 polyunsaturated fatty acids and metabolic syndrome: A systematic review and meta-analysis. *Clin Nutr*. Mar 2020;39(3):765-773. doi:10.1016/j.clnu.2019.03.032
269. Ding D, Li YH, Xiao ML, et al. Erythrocyte Membrane Polyunsaturated Fatty Acids Are Associated with Incidence of Metabolic Syndrome in Middle-Aged and Elderly People - An 8.8-Year Prospective Study. Article. *Journal of Nutrition*. 2020;150(6):1488-1498. doi:10.1093/jn/nxaa039
270. Asbaghi O, Choghakhori R, Abbasnezhad A. Effect of Omega-3 and vitamin E co-supplementation on serum lipids concentrations in overweight patients with metabolic disorders: A systematic review and meta-analysis of randomized controlled trials. *Diabetes Metab Syndr*. Jul-Aug 2019;13(4):2525-2531. doi:10.1016/j.dsx.2019.07.001
271. Huang YH, Chiu WC, Hsu YP, Lo YL, Wang YH. Effects of Omega-3 Fatty Acids on Muscle Mass, Muscle Strength and Muscle Performance among the Elderly: A Meta-Analysis. *Nutrients*. Dec 4 2020;12(12)doi:10.3390/nu12123739
272. Santo André HC, Esteves GP, Barreto GHC, Longhini F, Dolan E, Benatti FB. The Influence of n-3PUFA Supplementation on Muscle Strength, Mass, and Function: A Systematic Review and Meta-Analysis. *Adv Nutr*. Jan 2023;14(1):115-127. doi:10.1016/j.advnut.2022.11.005
273. López-Seoane J, Martinez-Ferran M, Romero-Morales C, Pareja-Galeano H. N-3 PUFA as an ergogenic supplement modulating muscle hypertrophy and strength: a systematic review. *Crit Rev Food Sci Nutr*. 2022;62(32):9000-9020. doi:10.1080/10408398.2021.1939262
274. Bird JK, Troesch B, Warnke I, Calder PC. The effect of long chain omega-3 polyunsaturated fatty acids on muscle mass and function in sarcopenia: A scoping systematic review and meta-analysis. *Clin Nutr ESPEN*. Dec 2021;46:73-86. doi:10.1016/j.clnesp.2021.10.011
275. Heileson JL, Funderburk LK. The effect of fish oil supplementation on the promotion and preservation of lean body mass, strength, and recovery from physiological stress in young, healthy adults: a systematic review. *Nutr Rev*. Dec 1 2020;78(12):1001-1014. doi:10.1093/nutrit/nuaa034
276. Lewis NA, Daniels D, Calder PC, Castell LM, Pedlar CR. Are There Benefits from the Use of Fish Oil Supplements in Athletes? A Systematic Review. *Adv Nutr*. Sep 1 2020;11(5):1300-1314. doi:10.1093/advances/nmaa050
277. Gil A, Gil F. Fish, a Mediterranean source of n-3 PUFA: benefits do not justify limiting consumption. *Br J Nutr*. Apr 2015;113 Suppl 2:S58-67. doi:10.1017/S0007114514003742
278. Hibbeln JR, Spiller P, Brenna JT, et al. Relationships between seafood consumption during pregnancy and childhood and neurocognitive development: Two systematic reviews.

Prostaglandins Leukot Essent Fatty Acids. Dec 2019;151:14-36. doi:10.1016/j.plefa.2019.10.002
279. Hamade A. Fish consumption benefits and PFAS risks: Epidemiology and public health recommendations. *Toxicol Rep*. Dec 2024;13:101736. doi:10.1016/j.toxrep.2024.101736
280. Donat-Vargas C, Bellavia A, Berglund M, Glynn A, Wolk A, Akesson A. Cardiovascular and cancer mortality in relation to dietary polychlorinated biphenyls and marine polyunsaturated fatty acids: a nutritional-toxicological aspect of fish consumption. Research Support, Non-U.S. Gov't. *Journal of Internal Medicine*. 2019;287(2):197-209. doi:https://dx.doi.org/10.1111/joim.12995
281. Bergkvist C, Berglund M, Glynn A, Wolk A, Akesson A. Dietary exposure to polychlorinated biphenyls and risk of myocardial infarction - a population-based prospective cohort study. Research Support, Non-U.S. Gov't. *Int J Cardiol*. Mar 15 2015;183:242-8. doi:10.1016/j.ijcard.2015.01.055

6.1 Appendix 1: Search strategy

Search strategy

Definitions of seafood used in this review

For this report, the term seafood is defined as finfish (vertebrates), cartilaginous fishes (e.g., sharks) and shellfish (invertebrates), whether of marine or freshwater origin, farmed or wild.

