Nutritional interventions

Toolkit technical report

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This report is produced in collaboration with Howard White. It is a derivative product, which summarises information from Campbell systematic reviews, and other reviews, to support evidence-informed decision making'.

Summary

This report provides a summary of the effects of nutritional interventions on future aggressive or antisocial behaviours as well as criminal offending. The review also contains evidence on barriers and facilitators to effective programme implementation. This technical report is based on the systematic review and meta-analysis of Konkolÿ Thege and colleagues (2024).

Researchers are exploring whether changes in nutrition might help reduce offending, as well as aggressive and antisocial behaviours. A nutritional intervention refers to any action taken to improve the availability of necessary substances in the human body, and it can involve three main approaches: i) *diet change:* making changes in what foods are consumed, such as eating more Vitamin D-rich foods; ii) *fortification:* fortifying common foods by adding extra nutrients, such as drinking milk with added Vitamin D; and iii) *supplementation:* taking supplements, which are pills or other products that provide specific groups of nutrients, such as a Vitamin D supplement. The second and third approach are quite similar and there are fewer studies on fortification; therefore, both were combined in the report and referred to as supplementation for simplicity.

The review reports on evidence from 50 impact evaluation studies providing 72 independent effect sizes for children and young people. The studies spanned the period from 1978 to 2023 and were mostly carried out in the USA, Europe, and Asia. We also searched for and identified 70 formal academic studies and other resources from the USA, Europe, and Asia to identify barriers and facilitators of nutritional interventions. These however were not restricted to studies in relation to child or youth aggression or offending as the same nutritional interventions are also implemented for other purposes and settings (e.g., in psychiatry).

This systematic review finds that nutritional interventions targeting a large number of nutrients, such as vitamins and minerals, are highly effective in reducing violent youth offending. The same type of broad-range nutritional interventions is also effective in decreasing aggression and antisocial behaviours in children and young people. Omega-3 fatty acid supplementation has a

beneficial effect in reducing both child and youth aggression and antisocial behaviour, while Vitamin D supplementation has a beneficial effect in reducing antisocial behaviours.

While there are several studies on other nutritional interventions, all of them are examined in a single study only, thus not allowing any conclusions beyond those of the original authors. Most study and intervention characteristics are not related to important differences in the outcomes. However, interventions with a broad nutritional target seem to be more effective in samples with a larger proportion of males.

Thematic synthesis of the literature on the barriers and facilitators of implementing nutritional interventions identified a large number of relevant factors on all five domains of implementation for both diet change and supplementation interventions: i) awareness and interest in the target population and other stakeholders regarding nutritional interventions; ii) access to nutritional interventions; iii) nutritional intervention characteristics; iv) user compliance; and v) intervention-interfering processes. While costs are often mentioned as barriers toward a healthier diet and long-term supplementation in the public discourse on nutrition, quantifying this burden is not easy due to its extreme variability across different diets, supplements, countries and before-intervention nutrition-related spending of individuals, families or organisations.

While many further questions remain to be answered regarding the effectiveness of nutritional interventions in reducing offending, aggression and antisocial behaviour - given that better nutrition does not only have the potential to reduce violence and antisocial behaviours, but is the basis for both physical and mental health in general, investment in nutritional interventions on all levels of society seems warranted.

Objective and approach

This report provides a summary of the effects of nutritional interventions on future aggressive and antisocial behaviours as well as offending. The review also contains data on barriers and facilitators to effective program implementation. This technical report is based on the systematic review and meta-analysis of Konkolÿ Thege and colleagues (2024).

Selection of the review for this technical report

To be eligible for use in this technical report, a meta-analysis had to consider the effects of nutritional interventions on aggressive or antisocial behaviours or offending in children and youth. While there have been a few reviews (Benton, 2007; Gajos & Beaver, 2016; Raine & Brodrick, 2024) conducted with a partial overlap with these criteria, none of them satisfies all these requirements. This is why this technical report is based solely on the review of Konkolÿ Thege and colleagues (2024).

Inclusion and exclusion criteria for studies in the review

The following inclusion criteria were used by the review authors to identify relevant impact evaluation studies for the review:

- Rigorous or moderately rigorous research designs where authors compared changes over time across at least two groups of participants: one receiving the nutritional intervention while the other not receiving it (i.e., control group);
- Study participants were children or young people (up to the age of 24), characterised by elevated level of aggression / antisocial behaviours / history of offending[1];
- Interventions were dietary manipulation or nutritional supplementation (including fortification or the use of supplements), both of which was long enough (minimum of one week) so that a significant change in nutritional status could be expected;
- Outcomes were i) criminal offending; ii) behavioural-level violence / aggression toward others in real-life (non-simulated) settings; and iii) antisocial behaviours (including for example disobedience, theft, lying, intentional property damage with or without aggression).

Studies were not considered in the review if

- They had a design with no control group (e.g., a single group investigated before and after the nutritional intervention);

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[1] The authors sought direct or indirect indicators for elevated level of aggression when identifying relevant studies. Direct indicators were, for instance, criminal charges for violent behaviour or above-average scores on behavioural assessment tools measuring aggression. Indirect indicators were diagnosed mental disorders often co-occurring with aggression such as conduct disorder, attention-deficit/hyperactivity disorder, or autism or involvement with the criminal justice system for any reason.

- Average age of participants was above 24 years;
- Interventions did not aim to improve the nutritional status of participants (e.g., investigation of the effects of a short-term intervention assumed to cause increase in behavioural problems (also known as ‘challenge protocol’) such as one-time exposure to a high-sugar meal);
- They investigated aggressive / angry / hostile emotions or thoughts without observable behaviours or aggressive tendencies presented in simulated environments (e.g., level of aggression expressed in a video game play situation, which is seen as substantially different from real-life situations).

No search restrictions were applied in terms of country of origin or date of publication. Search was restricted though to reports that had an English-language title and abstract. This approach resulted in the identification of two reports (Nogovitsina & Levitina, 2006; ter Maat-Wytsma et al., 1990), the full text of which were written in a language (Russian and Dutch, respectively) not spoken by the study team. The relevance or irrelevance of these reports could not be verified by the review authors and therefore they were not included in the evidence synthesis.

Outcomes

Offending was considered as the primary outcome of interest. A violent offense was defined as any actual, attempted, or threatened harm directed at another person, including nonconsensual sexual contact, that is punishable by law. While the review authors initially planned to separate violent crimes from non-violent ones, there was not enough data to do this, so they combined all types of criminal behaviour.

Additional outcomes were aggressive and antisocial behaviours. Violent or aggressive behaviour was defined as intentionally causing or trying to cause harm to someone else. This includes both reactive aggression (e.g., impulsive violence or anger-driven behaviour) and proactive aggression (violence aimed at gaining power). Aggressive behaviour in children and young people is often studied alongside other disruptive actions, like disobedience, stealing, lying, arson, or vandalism, and this broader range of behaviours was also considered under the umbrella term of ‘antisocial behaviour’.

The authors also collected and synthesised published information on the barriers and facilitators of implementing nutritional interventions with special attention dedicated to issues specific to young people (e.g., swallowing larger pills, the form of many nutritional supplements, is sometimes described as a barrier for children and researchers in the field also came up with solutions to this problem). A specific subdomain of implementation-related factors is the cost of interventions. The authors only collected some preliminary data in this regard to demonstrate the difficulties about this issue resulting from the vast cost variability across different diets, supplements, countries and default nutrition-related spending.

Description of interventions

The review looked at two main types of nutritional interventions: dietary changes and nutritional supplementation. Dietary manipulation involves intentionally changing what a person eats to improve their nutrition. The goal is to either: i) increase the intake of certain foods that provide nutrients lacking in their current diet, or ii) reduce or eliminate foods that contain substances that are helpful in moderation but harmful in excess (like too many carbohydrates), or substances that are unnecessary or harmful in any amount (like certain additives in highly processed food products).

On the other hand, nutritional supplementation focuses solely on adding nutrients to the person's system. This is done through manufactured products like pills, capsules, or liquids, which are regulated as dietary supplements (not medications, so they do not need a physician's prescription). These supplements include essential nutrients like vitamins (e.g., vitamin D), minerals (e.g., calcium, magnesium, zinc), and macronutrients (e.g., fatty acids and amino acids). Supplementation is defined as taking these manufactured products in addition to an unchanged diet. Other plant-based products (known as phytoceuticals) were also considered but no relevant studies have been found.

The interventions received by the control groups were diverse. Some received a placebo (a pill that looks like the supplement but has no active ingredient), others received simple healthy eating advice or were waitlisted for the actual intervention.