• Fish include marine pelagic, marine demersal, diadromous, and freshwater*.

• Shellfish include molluscs (e.g., bivalve molluscs such as clams, oysters, and mussels, and cephalopods such as octopus and squid), crustaceans (e.g. shrimp, crabs, and lobster), and echinoderms (e.g. sea cucumbers and sea urchins) are also included.

**In the context of this work, we include marine species that live part of their life in fresh water (not freshwaters species that live their entire life in freshwater).*

Search Terms

Electronic Database	Search Field	Search Terms Used
PubMed	Abstract, title, keywords, English 2015-present	(fish OR seafood OR Omega 3) AND (health) (fish OR seafood OR Omega 3) AND (health benefits) (fish OR seafood OR Omega 3) AND (nutrient value)
Medline Ovid	Abstract, title, keywords, English 2015-present, Clinically useful journals	(fish OR seafood OR Omega 3) AND (health) (fish OR seafood OR Omega 3) AND (health benefits) (fish OR seafood OR Omega 3) AND (nutrient value)
Scopus	Abstract, title, keywords, English 2015-present	(fish OR seafood OR Omega 3) AND (health) (fish OR seafood OR Omega 3) AND (health benefits) (fish OR seafood OR Omega 3) AND (nutrient value)
Cochrane Reviews	Abstract, title, keywords, English 2015-present	(fish OR seafood OR Omega 3) AND (health) (fish OR seafood OR Omega 3) AND (health benefits) (fish OR seafood OR Omega 3) AND (nutrient value)

Excluded:

- Books, book chapters
- Conference presentations
- Grey literature that is not peer-reviewed or evidence based
- Animal studies with no human health or human nutrient component

Outside the Scope of the review

- **L**ow level and emerging evidence, plus non-scientific and non-evidence-based literature
- Edible aquatic plants, seaweed, microphytes; marine mammals (whales, seals, dolphins, dugongs); aquatic reptiles; jellyfish; waterfowl; frogs; or cell-based cultured seafood.
- Animal feed or production (e.g., impact on size, quality, nutrient value)
- Labelling/mislabelling
- Nutritional profiles and nutritional values of seafood
- Sustainability and environmental impacts
- Comparison between wild catch and aquaculture
- Risks of seafood consumption.

NB: Whilst it was agreed to refer to wild or farmed seafood where mentioned in the literature, very few papers noted this differentiation, particularly where seafood was used in the form of oils or supplements to control intake or dose as per strict clinical study protocols.

6.2 Appendix 2: Summary of key findings for industry

Title: **The Health Benefits of Eating Seafood: Evidence Based Science**

Subtitle: **Summary of the key findings for industry**

Authors: **Dr Wendy Hunt, Professor Alexandra McManus**

Funded by: **Fisheries Research Development Corporation (FRDC) and International Coalition of Fisheries Associations as part of the Global Seafood Communicators Nutrition Toolkit Project 2025**

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Curtin University

Murdoch University

Abbreviations and Glossary of Terms

ALA	Alpha linoleic acid
CHD	Coronary heart disease
CV	Cardiovascular
CVD	Cardiovascular disease
DHA	Docosahexaenoic acid
DPA	Docosapentaenoic acid
EPA	Eicosapentaenoic acid
HDL-C	High density lipoprotein cholesterol
LC PUFA	Long chain polyunsaturated fatty acids
LDL-C	Low density lipoprotein cholesterol
PUFA	Polyunsaturated fatty acids
n-3 PUFA	Omega-3 polyunsaturated fatty acids
n-6 PUFA	Omega-6 polyunsaturated fatty acids
VLDL	Low density lipoprotein cholesterol

Oily Fish: "Oil-rich fish (or oily fish) are those that have oil distributed through their body, in contrast to white fish, where the main concentration of oils is located in the liver. Oily fish (e.g., Anchovies, Herring, Mackerels, Salmons, Trouts, Swordfish and Eels) contain higher levels of long chain polyunsaturated fatty acids (LC PUFA).