Theory of change (presumed causal mechanisms)

In recent years, there has been a lot of interest in how diet, especially the negative effects of eating too many *ultraprocessed* foods, impacts health (Monteiro et al., 2019). Research is also exploring how certain nutrients—like certain fatty acids, vitamins, and minerals might help reduce aggression and violence (Rucklidge et al., 2015). Studies have found connections between a person's nutritional status and various antisocial behaviours. For example, one study of 1,324 Australian adolescents showed that aggressive and delinquent behaviours were associated with a 'Western style' diet (Oddy et al., 2009), which typically consists of red meat and refined carbohydrates like bread. Other studies have found that children who were malnourished in their early years were more likely to have behavioural problems later on (Galler et al., 2012; Liu et al., 2004). A study in Australia also found that children who ate more highly processed foods, like sugary foods, at age 11 were more likely to exhibit antisocial behaviours at age 14 (Trapp et al., 2016). A similar study in Colombia showed that children who ate more dairy and high-quality meat had lower levels of aggression later in life, compared to those who ate a lot of carbohydrates or lower-quality meats (Robinson et al., 2021). A large study in Brazil found that a diet high in processed foods and refined carbohydrates, but low in fruits, vegetables, and legumes was linked to bullying perpetration and physical aggression (Okada et al., 2024).

Research also suggests that food insecurity—when people cannot always get enough acceptable-quality food—can lead to higher levels of delinquent behaviours. Children raised in households with limited access to nutritious food were more likely to engage in behaviours like aggression, substance use, skipping school, and vandalism (Jackson et al., 2018). Socioeconomic factors, which are linked to both food choices and offending outcomes, may make this connection even stronger. There is also evidence that improving childhood nutrition can reduce the likelihood of offending later in life. For example, each additional year of participation in a nutritional assistance program was linked to a 2.5% decrease in the likelihood of being convicted of a violent crime as a young adult; although there was no association with property crimes (Barr & Smith, 2023). While these studies do not prove a direct cause-and-effect relationship, they suggest that certain diets may increase antisocial behaviours, and improving nutrition could help reduce aggression and violent crime.

The brain’s role in aggression is complex and not fully understood. Neurochemicals in the body can affect aggression by influencing brain development in childhood and how the brain functions throughout life (Rosell & Siever, 2015). Chemicals like serotonin, dopamine, gamma-aminobutyric acid (GABA), oxytocin, testosterone, and cortisol have all been shown to play a role in aggression and its regulation (Siever, 2008). The ability to regulate aggression depends on healthy brain development and functioning in childhood and adolescence and these processes rely on having the right nutrients to support the brain's growth and function (Roberts et al., 2022).

Nutrients can affect brain function and behaviour in several ways (see Fig 1). Micronutrients help create neurotransmitters, like serotonin and dopamine, that regulate mood and behaviour (Rucklidge et al., 2021). Further, a lack of omega-3 fatty acids can interfere with the production and use of serotonin in the nervous system, while a high-protein diet can affect dopamine production (Muth & Park, 2021). Nutrition also plays a role in how the brain deals with harmful environmental chemicals—poor nutrition can make the brain more vulnerable to toxins from the environment (e.g., air pollution, pesticides), while the right nutrients can protect brain structure (Muth & Park, 2021). In addition, micronutrients are involved in processes that affect how genes work, which can also influence behaviour (Rucklidge et al., 2021). Another way nutrition may affect behaviour is through the gut microbiome (bacteria, viruses, and fungi in the gut), which is linked to brain function. Neural and endocrine signals from the gut can influence brain activity and so ultimately, behaviour (Dinan et al., 2015).

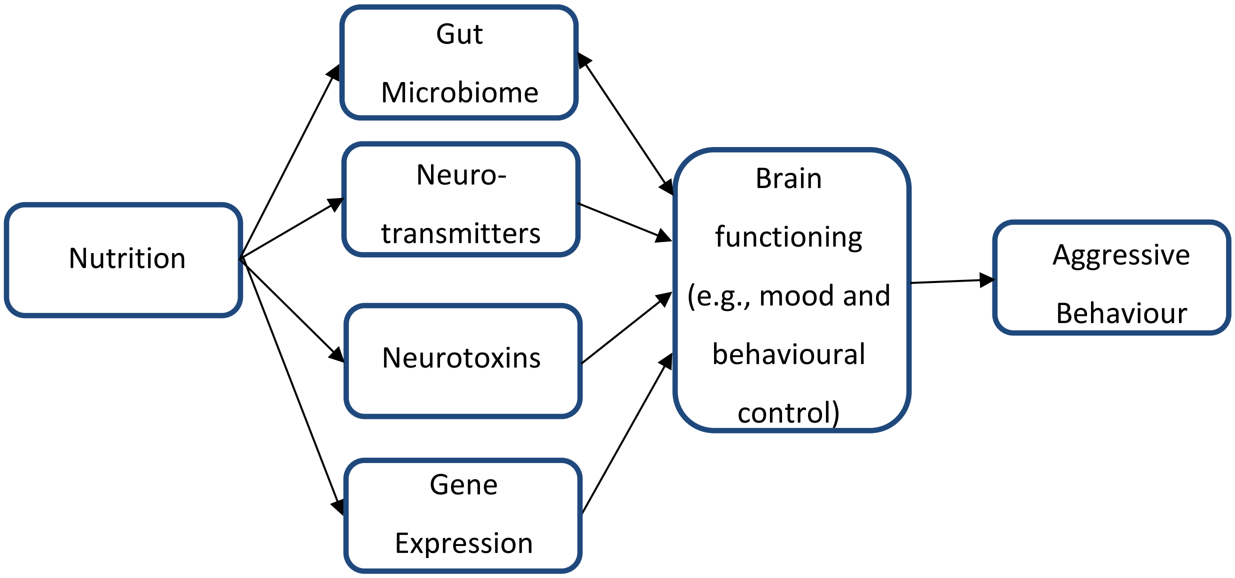

Figure 1: The hypothesized links between nutrition and behaviour

Evidence base

Descriptive overview

The search for relevant studies was applied to seven electronic databases. Additional web sources were searched to identify relevant unpublished works not indexed in academic databases. Other search methods included hand-searching the reference lists of existing reviews in the field and the reference lists of all studies included in the review. The search resulted in identifying 50 eligible impact evaluation studies: 18 investigating aggression, 43 investigating antisocial behaviours, and two studies investigating offending (there were studies investigating more than one type of outcome). Most important characteristics of the included studies are summarised in Appendix A1 & A2.

Out of the 50 studies reviewed, 28 (56%) were conducted in community or school settings[2], eight (16%) in outpatient psychiatry and custody settings each, and two (4%) in inpatient or residential settings. The setting was not specified in four studies (8%). The data collection typically occurred

[2] In most cases, the intervention (i.e., supplements, meal plans) and materials (e.g., logbook, dietary guidelines) were distributed in these settings but were administered at home by the parents

in North America (36%), Europe (30%)[3] and Asia (26%). Of the included studies, 70% involved participants with a medical diagnosis less closely related to aggression or antisocial behaviour (e.g., ADHD, autism), 20% involved young people on probation or in custody, and 10% focused on participants with a medical diagnosis directly related to aggression or antisocial behaviour (e.g., conduct disorder) or those showing elevated level of aggression or antisocial behaviour in assessments identifying these specific characteristics.

Eight studies (16%) focused exclusively on males, while 41 studies (82%) included both males and females (participants' sex composition was not reported in one study). On average, 79% of participants were male, with a standard deviation of 14.3%. The average age of participants across all studies was 10.4 years, with a range from 3.3 to 22.8 years. Most studies (68%) did not specify the race or ethnicity of participants. In the studies that did report this, 63.4% of participants were Caucasian on average, with a large variation (from 0% to 100%). Only one study reported race-stratified results, finding no difference in intervention effectiveness between White and Black participants (Schoenthaler, 1983a). Another study investigated the effect of sex and found no difference in intervention efficacy between boys and girls (Johnstone et al., 2022).

Out of the 50 studies reviewed, 22% investigated change of diet; in 4% of the studies, the intervention was fortification with omega-3 fatty acids, while in the remaining 74% of the studies, nutritional supplements were used. In the studies on supplementation, 18 examined omega-3 fatty acid supplements, 10 used broad range supplementation, four studies investigated vitamin D, two studied the effects of zinc, while magnesium, histidine and l-tryptophan was studied in one study each.

[3] Out of the 50 intervention studies, three were conducted in the UK (Gesch et al., 2002; Ghose, 1983; Richardson & Montgomery, 2005).

In the primary analyses, studies on dietary improvements[4] and broad-range supplementation were combined (and labelled as 'broad-spectrum nutritional interventions') as both interventions improve the availability of many nutrients in the body. In the subgroup analyses, data on dietary improvements versus broad-range nutritional supplementation were analysed separately to allow the comparison of these two different types of interventions.

The average duration of interventions was 100.8 days, with a standard deviation of 63.5 days and a range from 11 to 365 days. Most studies (68%) used interventions lasting 105 days or less, while the remaining studies (32%) used longer interventions.

Assessment of the strength of evidence[5]

A modified version of the AMSTAR2 critical appraisal tool was used to appraise the review that informs the current technical report. The review of Konkolÿ Thege et al. (2024) is rated high confidence. The authors have clear inclusion criteria related to the PICOS, employed double screening and coding, report details of included studies, identified factors associated with heterogeneity of effects, use the Cochran risk of bias tool, and declare that there is no conflict of interest (see Appendix B for details).