Introduction

Seafood is an excellent source of energy and contains a range of nutrients that are beneficial for human health. These include Omega-3 fatty acids (n-3 PUFA), protein, calcium, iodine, iron, Vitamins A, B12, D and E, zinc, selenium, copper, manganese, phosphorus and taurine. Details of the impact of the consumption of these nutrients and minerals on the human body are provided in Appendix 1 together with examples of seafood that contain them.

Methods

A rapid literature review of peer reviewed journal articles published between January 2015 and January 2025 was conducted. A summary of the key findings from this literature review[1] are included in dot point form in the results section of this document.

Results

All-cause mortality

- Fish and n-3 PUFA consumption reduce all-cause mortality
- Moderate consumption of seafood has the greatest effect (2-4 serves per week)
- The strong evidence of health benefits relates to DHA consumption
- The greatest benefit is gained from the ingestion of seafood as part of a healthy diet

Asthma and allergies

- n-3 PUFA during pregnancy helps to reduce the incidence of asthma, allergy and wheezing in infants
- Consumption of fish (particularly seafood high in n-3 PUFA and Vitamin D) in the first year of life reduces the risk of eczema, allergic rhinitis, asthma and wheeze
- Infant formula fortified with n-3 PUFA aids immune development.

Bone health

- Fish consumption and n-3 PUFA may protect bone health and reduce the risk of hip fracture
- Consumption of $\geq$ 5 serves of oily fish each week protects bone health and reduces the risk of fracture, particularly in senior women

Cancer

- A diet high in seafood and n-3 PUFA is protective against a number of cancers
- A high n-3 PUFA status is associated with lower fatigue in cancer patients
- n-3 PUFA as part of a healthy diet increases appetite and nutritional status in chemotherapy patients
- n-3 PUFA supplementation during chemotherapy improves bone density and survival rates in cancer patients

- ***Breast cancer***
  - High levels of fish consumption and n-3 PUFA are associated with a reduction in all-cause mortality in women with breast cancer
  - n-3 PUFA are beneficial to the prevention, progression and development of breast cancer

- ***Colorectal cancer***
  - ≥ 2 serves of oily fish per week reduces the risk of cancers in adults including liver, gallbladder, colorectal and lung cancer

- ***Lung cancer***
  - n-3 PUFA in adults (≥ 2 serves seafood /week) reduces the risk of lung cancer
  - n-3 PUFA improves nutritional status and reduces inflammation in lung cancer patients undergoing radio or chemotherapy
  - n-3 PUFA increases weight and quality of life in patients with lung cancer

- ***Other cancers***
  - n-3 PUFA (particularly DHA) reduces the risk of neck, head, oesophageal, pancreatic and endometrial cancers
  - Adequate intake of n-3 PUFA reduces inflammation and improves immune function in cancer patients.

Cardiovascular disease (CVD)

- Seafood as part of a balanced diet is associated with a reduced risk of CVD mortality, coronary heart disease (CHD), myocardial infarction and stroke
- ≥ 2 serves of seafood/week (particularly oily fish) is recommended to reduce the risk of congestive heart failure, CHD, ischemic stroke and sudden cardiac death

- ***n-3 PUFA supplementation***
  - Higher intakes of n-3 PUFA, EPA and DHA (≥ 2 serves per week) are associated with a reduced risk of all-cause mortality, CV events, CHD mortality and premature death
  - There is strong evidence supporting the cardioprotective role of EPA and DHA across the lifespan, particularly from marine based sources
  - There is strong emerging evidence that fish oil supplementation reduces the length of stay in Intensive Care Units (ICU) and in hospital following coronary artery bypass surgery
  - There is strong evidence that n-3 PUFA supplementation (especially DHA) reduces heart rate and blood pressure

- ***Blood lipids - cholesterol***
  - n-3 PUFA supplementation and consumption of seafood high in n-3 PUFA help to maintain appropriate cholesterol levels in the body
  - High levels of triglycerides (increases risk of cardiac events) may be mitigated with adequate intake of n-3 PUFA
  - Fish oil and Vitamin E supplementation has proven effective in reducing high cholesterol levels in menopausal women.