Of the 50 included studies, 88% had a high-quality design (randomised controlled trial), while 12% had a moderately rigorous design (employed a non-randomised control group). All extracted effect sizes were assessed using the Cochrane Collaboration's appropriate risk of bias assessment tool (version depending on study design). Using these tools, only a small number (16.7%) of effect sizes was associated with low risk of bias, the majority (47%) was characterised by moderate or high (36%) risk of bias, which pattern somewhat reduces our confidence in the overall credibility of the findings.

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[4] All but one dietary change study used an intervention, which improved the overall nutritional status of intervention participants (e.g., beyond eliminating gluten from the diet, investigators also increased the amount of fruits and vegetables consumed by participants). The one study where only the reduction of sugar intake occurred but no improvement was made regarding other aspects of diet (Longhurst & Mazer, 1988) was not considered as a broad-spectrum nutritional intervention; instead, it was reported on separately.

[5] This evaluation was conducted by Professor Howard White, a researcher independent of the authors of the review.

While there have been several studies looking at the effects of broad-spectrum nutritional interventions on aggression (seven studies with a total of 797 participants) and antisocial behaviours (13 studies with a total of 2,109 participants), only two studies focused on offending, with just 117 participants, which limits how much we can generalise the findings related to this outcome.

It is important to note though that studying the impact of dietary changes on aggression is particularly challenging, as most studies with dietary manipulation necessarily have a high risk of bias. According to the Cochrane Risk of Bias Tool, a study is considered to have a high risk of bias if the individuals assessing the outcome variables know which intervention was used (Higgins et al., 2019). In most dietary studies, the participants or their family members are the ones assessing the outcomes (e.g., parent-report on child's aggressive behaviour) or they are involved in both delivering the intervention and evaluating the results. Even when others, like custody officers, assess the outcomes, those closely involved with the participants are likely to notice changes in both behaviour and diet. Therefore, studies on dietary manipulation will likely always have a high risk of bias, unless the context allows for objective measures, like (re)offending statistics in probation settings where the person's diet is not known when making decision on the outcome.

Impact

Most important statistical details regarding intervention impact are displayed in Table 1 (impact evaluations results), Appendix C (moderators of effectiveness), and Appendix D (percentage change calculations).

Offending as outcome

Two studies (with 117 participants) examined how nutrition affects reoffending (both samples consisted of people already convicted at the time of study enrolment); both with a broad nutritional focus. One study focused on improving overall diet in a probational setting, and the other used micronutrient supplementation in a custody setting. The results showed that the intervention was highly effective in reducing reoffending (82% reduction). Given the low number of included studies and the high I^2 value of the meta-analysis, the overall evidence security rating for this finding is 1, suggesting very low confidence on the impact on the outcome explored.

The two studies showed some differences in their results: the study on diet change showed a much stronger effect than the supplementation study. The results were not inconsistent in direction (harmful vs. beneficial) but varied only in how strong the beneficial effect was. Considering that even the less effective study indicated high effectiveness (Hedges'g of 0.73), the high I^2 value is not a true limitation of the results. Because there were only two studies in this group, publication bias (the idea that studies showing positive results are more likely to be published) was not tested[6], and there was no need for eliminating studies due to very low quality as both of these studies were characterised by only moderate risk of bias.

Aggression as outcome - Broad-spectrum nutritional interventions

Out of the 18 studies on aggression, seven looked at interventions aimed at improving nutrition in general, such as providing supplements with a large number of nutrients or making major changes to the overall diet. These seven studies involved 797 participants. The results showed that it was highly effective in reducing aggression (36% reduction). Given the relatively low number of included studies, the overall evidence security rating is 3.

When excluding studies that had a high risk of bias, only two studies remained to be analysed. In this smaller group, the effect became small and no longer statistically significant, but still favoured the intervention. When all seven studies were included, there was no strong evidence of differences across the studies in terms of the magnitude of effect, meaning the results were fairly consistent. About 75% of the differences seen were due to random chance rather than real differences. Because there were only a few studies, publication bias was not tested.

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[6] Publication bias can be studied meaningfully only above a certain number of included studies, which minimal threshold is typically considered to be ten.

Subgroup analysis showed no major differences across study designs, types of populations, age groups, or length of the intervention. However, there was a difference based on the percentage of male participants in each study. Studies with mostly male participants (80% or more) showed a larger effect compared to those with fewer males. Finally, studies that focused on modifying the diet had a significantly stronger effect on reducing aggression compared to those that only gave nutritional supplements.

Aggression as outcome – Omega-3 fatty acids

Out of the 18 studies on aggression, nine looked at the effects of omega-3 fatty acid supplementation (with 706 participants). The overall results showed a high impact on aggression (38% reduction). The evidence security rating is 2 given the relatively low number of included studies and high I^2 value.

When one study that had a high risk of bias was removed, the results did not change. Looking at all nine studies together, there was significant variation in the results, meaning the effects were not consistent across the studies. A large portion of this variation was due to real differences in the studies, not just random chance. When the studies were divided into subgroups, no significant differences were found based on study design, the population, the proportion of males, age groups, or the duration of the intervention. This suggests that the sources of the variation in results were due to factors not specifically looked at in the review. Publication bias was not studied here either due to the low number of studies involved in these analyses.

The analysis also looked at the effects of the nutritional interventions after participants stopped taking the supplements. For three outcomes that were measured both at the end of the intervention and during the 3-month follow-up, the effects were moderate.

Aggression as outcome – Amino acids

The last two studies on aggression (with 84 participants) looked at the effects of amino acid supplements (L-tryptophan and histidine). The overall results showed a small harmful effect, meaning there was no clear evidence that these supplements increased aggression but they were clearly not beneficial (58% increase in aggression). Given the very low number of included studies, the overall evidence security rating for this finding is 1.

There was no significant difference between the two included studies, suggesting that their results were similar. About one-third of the differences in results could be due to actual differences between the studies, while the rest likely came from random chance. Because there were only two studies, subgroup analyses could not be done. Both studies had a high risk of bias, meaning their results might not be as reliable.

Antisocial behaviour as outcome - Broad-spectrum nutritional interventions

Out of the 43 studies on antisocial behaviour, 13 (with 2,109 participants) looked at interventions aimed at improving nutrition in general, such as providing supplements with a large number of nutrients or making major changes to the overall diet. The results showed the intervention to be highly effective in reducing antisocial behaviour (52% reduction). Given the high I^2 value in the meta-analysis and the indirect nature of the outcome in terms of actual violence, the overall evidence security rating is 4, suggesting we have a high level of confidence in this impact rating.

When three studies with a high risk of bias were removed, the effect size was smaller but still significant, meaning the overall finding still held up. Looking at all 13 studies together, there was a lot of variation in the results, meaning the effects were not the same across all studies. A large portion of this variation was due to real differences between the studies rather than random chance. The range of possible effects was quite wide, suggesting there might be no effect at all in some cases. Subgroup analysis showed no significant differences between included studies across design, population, age group, or intervention duration. However, the effect was stronger in studies with more than 80% male participants compared to those with fewer males.

Additionally, studies focusing on dietary changes showed much larger effects than those focusing on nutritional supplements.

The analysis also looked at the effects of these interventions around 3 months after they ended. For three outcomes that were measured both at the end of the intervention and during follow-up, the effect was small, and there was no significant difference between the two. Finally, publication bias was also investigated. These investigations did not find any strong evidence of publication bias, and adjusting the analysis for this did not change the main results.

Antisocial behaviour as outcome – Omega-3 fatty acid supplementation

Out of the 43 studies on antisocial behaviour, 21 studies (with 2,081 participants) focused on the effects of omega-3 fatty acid supplements. The results showed a moderate effect antisocial behaviour (20% reduction). This was assigned an evidence rating of 5, suggesting we have a high level of confidence in this impact rating.

When 10 studies with high risk of bias were removed, the effect was smaller. Looking at all 21 studies together, there was some variation in the results, but it was not enough to be considered statistically significant. About one-third of the differences between the studies could be due to real effects, while the rest was likely random chance. Subgroup analysis showed no significant differences across studies based on study design, population, proportion of males, or age group. However, the effect was different depending on how long the intervention lasted: surprisingly, shorter interventions (105 days or less) had a somewhat larger effect compared to studies with longer interventions, though the longer studies had a higher risk of bias raising the possibility that this counterintuitive finding is a byproduct of poor methodological quality.

The analysis also looked at how effective the omega-3 supplements were at follow-up, about 3 months after the intervention ended. The results showed no significant effect either at the end of the intervention or at follow-up and there was no meaningful difference between these two points.

Finally, publication bias was also investigated in different ways. One indicated no significant signs of bias, while the other suggested some bias, the correction of which led to a slightly smaller effect size than in the main analysis.

Antisocial behaviour as outcome – Other nutritional interventions

Four studies (with 226 participants) looked at how Vitamin D supplementation affects antisocial behaviour. The results showed that, overall, Vitamin D was highly effective in reducing antisocial behaviour (51% reduction). Given the low number of studies, an evidence security rating of 2 was assigned, suggesting a low level of confidence in this impact rating. When two studies with a high risk of bias were excluded, the positive effect was still present, though smaller. The studies were consistent with each other, showing no major differences in results. All studies had similar designs and participants, and so only the percentage of males was investigated in subgroup analysis, which indicated no difference across studies with more versus less males among their participants.

The remaining five studies on antisocial behaviour as the outcome investigated the effects of reduced sugar intake (a dietary change) as well as magnesium-, zinc-, and amino acid supplementation. Given the large differences across these interventions, the authors argued against the interpretation of these studies in a combined way; instead, they suggested to consider each study individually. When doing so, only the reduced sugar diet proved to be highly effective in reducing antisocial behaviours (Longhurst & Mazer, 1988).

Table 1. Summary table of impact evaluation results

Outcome	Nutritional intervention	Number of studies [k]	Total number of participants	Hedges' g (95% confidence interval)	Impact Rating	Prediction interval	Percentage change in outcome	Evidence security rating	Statistically significant heterogeneity in effect / I^2
Offending	Broad-spectrum diet change and supplementation	2	117	-1.25 (-2.39 – -.11)	Highly effective	N/A due to small k	-81.8%	1/5 Very low confidence	Yes / 79%
Aggression	Broad-spectrum diet change and supplementation	7	797	-.31 (-.50 – -.12)	Highly effective	-.71 – .09	-36.1%	3/5 Moderate confidence	No / 23.6%
	Omega-3 fatty acid supplementation	9	706	-.33 (-.87 – .22)	Highly effective	-2.31 – 1.66	-38.1%	3/5 Moderate confidence	Yes / 95%
	Amino acid supplementation	2	84	.37 (-.50 – 1.24)	Treatment harm	N/A due to small k	58.0%	2/5 Low confidence	No / 31%
Antisocial behaviour	Broad-spectrum diet change and supplementation	13	2,109	-.49 (-.73 – -.24)	Highly effective	-1.42 – .44	-51.9%	4/5 High confidence	Yes / 84%
	Omega-3 fatty acid supplementation	21	2,081	-.15 (-.26 – -.03)	Moderately effective	-.46 – .17	-19.8%	5/5 Very high confidence	No / 29.8%
	Vitamin D supplementation	4	226	-.48 (-.74 – -.22)	Highly effective	-.46 – .17	-51.3%	2/5 Low confidence	No / 0%

Implementation

Implementing nutritional interventions, whether through dietary modifications or supplementation and fortification, involves navigating a range of challenges and supportive factors. The review organised these factors into five stages of implementation: i) Awareness regarding the relevance of nutritional interventions among decision makers and the actual target group; ii) Access to nutritional interventions; iii) Specific characteristics of nutritional interventions influencing implementation; iv) User compliance with nutritional interventions; and v) Intervention-interfering behaviours or physiological processes.

Dietary modifications

Efforts to implement dietary modifications face substantial barriers rooted in awareness and interest. Among children and young people and adult stakeholders, negative attitudes toward healthy foods and a heavy reliance on non-reputable sources like social media for nutrition information are common. Resistance from food providers and parents, often due to the perceived burden of implementing nutrition policies, further complicates efforts. On the practical side, access to fresh, nutritious foods may be limited by physical and geographical constraints, high operational costs, and inadequate infrastructure. Voluntary policies aimed at improving nutrition are often dismissed without robust enforcement, undermining efforts to achieve dietary changes. Furthermore, a lack of clarity about what constitutes a “healthy diet,” inconsistent guidelines, and challenges in determining the optimal duration for dietary interventions create additional obstacles. User compliance is another significant hurdle, with individuals frequently resisting dietary changes due to negative perceptions, competing priorities, and ingrained habits. Social pressures, particularly a lack of support from family or peers, and specific challenges like picky eating behaviours in children exacerbate the issue. Dietary interventions may also be hampered by underlying physiological or genetic factors, such as gut health issues, low nutritional quality of available foods, and individual metabolic needs that require higher nutrient intake.

Despite these challenges, there are facilitators that can enable successful dietary modifications. Initiatives to increase awareness through networking among organizations and tailored educational programs have been effective in addressing resistance. Positive engagement by educators and stakeholders, coupled with clear communication and collaboration, fosters support for nutrition policies. Improved access to nutritious foods is made possible through innovative strategies such as local sourcing, alternative storage methods, and collaborations between policymakers and food providers to reduce costs. The implementation of consistent, mandatory policies endorsed by governments or workplaces has also been instrumental in overcoming operational barriers. Interventions that account for individual and cultural variability in dietary needs, as well as the use of visual dietary guides, help clarify nutritional goals and promote adherence. Community engagement plays a pivotal role in encouraging compliance, with initiatives such as cooking classes, peer support networks, and taste-testing sessions helping to shift perceptions of healthy eating. Addressing physiological barriers, such as promoting gut health through prebiotic and probiotic diets and improving the quality of available foods, can further enhance the success of dietary interventions.

Nutritional supplementation and fortification

The implementation of nutritional supplementation or fortification strategies also encounters unique barriers. Limited awareness of the importance of supplementation among children and young people and a lack of motivation among professionals to promote such interventions are significant challenges. Costs and logistical constraints in distribution can create access issues, particularly in resource-limited settings. Uncertainty about the appropriate nutrients, dosages, and duration of supplementation compounds the difficulty, as do potential interactions between supplements and psychiatric and neurological medications. User compliance is sometimes also hindered by resistance to taking supplements due to their side effects, inconvenient distribution methods, and difficulties with capsule swallowability. Forgetfulness and a lack of social support further reduce adherence. Physiological factors, such as individual genetic differences, medication use, and substance abuse can interfere with the effectiveness of supplementation.

Several facilitators, however, can enhance the feasibility and impact of supplementation initiatives. Educational initiatives aimed at children and young people and healthcare professionals are critical in bridging knowledge gaps and increasing motivation. Community engagement, along with financial strategies like subsidized supplements or health insurance coverage, helps alleviate access challenges. Direct distribution methods, such as healthcare professionals providing supplements or organisations offering door-to-door delivery, improve convenience for users. However, these methods may have cost implications that could limit scalability. Exploring cost-effective alternatives, such as leveraging digital platforms for ordering and tracking, or utilising community networks to distribute supplements through schools, or local centres could enhance accessibility while keeping costs manageable. Advances in research to determine optimal nutrient targets, dosages, and intervention duration can provide much-needed clarity for implementation. To translate these findings into practice, developing and disseminating guidance based on broad-range supplementation trials and regulatory recommendations is essential for effective decision-making. Equipping healthcare providers with training on drug-nutrient interactions further enhances intervention implementation, ensuring that supplementation aligns with individual health needs. Enhancements in supplement formulations, such as alternative flavouring options can also help address user resistance. Finally, addressing physiological and behavioural barriers through a multidisciplinary approach, including education on drug-nutrient interactions and tailored supplementation plans can ensure more robust intervention outcomes.

Cost analysis

Konkolÿ Thege and colleagues (2024) have not reported on studies that focused on the costs of implementing nutritional interventions, which is unfortunate from the practice perspective but understandable considering the complexity of the question, especially in the international context.

First, in contrast to many other interventions to reduce violence and offending, nutritional interventions ideally are not one-time or temporary interventions. An optimally functioning nervous system requires the availability of necessary nutrients on an ongoing, long-term basis. This is true even if effectiveness studies – for practical reasons (e.g., funding for outcome monitoring) – examine these interventions in the short and middle term. While in the absence of empirical data, we cannot know this for sure, considering what we know about nutrition in general, it is highly unlikely that short- or mid-term nutritional interventions (especially after the early childhood years when the development of the nervous system is the most intense) would have long-lasting effects on aggression / offending after discontinuation. Therefore, any cost estimate would be highly dependent on the time period considered (one month, one year, 15 years etc.).

Second, cost of dietary changes toward making an overall diet healthier depends on the focus of such efforts. Some interventions focus on reducing the amount of highly-processed foods in the diet, which if not replaced by anything else (eliminating high-sugar snacks) or replaced by practically free products (sugary beverages replaced by tap water) could actually result in savings instead of additional costs.

Third, if a given intervention aims to improve food quality by replacement with more costly items, its net costs are very heavily dependent on the country (e.g., cost of fresh produce varies largely across countries depending on climate, among other factors) and the original food items to be replaced. For instance, replacing sugary snacks (e.g., cookies, ice cream) with vegetables or cheese most likely adds to the cost of food overall, while replacing ultra-processed or even fresh meat products with plant-based proteins (e.g., tofu, legumes) would result in savings. A 2018, UK-based study found that following the Mediterranean diet (the most frequently studied, recommended diet in the general literature) more closely was related with only marginally higher costs (+5.45%, £0.2 per day), which could be offset by savings from reducing unhealthy food consumption (Tong et al., 2018). A study from Spain indicated that following the Mediterranean diet cost consumers 16.4% more (in 2010) than following a less healthy diet (Schröder et al., 2016); and a comparable metric in a Belgian study was 14.5% (Pedroni et al., 2021). An Australian study on the other hand reported slight monetary savings when considering the prices of the items comprising the Mediterranean versus the standard ‘Western’ diet (Bracci, Davis, & Murphy, 2023). An additional complicating factor is consumers’ willingness to prepare their own food from raw or slightly processed ingredients (e.g., frozen produce), which drastically influences costs in comparison to eating out in a healthy way.