Diabetes

- Adequate intake of n-3 PUFA impacts positively on all nutrition-related aspects of type 2 diabetes treatment and management (≥ 2 serves per week)
- Adequate intake of n-3 PUFA improves eye health
- n-3 PUFA and Vitamin D supplementation improves sleep quality, depression and anxiety in women of reproductive age with pre-diabetes and low Vitamin D status
- Fish oil supplementation in pregnant women with type 2 diabetes has significant benefits associated with insulin resistance

Fertility

- There is strong emerging evidence that seafood consumption or n-3 PUFA supplementation can improve semen quality, concentration and motility

Healthy ageing

- There is strong evidence that a diet high in seafood (≥ 2 serves per week) as part of a healthy diet has considerable, positive health effects across the lifespan
- The anti-inflammatory properties of n-3 PUFA are extremely beneficial during the ageing process
- The significant benefits offered by n-3 PUFA associated with healthy ageing include: reduced all-cause mortality, improved cognitive function, preservation of muscle strength and improved balance (leading to a reduction in disabling falls)

- ***Alzheimer's disease and dementia***
  - Two serves of fish a week is protective against cognitive decline
  - ≥ 4 serves per week of seafood improves executive function, cognition, memory, and neuro inflammation (association with cognitive decline)
  - There is significant evidence that a high intake of n-3 PUFA delays the onset to Alzheimer's disease and slows progression of the disease following onset.
  - A high intake of fish in mid-life may reduce the likelihood of developing dementia

- ***Age related cognitive decline***
  - Evidence clearly supports the ingestion of (≥ 2 serves per week) oily fish to improve brain function and slow the rate of cognitive decline
  - Higher consumption of oily fish may prevent frailty in older adults
  - Oily fish consumption and n-3 PUFA (EPA and DHA) may reduce pain associated with inflammatory conditions such as arthritis in older adults

Hospitalisation

- The n-3 PUFA status of critically ill patients is associated with a reduced risk of infection, plus shortened hospital and ICU lengths of stay
- EPA and DHA emulsions improve survival rates in critically ill septic patients

Inflammatory conditions

- Consumption of a Mediterranean diet (including ≥ 2 serves per week) significantly reduces airway inflammation in children
- n-3 PUFA supplementation reduces inflammation associated with many health-related conditions (e.g., diabetes, CV events, arthritis, metabolic syndrome, gut-related problems, systemic lupus, peripheral vascular conditions, kidney disease)

Kidney health

- Higher consumption of marine n-3 PUFA is associated with a lower risk of chronic kidney disease
- n-3 PUFA supplementation reduces CV mortality in patients on haemodialysis

Liver health

- n-3 PUFA improve metabolic indicators, liver enzymes and reduces liver fat content in patients with non-alcoholic fatty liver disease

Maternal health

- There is significant evidence supporting n-3 PUFA supplementation in later pregnancy (24 weeks onwards) to prolong pregnancy and improving birth weight.
- n-3 PUFA consumption during pregnancy can reduce the risk of preeclampsia
- Maternal n-3 PUFA intake during pregnancy and lactation reduces the risk of infant food allergy and food sensitisation during childhood
- n-3 PUFA and iodine from fish consumption reduce maternal depression and anxiety and increase neurocognitive child development

- ***Infant health***
  - DHA is an essential component of the brain. In cases where amino acid metabolism is compromised, DHA supplementation has proven effective in improving DHA levels within brain structures
  - Consumption of fatty fish during pregnancy benefits infant cognitive function
  - Consumption of fish in the first year of life reduces the risk of eczema and allergic rhinitis (severe hay fever)

Menopause

- n-3 PUFA can reduce night sweats in menopausal women
- Fish oil and Vitamin E supplementation reduces total and LDL cholesterol in menopausal women

Mental health – anxiety and depression

- Mediterranean diet and supplementation with fish oil reduces depressive and dementia symptoms, improves mental health and quality of life index
- High adult fish consumption (≥ 4 serves per week) reduces rates of depression compared with low fish consumption (< 1 serve per week), especially in females
- n-3 PUFA supplementation has a significant effect on perinatal depression
- n-3 PUFA (EPA and DHA) supplementation is effective in reduction of depression symptoms

- ***Mental health – behavioural disorders***
  - Low intakes of marine n-3 PUFA increases the risk of attention deficit hyperactivity disorder, autism, bipolar disorder, depression and suicide ideation
  - Treatment with n-3 fatty acid supplementation has proven effective in improving the social and interpersonal skills of children with some personality disorders.