Even supplements, which are easier to standardise in terms of costs, can vary largely across countries, products, and dosages. For example, in the UK, a Vitamin D supplement with 1000 international unit per day can be purchased for £2.5 per month, an omega-3 fatty acid supplement with about 900 mg dosage per day costs £12 per month, while a broad-range micronutrient supplement in the studied dosages (and importing the studied supplements produced overseas) can cost up to £80 per month.

It is also worth of mentioning that all nutritional interventions most likely would also improve overall mental and physical health, resulting in enormous financial benefits on the societal level, which is even harder to quantify, especially in the long term.

What do we need to know? What don’t we know?

Overall, the systematic review found that nutritional interventions targeting a large number of nutrients are effective in reducing aggression, antisocial behaviour, and offending. For all three outcomes, diet change was considerably more effective than supplementation. Omega-3 fatty acid supplementation also proved to be effective in reducing both aggression and antisocial behaviour, while vitamin D supplementation was shown to have a positive effect on antisocial behaviour.

The studies included in this review come from a wide range of countries (see Appendix A1) showing the global interest in this topic. However, the wide differences in study design, types of interventions, and participant groups mean that some interventions or populations were studied in very specific or limited contexts only. For example, all four studies on Vitamin D were completed in the Middle East, where sun exposure and Vitamin D deficiency might not be as relevant an issue as in countries with less sunlight. Similarly, both studies looking at offending behaviour were conducted in the United States, where the general population tends to have a less healthy diet compared to places like the Middle East (Wang et al., 2020).

Further, most of the studies focused on younger children with neurodevelopmental disorders, such as ADHD, in community settings. As a result, there has been less research on adolescents or young adults who do not have a neurodevelopmental disorder diagnosis (although this does not necessarily mean they do not have such a disorder undiagnosed) or those living in residential settings or interacting with the criminal justice system. Given the broad differences in the populations studied, the interventions used, and the mixed results in some of the analyses, the findings of this review should not be seen as final.

Thematic synthesis of the literature on the barriers and facilitators of implementing nutritional interventions identified a large number of relevant factors on all five domains of implementation While costs are often mentioned as barriers toward a healthier diet / long-term supplementation in the public discourse on nutrition, quantifying this burden is not easy due to its extreme variability across different diets, supplements, countries and default nutrition-related spending of individuals, families or organisations.

Implications for practice

We argue that while the evidence is not definitive yet, these treatments are safe (especially compared to psychiatric medications), relatively easy to use (especially supplements), and can be inexpensive (especially when considering the population as a whole). These features make them an appealing option in preventing violence and crime (Logan & Schoenthaler, 2023). In addition, better nutrition supports overall health, both physical and mental. Therefore, investing in improving nutrition, either through better diet or specific supplements for brain health, seems worth pursuing. While the review authors also highlighted numerous challenges to implementing nutritional interventions, most of these challenges can be overcome or at least significantly reduced, making large-scale implementation efforts feasible.

Implications for research

It is important to recognize the significant limitations of the current body of research on the effects of nutritional interventions in reducing violence and offending. Nutritional interventions themselves are complex; different nutrients are involved and they come in different dosages. These interventions can also be influenced by many factors, like individual differences in metabolism, medications, and gut health, which affect how nutrients are absorbed. We also do not fully understand the brain mechanisms behind aggression, so it is unclear if study populations that differ greatly, such as young children with ADHD or autism compared to youth in custody, should be given the same treatment. Their aggressive behaviours may or may not have different underlying neurobiological mechanisms; therefore, it is uncertain whether it makes sense to test nutritional interventions in the same way across these groups.

To draw clearer conclusions, future studies need to focus on more similar individuals at a time and use more consistent types of nutritional interventions (with similar nutrients and dosages). This will help determine who benefits most from these treatments (e.g., some studies suggest that males might experience stronger effects than females).

Another key area for future research should be understanding how different types of aggression—like reactive aggression (responding to a trigger), proactive aggression (aggression used to achieve a goal), or self-directed aggression (directed at oneself)—might respond differently to nutritional interventions. While some studies have begun to explore this, the amount of data is very limited, and the findings are not conclusive.

From a theoretical perspective, it would also be important to investigate how exactly nutritional interventions might reduce aggressive and antisocial behaviours. One possible explanation is that better nutrition might help prevent the development of irritability and anger. Another possibility is that improving nutrition might enhance executive functions, such as the ability to control one’s reactions to frustration or anger.

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Appendix A1: Characteristics of included studies in the systematic review and meta-analysis

Study	Design	General sample characteristics	Country & setting	Sample size	Males (%)	Age in years Mean (SD)	Ethnicity and/or race
(Ābele et al., 2021)	Non-randomized controlled	Children with autism	Latvia, community	12	76.5	7.9 (4.1)	Not reported
(Adams et al., 2018)	RCT (parallel group)	Children and young adults with autism)	USA, community	37	82	11.5 (8.5)	Not reported
(Aman, Mitchell, & Turbott, 1987)	RCT (cross-over)	Children with ADHD	New Zealand, unclear	31	87.1	8.86 (1.88)	Not reported
(Arnold et al., 2011)	RCT (parallel group)	Children with ADHD	USA, mixed	52	82.7	9.8 (±2.9)	15.4% African American, 80.8% Caucasian, 3.8% other
(Bos et al., 2015)	RCT (parallel group)	Boys with ADHD	Netherlands, mixed	40	100	10.3 (2.0)	Not reported
(Chang et al., 2019)	RCT (parallel group)	Youth aged 6–18 years with ADHD	China, outpatient psychiatry	103	85.9	9.49 (3.05)	Not reported
(Crippa et al., 2019)	RCT (parallel group)	Children with ADHD	Italy, outpatient psychiatry	50	92	10.99 (1.64)	100% Caucasian
(Dean et al., 2014)	RCT (cross-over)	Children with oppositional defiant disorder or conduct disorder (and often ADHD)	Australia, psychiatric outpatient	21	81	10.3 (2.2)	Not reported
(Dopfner et al., 2021)	RCT (parallel group)	Children with ADHD	Germany, school	40	75	5.26 (0.77)	Not reported

Study	Design	General sample characteristics	Country & setting	Sampl e size	Males (%)	Age in years Mean (SD)	Ethnicity and/or race
(Elshorbagy et al., 2018)	RCT (parallel group)	Children with ADHD and vitamin D deficiency	Saudi Arabia, psychiatric outpatient	40	~56	~9.3 (2.6)	Not reported
(Gast et al., 2023)	RCT (parallel group)	Aggressive individuals with intellectual disability and autism / ADHD	Netherlands, psychiatric inpatient	113	65.5	22.8 (7.2)	Not reported
(Gesch et al., 2002)	RCT (parallel group)	Young adult prisoners	UK, prison	231	100	Not reported	Not reported
(Ghose, 1983)	RCT (cross-over)	Children with ADHD and intellectual disability	UK, residential school	11	100	11.3 (SD not reported)	Not reported
(Gustafsson et al., 2010)	RCT (parallel group)	Children with ADHD and oppositional problems	Sweden, school	48	80	Range= 7-12 years	100% Caucasian
(Hemamy et al., 2020)	RCT (parallel group)	Children with ADHD	Iran, community	66	69.7	9.11 (1.61)	Not reported
(Hamazaki & Hirayama, 2004; Hirayama, Hamazaki, & Terasawa, 2004)	RCT (parallel group)	Children with ADHD and comorbid disorders (autism, conduct disorder, learning disorder, or mood disorder)	Japan, mixed	40	80	Range=6-12	Not reported
(Johnson et al., 2010)	RCT (parallel group)	Preschoolers with autism	USA, community	23	Not reporte d	3.4 (0.7)	Not reported
(Johnson et al., 2011)	RCT (parallel group)	Preschool children with autism	USA, outpatient child medical center	22	81.8	3.3 (0.7)	Not reported

Study	Design	General sample characteristics	Country & setting	Sample size	Males (%)	Age in years Mean (SD)	Ethnicity and/or race
(Johnstone et al., 2022)	RCT (parallel group)	Children with ADHD and elevated irritability / anger	USA & Canada, community	135	73	9.8 (1.7)	Race: 3% Asian; 3% African American/Black; 88% White; 6% Other. Ethnicity: 85% not Hispanic or Latino; 8% Hispanic or Latino; 7% Other
(Khoshbakht et al., 2021)	RCT (parallel group)	Children with ADHD	Iran, community	80	98	Range= 6-12 years	Not reported
(Longhurst & Mazer, 1988)	RCT (parallel group)	Juvenile offenders	USA, youth prison	140	100	Range=11.8-17.4 years	50% Caucasian, 44% Black, 3% biracial, 3% Spanish-American, Oriental, or American Indian
(Mankad et al., 2015)	RCT (parallel group)	Children with autism	Canada, community	38	73.7	3.7 (1.1)	Not reported
(Manor et al., 2012)	RCT (parallel group)	Children with ADHD	Israel, community	200	70.7	9.2 (1.9)	Not reported
(Milte et al., 2015)	RCT (cross-over)	Children with ADHD	Australia, community	87	77	8.9 (1.7)	Not reported
(Mohammadpour et al., 2018)	RCT (parallel group)	Children with ADHD	Iran, psychiatric outpatient	54	74.4	7.87 (1.61)	Not reported
(Naeini et al., 2019)	RCT (parallel group)	Children with ADHD	Iran, community	84	83.1	Range=6–13	Not reported
(Nishijo et al., 2021)	Non-randomized controlled	Children exposed to dioxin with elevated level of aggression	Vietnam, community	62	41.9	7.8 (0.10)	Not reported
(Noorazar et al., 2021)	RCT (parallel group)	Children with ADHD	Iran, community	40	50	9.2 (1.5)	Not reported

Study	Design	General sample characteristics	Country & setting	Sample size	Males (%)	Age in years Mean (SD)	Ethnicity and/or race
(Pelsser et al., 2009)	RCT (parallel group)	Children with ADHD	Netherlands & Belgium, community	27	81.5	6.2 (1.7)	Not reported
(Pelsser et al., 2011)	RCT (parallel group)	Children with ADHD (often with comorbid oppositional defiant disorder / conduct disorder)	Netherlands, community	100	86	6.9 (1.3)	Not reported
(Perera et al., 2012)	RCT (parallel group)	Children with ADHD (often with comorbid oppositional defiant disorder / conduct disorder)	Sri Lanka, psychiatric outpatient	98	73.4	9.3 (1.5)	Not reported
(Raine et al., 2016)	RCT (parallel group)	Children with conduct disorder or oppositional defiant disorder or above-normal aggression level	USA, community	290	53.3	11.4 (0.52)	10% White, 90% 'minority'
(Raine et al., 2019)	RCT (parallel group)	Children with oppositional defiant disorder, conduct disorder or ADHD	Singapore, psychiatric outpatient	282	87.6	10.6 (1.91)	81.6% Chinese, 6.7% Malay, 8.2% Indian, 3.5% other
(Raine et al., 2020)	RCT (parallel group)	Young male offenders	Singapore, youth prison	94	100	19.25 (1.46)	37.7% Chinese, 53.2% Malay, 3.2% Indian, 3.2% other
(Richardson & Montgomery, 2005)	RCT (parallel group)	Children with dyspraxia	UK, school	102	67	8.8(1.36)	Not reported

Study	Design	General sample characteristics	Country & setting	Sample size	Males (%)	Age in years Mean (SD)	Ethnicity and/or race
(Rodriguez-Hernandez et al., 2020)	Non-randomized controlled	Children with behavioral problems but no psychiatric disorder	Spain, community	621	69.1	8.5 (1.8)	Not reported
(Rucklidge et al., 2018)	RCT (parallel group)	Children with ADHD	New Zealand, community	93	76	9.75 (1.55)	78% New Zealanders of European descent, 22% Mäori or Tongan
(Schauss & Schauss, 1978)	RCT (parallel group)	Probationers who had committed misdemeanour offences	USA, community	55	85	<25 years	Approximately 85% were White
(Schoenthaler, 1982)	Non-randomized controlled	Incarcerated juveniles	USA, prison (juvenile detention home)	58	100	Range=12-18 years	Not reported
(Schoenthaler, 1983a)	Non-randomized controlled	Incarcerated young offenders (juveniles)	USA, juvenile detention center	276	82.2	Range=12-18 years	76.6% White, 23.4% other
(Schoenthaler, 1983b)	Non-randomized controlled	Incarcerated non-adult offenders (juveniles)	USA, secure juvenile detention facility	481	67	15.4 (SD not reported)	74% White, 26% other
(Schoenthaler et al., 1997)	RCT (parallel group)	Juvenile delinquents with a history of repeated delinquency (often with a DSM-III diagnosis referring to maladaptive level of aggression)	USA, unclear	62	66	15.2 (SD not reported)	77.4% White, 22.6% other
(Schoenthaler & Bier, 2000)	RCT (parallel group)	Formally disciplined school children	USA, school	80	68.8	Range=6-12 years	Not reported

Study	Design	General sample characteristics	Country & setting	Sample size	Males (%)	Age in years Mean (SD)	Ethnicity and/or race
(Schoenthaler et al., 2023)	RCT (parallel group)	Young adult prisoners	USA, youth prison	402	100	19.4 (1.4)	African American: 25.4%, Asian: 6.2%, Caucasian: 40%, Hispanic: 28.4%
(Sinn & Bryan, 2007)	RCT (parallel group)	Children with ADHD	Australia, community	104	74	9.4 (1.9)	Not reported
(Stevens et al., 2003)	RCT (parallel group)	Children with ADHD	USA, community	50	87.8	9.8 (1.9)	Not reported
(Voigt et al., 2001)	RCT (parallel group)	Children with ADHD	USA, community	53	78	9.3 (1.9)	7.4% Black, 92.6% White
(Widenhorn-Müller et al., 2014)	RCT (parallel group)	Children with ADHD	Germany, community	110	77.9	8.91 (1.35)	Not reported
(Young et al., 2017)	RCT (parallel group)	Children with depression (often with comorbid anxiety disorder, ADHD or disruptive behaviour disorder).	USA, community	48	52.1	11.2 (2.2)	62.5% White (8.3% Hispanic), 29.2% Black, 8.3% biracial
(Zaalberg et al., 2010)	RCT (parallel group)	Young adult incarcerated offenders	Netherlands, prison	326	100	21 (1.5)	Not reported

Appendix A2: Characteristics and results of the included studies in the systematic review and meta-analysis

Study	Intervention	Intervention duration (days)	Outcome	Drop-out from intervention (%)	Risk of bias	Findings reported by original authors[7]
(Ābele et al., 2021)	Low-carb, gluten-free, probiotic diet combined with omega-3 fatty acid-, ascorbyl-palmitate-, probiotics-, vitamin D3-, and vitamin C supplementation	90	Aggression	0	High	No relevant analyses were reported for our purposes.
(Adams et al., 2018)	Vitamin & mineral-, fatty acid-, carnitine, digestive enzyme supplementation combined with a healthy gluten-free, casein-free, soy-free diet	365	Aggression	24.3	High	The treatment group had significantly greater improvements on the aggression subscale score of the Parent Global Impressions 2 (p=0.01, test statistics and effect size not reported)
(Aman, Mitchell, & Turbott, 1987)	Essential fatty acid supplementation	28	Antisocial behaviour	0	Moderate	No significant difference between intervention and placebo phase (F=2.364, p>.1)
(Arnold et al., 2011)	Zinc supplementation, 15mg/day	56	Antisocial behaviour	0	Moderate	No relevant analyses reported for our purposes.
	Zinc supplementation, 30mg/day	56	Antisocial behaviour	12.5	Moderate	No relevant analyses reported for our purposes.
(Bos et al., 2015)	Omega-3 fatty-acid fortified margarine	112	Aggression	2.5	Moderate	There were no significant effects of treatment on the CBCL Aggressive Behavior subscales [no p value or effect size reported]
	Omega-3 fatty-acid fortified margarine	112	Antisocial behaviour	2.5	Moderate	There were no significant effects of treatment on the CBCL Rule Breaking subscale [no p value or effect size reported]

[7] Results are reported here if the original authors formally investigated the difference between the trajectories of change in the intervention versus the control group (group x time interaction) in relation to the change from baseline to intervention-end (and/or 3 months follow-up separately). If all reported analyses also included subgroups / time points irrelevant for our purposes or if the time x group interaction was not analysed (e.g., only pre-post comparison is reported for both study arms separately) then we use the notion in the table: 'No relevant analyses reported for our purposes'. Raw data even in these cases were extracted from the studies and used in the meta-analyses; both the details of these analyses and the extracted raw data can be found in the original review of Konkolÿ Thege and colleagues (2024).