- ***Mental health -other issues***
  - Greater consumption of oily fish is associated with better sleep quality
  - DHA associated with health benefits related to Alzheimer's disease, schizophrenia, stroke and traumatic brain injury
  - n-3 fatty acid supplement has proven effective in reducing the frequency of seizures in both adults and children with epilepsy
  - n-3 PUFA supplementation for young people at high-risk of psychosis was found to be a safe, user-friendly and effective treatment therapeutic benefits at both early onset and as a long-term treatment option

Metabolic syndrome

- n-3 PUFA lower the risk of metabolic syndrome
- Short term fish oil supplementation of adults with metabolic disorder increased insulin sensitivity

Muscle health and performance

- n-3 LC PUFA may maintain or increase neuromuscular function during ageing
- n-3 PUFA may lead to small increases in muscle strength
- n-3 PUFA improve recovery from onset muscle soreness during exercise
- Fish oil supplementation in athletes benefits the central nervous system, CV system, skeletal muscle and reduces proinflammatory cytokines

Health benefits associated with eating seafood

- The benefits of seafood and fish consumption and the role of n-3 PUFA in health at all stages of life, from conception through ageing, outweigh the potential risks (with the exception of a few selected species in sensitive populations)

Summary

In summary, there is good evidence that a healthy diet high in seafood provides substantial health benefits including:

- prevention of all-cause mortality;
- improved heart and cardiovascular health;
- reduction and management of asthma and allergies;
- maintenance of bone health and reduction of fractures;
- protection against some cancers (breast, colorectal, lung);
- improved nutritional status during cancer treatment;
- reduced inflammation;
- management and treatment of type 2 diabetes mellitus;
- promotion of healthy ageing across the lifespan;
- significant benefits to both maternal and infant health;
- protection against Alzheimer's disease and dementia;
- improved kidney and liver health;
- significant benefits to many mental health related conditions; and
- significant health benefits may be gained from as little as 2 serves per week.

Scientific research has demonstrated clear evidence that consumption of seafood as part of a healthy diet provides significant health benefits throughout the lifespan.

Reference

1. Hunt W, McManus A. 2025 The health benefits of eating seafood: Evidence based science. Medical, Molecular and Forensic Science, Murdoch University, Australia and Faculty of Health Sciences, Curtin University, Australia. Report # 27032025

Appendix Table 1: The health benefits of eating seafood

Nutrient/mineral	Health benefits provided	Examples of Australian seafood high in nutrient/mineral*
Omega-3 fatty acids	Essential for health (human bodies can't make them) Essential for brain development and function Reduces heart disease and aids blood vessel function Helps to maintain and improve eyesight May reduce asthma and allergies	Atlantic Salmon, Sardines
Calcium	Works with Vitamin D to develop and maintain strong bones Vital for muscle, nerve and heart function Helps to prevent osteoporosis	Salmons, Sardines, Oysters,
Iodine	Essential for thyroid function, growth, metabolism, cellular oxygenation and maintenance of the central nervous system	Scallops, Oysters, mussels
Iron	Production of energy; necessary for muscle function Facilitates blood oxygenation	Oysters, Sardines, mussels
Vitamin A and E (antioxidants)	Important of heart and skin Essential for nervous and circulatory systems function	Mackerels, Salmons, Herring (Vitamin A) Trouts, Abalone, Salmons (Vitamin E)
Vitamin B12	Aids DNA synthesis and normal blood function Aids neurological function - helps to retain cognitive function in ageing	Tunas, Sardines, mussels
Vitamin D	Seafood is the best source of Vitamin D (second only to the sun) Improves immune function, skin condition and muscle strength	Salmons, Silver Perch
Zinc	Aids immunity and healing	Oysters, crab, lobster
Protein	Repairs and maintains cells (muscles, bones, fingernails, hair) Vital for digestive function and antibody production Source of energy	Tunas, Trouts, Barramundi
Selenium	Prevents cellular damage Supports a healthy immune function - regulates thyroid function	Mullets, Tunas, Gemfish
Copper	Keeps nerve cells and immune systems healthy Helps make red blood cells	Prawns, Salmons (smoked), crab
Manganese	Helps form connective tissue, bones, blood and sex hormones Helps metabolise fats and carbohydrate Aids calcium absorption and blood sugar regulation	Oysters, clams, mussels
Phosphorous	Essential for bone and teeth health Helps filter waste from kidneys Helps the body store and use energy Reduces muscle pain following exercise	Salmons, Mackerels, Herring
Taurine	Essential for heart health, plus nervous system and brain function	Scallops, clams, mussels

*For nutritional information about locally sourced and locally consumed seafood, refer to trusted regional nutritional data.