Study	Intervention	Intervention duration (days)	Outcome	Drop-out from intervention (%)	Risk of bias	Findings reported by original authors[7]
(Chang et al., 2019)	Omega-3 fatty-acid supplementation	84	Antisocial behaviour	<5.9	High	There were no differences in the changes of the SDQ Conduct (p=0.885, test statistics and effect size not reported) subscale scores between the intervention and placebo group
(Crippa et al., 2019)	Omega-3 fatty-acid supplementation	182	Antisocial behaviour	4	Low	No relevant analyses were conducted for our purposes.
(Dean et al., 2014)	Omega-3 fatty-acid supplementation	42	Aggression	14.3	Moderate	No effect of fish oil treatment was observed on change in aggression scores (F=0.05, p=0.82).
	Omega-3 fatty-acid supplementation	42	Antisocial behaviour	14.3	Moderate	A trend suggested that fish oil supplementation decreased conduct problem scores (F=4.34, p=0.056) less than the control condition.
(Dopfner et al., 2021)	Omega-3/Omega-6 fatty acid supplementation	122	Antisocial behaviour	<20	Moderate	Beneficial effects of intervention on parent-rated externalizing symptoms (F=4.58, p=.04, d=0.54).
(Elshorbagy et al., 2018)	Vitamin D supplementation	84	Antisocial behaviour	20	High	No relevant analyses were conducted for our purposes.
(Gast et al., 2023)	Multivitamin-, mineral- and omega-3 fatty acid supplementation	112	Aggression	17.5	Low	No relevant analyses were conducted for our purposes.
(Gesch et al., 2002)	Multivitamin-, mineral- and omega-3 fatty acid supplementation	143	Antisocial behaviour	7.8	Moderate	Intervention caused a 26.3% (95% CI=8.3-44.3%) reduction in antisocial behaviour compared to those receiving placebo (p=0.03).
(Ghose, 1983)	L-tryptophan supplementation	35	Aggression	0	High	There was no statistically significant difference between l-tryptophan and placebo condition (no test statistic, p-value or effect size reported).

Study	Intervention	Intervention duration (days)	Outcome	Drop-out from intervention (%)	Risk of bias	Findings reported by original authors[7]
	L-tryptophan supplementation	35	Antisocial behaviour	0	High	There was no statistically significant difference between l-tryptophan and placebo condition (no test statistic, p-value or effect size reported).
(Gustafsson et al., 2010)	Omega-3 fatty acid supplementation	105	Antisocial behaviour	unknown	High	Significantly larger improvement in oppositional behaviour in the intervention group (unspecified metric of effect size=0.59, p-value=0.04)
(Hemamy et al., 2020)	Vitamin D & magnesium supplementation	56	Antisocial behaviour	0	Low	Supplementation with Vitamin D and magnesium caused a significantly larger decrease in conduct problems (p=0.001, test statistics and effect size not reported) in the intervention group.
(Hamazaki & Hirayama, 2004; Hirayama, Hamazaki, & Terasawa, 2004)	Fortification with omega-3 fatty acids	60	Aggression	0	Moderate	In the intervention group, aggression was significantly (p=0.01) more reduced than in the control group with baseline as covariate (effect size, test statistics not reported).
(Johnson et al., 2010)	Omega-3 fatty acid supplementation	91	Aggression	10	Moderate	There were no significant differences between study groups on the outcome (F=0.404, p=0.532, effect size not reported).
(Johnson et al., 2011)	Gluten Free / Casein Free diet containing lots of fruits and vegetables	90	Aggression	0	High	Significantly larger improvement in aggression in the intervention group (F=4.56, p=.046, effect size not reported).
(Johnstone et al., 2022)	Broad-range micronutrient (vitamins minerals, amino acids and antioxidants) supplementation	56	Antisocial behaviour	9	Moderate	No significant difference in antisocial behaviour between intervention and control group (p=0.52; test statistics and effect size not reported).

Study	Intervention	Intervention duration (days)	Outcome	Drop-out from intervention (%)	Risk of bias	Findings reported by original authors[7]
	Broad-range micronutrient (vitamins minerals, amino acids and antioxidants) supplementation	56	Aggression	9	Moderate	No significant difference in aggressive behaviour between intervention and control group (p=0.46; test statistics and effect size not reported).
(Khoshbakht et al., 2021)	DASH diet (high amounts of whole grains, fruits, vegetables, low-fat dairy products, nuts, and beans, as well as low amounts of saturated fats, cholesterol, refined grains, sweets, and red meat).	84	Antisocial behaviour	7	High	No significant difference between study groups regarding conduct problems scores (p=0.73, test statistics and effect size not reported)
(Longhurst & Mazer, 1988)	Diet containing foods with lower glycemic index than the same type of foods served to the control group	213	Antisocial behaviour	0	Moderate	The proportion of participants with at least one documented severe antisocial behaviour was significantly lower in the treatment group (x2=5.78, p=0.02, effect size not reported).
(Mankad et al., 2015)	Omega-3 fatty acid supplementation	182	Antisocial behaviour	10.5	High	Participants randomized to placebo showed a mild improvement, whereas the treatment group demonstrated worsening externalizing problem scores (t=−2.55, p=0.02, effect size not reported).
(Manor et al., 2012)	Omega-3 fatty acid supplementation	105	Antisocial behaviour	≤19.7	High	No difference in oppositional problem scores across study groups (p= 0.987; test statistics and effect size not reported)
(Milte et al., 2015)	Omega-3 fatty acid supplementation (primarily eicosapentaenoic acid)	120	Antisocial behaviour	35.6	High	There was no significant treatment effect (test statistics, p-value and effect size not reported).
	Omega-3 fatty acid supplementation (primarily docosahexaenoic acid)	120	Antisocial behaviour	37.9	High	There was no significant treatment effect (test statistics, p-value and effect size not reported).

Study	Intervention	Intervention duration (days)	Outcome	Drop-out from intervention (%)	Risk of bias	Findings reported by original authors[7]
(Mohammadpour et al., 2018)	Vitamin D supplementation	56	Antisocial behaviour	19.4	Moderate	No relevant analyses reported for our purposes.
(Naeini et al., 2019)	Vitamin D supplementation	90	Antisocial behaviour	≤14.3	High	No relevant analyses reported for our purposes.
(Nishijo et al., 2021)	Histidine (essential amino acid) supplementation via dried bonito broth	60	Aggression	50	High	No relevant analyses conducted for our purposes.
	Histidine (essential amino acid) supplementation via dried bonito broth	60	Antisocial behaviour	50	High	No relevant analyses conducted for our purposes.
(Noorazar et al., 2021)	Magnesium supplementation	56	Antisocial behavior	0	Moderate	No relevant analyses conducted for our purposes.
(Pelsser et al., 2009)	Elimination diet consisting of rice, turkey, lamb, vegetables, fruits, margarine, vegetable oil, tea, pear juice and water exclusively.	63	Antisocial behaviour	13.3	Moderate	Oppositionality scores decreased significantly more in the intervention group (test statistics not reported, $p<0.02$, Cohen's $d=1.1$).
(Pelsser et al., 2011)	Elimination diet consisting of the few foods diet (i.e., rice, turkey, lamb, a range of vegetables - lettuce, carrots, cauliflower, cabbage, beet - pears and water) complemented with potatoes, fruits, and wheat.	35	Antisocial behaviour	18	High	The difference between groups regarding oppositional behaviour was significant, favouring the intervention ($p<0.0001$; test statistics and effect size not reported).
(Perera et al., 2012)	Omega-3 & -6 fatty acid supplementation	183	Aggression	2	Low	The intervention was more effective in reducing aggression with a large effect size ($d=1.42$, 95% CI=1.28 - 1.55; test statistics and p value not reported)

Study	Intervention	Intervention duration (days)	Outcome	Drop-out from intervention (%)	Risk of bias	Findings reported by original authors[7]
(Raine et al., 2016) Comparison I (supplementation only vs. no intervention)	Omega-3 fatty acid-, multivitamin-, & mineral supplementation	90	Antisocial behaviour	≤47.2	Moderate	No relevant analyses were conducted for our purposes
(Raine et al., 2016) Comparison II (CBT+ supplementation vs. CBT only)	Omega-3 fatty acid-, multivitamin-, & mineral supplementation	90	Antisocial behaviour	≤58.9	Moderate	No relevant analyses were conducted for our purposes
(Raine et al., 2019) Comparison I (supplementation only vs. placebo)	Omega-3 fatty acid supplementation	182	Aggression	32.3	Low	No relevant analyses were conducted for our purposes.
(Raine et al., 2019) Comparison II (supplementation only vs. placebo)	Omega-3 fatty acid supplementation	182	Antisocial behaviour	32.3	Moderate	No relevant analyses were conducted for our purposes.
(Raine et al., 2019) Comparison III (supplementation +social skills training VS. placebo+social skills training)	Omega-3 fatty acid supplementation	182	Aggression	<32	Low	No relevant analyses were conducted for our purposes.

Study	Intervention	Intervention duration (days)	Outcome	Drop-out from intervention (%)	Risk of bias	Findings reported by original authors[7]
(Raine et al., 2019) Comparison IV (supplementation +social skills training VS. placebo+social skills training)	Omega-3 fatty acid supplementation	182	Antisocial behaviour	<32	Moderate	No relevant analyses were conducted for our purposes.
(Raine et al., 2020)	Omega-3 fatty acid supplementation	90	Aggression	0	High	No significant difference was found between the intervention and placebo group at intervention-end (test statistics, p value and effect size not reported).
	Omega-3 fatty acid supplementation	90	Antisocial behaviour	0	High	Significantly reduced scores in the omega-3 group compared to the placebo group at intervention-end (p=0.019) and 3-month follow-up (p=0.024); effect size not reported.
(Richardson & Montgomery, 2005)	Omega-3 fatty acid supplementation	90	Antisocial behaviour	8.3	Moderate	Reduction in oppositional behaviour was significantly greater for the active treatment than for placebo (Z=2.42; p<0.02; effect size not reported).
(Rodriguez-Hernandez et al., 2020)	Omega-3 fatty acid supplementation	90	Antisocial behaviour	0	High	Percentage of children with improvement in the supplementation group was 56.5%, while 45.8% in the control group (p<0.05; test statistics .and effect size not reported)
(Rucklidge et al., 2018)	Broad-range micronutrient (vitamins minerals, amino acids and antioxidants) supplementation	70	Antisocial behaviour	4.3	Low	Significantly larger decrease in problem behaviour scores was observed in the intervention than in the control group (test statistics not reported, p=0.015, d=0.52).

Study	Intervention	Intervention duration (days)	Outcome	Drop-out from intervention (%)	Risk of bias	Findings reported by original authors[7]
(Schauss & Schauss, 1978)	Nutritional education to improve general diet quality (e.g., avoidance/reduction of sugar consumption and reduction in coffee intake)	274	Offending (violent & non-violent combined)	0	Moderate	No relevant analyses were conducted for our purposes.
(Schoenthaler, 1982)	Overall improved quality of diet (e.g., reduced-sugar content, more fresh produce with higher vitamin and mineral content)	26	Antisocial behaviour	0	Low	The children on the modified diet exhibited a 45% lower incidence of formal disciplinary actions (t=2.45, p<0.01).
(Schoenthaler, 1983a)	Overall improved quality of diet (e.g., reduced-sugar content, more fresh produce with higher vitamin and mineral content)	30	Antisocial behaviour	0	Low	48% lower rate of disciplinary actions was recorded for the group of juveniles who received a low sugar diet (t=4.09, p<.0001). The percentage of offenders who committed disciplinary actions more frequently than every three days—the chronic antisocial-behaviour group—declined 56% (from 36% of the population to 16% of the population). The children who were accused of committing violent crimes and who experienced the low-sugar diet became the best-behaved of all.
(Schoenthaler, 1983b)	Addition of undetermined but unlimited amount of orange juice (without added sugar or additives) to the diet	11	Antisocial behaviour	unknown	Low	The intervention group's number of antisocial behaviours per day was 46.7% lower than that of the control group (F=4.524, p=0.034).
(Schoenthaler et al., 1997)	Broad-spectrum micronutrient (vitamin and mineral) supplementation	91	Violent offending	0	Moderate	Average violent rule infraction per week fell, on average, 80% in the active group and 56% in the placebo group (F=4.236, p=.044).

Study	Intervention	Intervention duration (days)	Outcome	Drop-out from intervention (%)	Risk of bias	Findings reported by original authors[7]
	Broad-spectrum micronutrient (vitamin and mineral) supplementation	91	Non-violent offending	0	Moderate	Average non-violent rule infraction per week fell, on average, 83% in the active group and 49% in the placebo group (F=7.646, p=.008).
(Schoenthaler & Bier, 2000)	Broad-spectrum micronutrient (vitamin and mineral) supplementation	120	Antisocial behaviour	0	Moderate	The active group's mean rate of rule violations was 1 per subject, while the placebo control's mean rate of rule violations was 1.875 per subject, a difference of 47% (CI: 29% to 65%, F=4.466, p=.038).
(Schoenthaler et al., 2023)	Broad-spectrum micronutrient (vitamin and mineral) supplementation / 'low dose' (approx. 100% of the US RDA for most of the vitamins and minerals)	97	Aggression	0	High	There were 34% [rate ratio of .66, 95% CI: .38–1.15, p=.14] fewer violent incidents in the lower-dose supplement group compared to placebo.
	Broad-spectrum micronutrient (vitamin and mineral) supplementation / 'low dose' (approx. 100% of the US RDA for most of the vitamins and minerals)	97	Antisocial behaviour	0	High	There were 42% [rate ratio of .58, 95% CI: .37–.92, p=.02] fewer non-violent incidents in the lower-dose supplement group compared to placebo.
	Broad-spectrum micronutrient (vitamin and mineral) supplementation / 'high dose' (higher dose B and C vitamins and addition of Selenium, Chromium, Manganese, and Molybdenum)	97	Aggression	0	High	There were 6% [rate ratio of .94, 95% CI: .56–1.56, p=.80] fewer violent incidents in the higher-dose supplement group compared to placebo.

Study	Intervention	Intervention duration (days)	Outcome	Drop-out from intervention (%)	Risk of bias	Findings reported by original authors[7]
	Broad-spectrum micronutrient (vitamin and mineral) supplementation / 'high dose' (higher dose B and C vitamins and addition of Selenium, Chromium, Manganese, and Molybdenum)	97	Antisocial behaviour	0	High	There were 11% [rate ratio of .89, 95% CI: .58–1.35, p=.58] fewer non-violent incidents in the higher-dose supplement group compared to placebo.
(Sinn & Bryan, 2007)	Omega-3 fatty acid supplementation for all participants and 53% also received multi-vitamin/mineral supplementation	105	Antisocial behaviour	unknown	High	There was a significantly larger improvement in the treatment groups (fatty acid versus fatty acid + multivitamins combined) compared to placebo in oppositional behaviour ($F=8.06$, $p<0.01$, $d=0.43$). There was no additional treatment effects in the fatty acid + multivitamins combined group compared to the fatty acid alone group (test statistics, p-value and effect size not reported).
(Stevens et al., 2003)	Omega-3 fatty acid supplementation	121	Antisocial behaviour	28	High	Larger improvement in the intervention than in the control group ($p=0.05$; test statistics and effect size not reported) regarding disruptive behaviours.
(Voigt et al., 2001)	Omega-3 fatty acid supplementation	121	Antisocial behaviour	9.4	Moderate	No relevant analyses were conducted for our purposes.
(Widenhorn-Müller et al., 2014)	Omega-3 fatty acid supplementation	112	Aggression	10.9	Moderate	There was no significant intervention effect for aggressive behaviour (test statistics, p value and effect size not reported).
	Omega-3 fatty acid supplementation	112	Antisocial behaviour	10.9	Moderate	There was no significant intervention effect for delinquent behaviour (test statistics, p value and effect size not reported).

Study	Intervention	Intervention duration (days)	Outcome	Drop-out from intervention (%)	Risk of bias	Findings reported by original authors[7]
(Young et al., 2017) Comparison I (supplementation vs. placebo)	Omega-3 fatty acid supplementation	84	Antisocial behaviour	unknown	Moderate	No relevant analysis was conducted for our purposes.
(Young et al., 2017) Comparison II (supplementation + psychological intervention vs. psychological intervention alone)	Omega-3 fatty acid supplementation	84	Antisocial behaviour	unknown	Moderate	No relevant analysis was conducted for our purposes.
(Zaalberg et al., 2010)	Broad-spectrum micronutrient (vitamin and mineral) supplementation	76	Aggression	<32%	High	A significant reduction was found in the number of reported incidents involving prisoners who took supplements as compared with prisoners who received placebos (incident rate ratio=.60; 95% CI: 0.37–0.98; one-tailed p =.020)

Appendix B: AMSTAR quality rating of the review of Konkolÿ Thege et al, 2024

	Modified AMSTAR criteria	Scoring guide	Rating
1.	Did the research questions and inclusion criteria for the review include the components of the PICOS?	To score 'Yes' appraisers should be confident that the 5 elements of PICO are described somewhere in the report	Yes Section 4.1
2.	Did the review authors use a comprehensive literature search strategy?	At least two bibliographic databases should be searched (partial yes) plus at least one of website searches or snowballing (yes).	Yes Section 4.2
3.	Did the review authors perform study selection in duplicate?	Score yes if double screening or single screening with independent check on at least 5-10%	Yes Section 4.3.2
4.	Did the review authors perform data extraction in duplicate?	Score 'yes' if double coding	Yes Section 4.3.3
5.	Did the review authors describe the included studies in adequate detail?	Score 'yes' if a tabular or narrative summary of included studies is provided.	Yes Section 5.1.2 and appendices
6.	Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?	Score 'yes' if there is any discussion of any source of bias such as attrition, and including publication bias.	Yes Section 4.3.4
7.	Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?	'Yes' if the authors report heterogeneity statistic. Partial yes if there is some discussion of heterogeneity.	Yes Section 5.3
8.	Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?	'Yes' if authors report funding and mention any conflict of interest	Yes
Overall quality			High

Appendix C: Details of the moderator analyses (factors potentially influencing effectiveness)

	Outcome: Aggression Intervention: Broad-spectrum nutritional interventions							
	Within-group						Between-group	
	k	g	95% CI - lower	95% CI - upper	z	p	Q	p
Study design							.07	.792
Parallel RCT	6	-.31	-.51	-.1	-2.94	.003		
Observational	1	-.48	-1.74	.78	-.75	.454		
Study population							.56	.456
Non-aggressive diagnosis	5	-.24	-.51	.03	-1.78	.076		
Offender	2	-.39	-.66	-.11	-2.73	.006		
Proportion of males							4.53	.033
<80%	3	-.09	-.34	.16	-.72	.473		
>=80%	4	-.44	-.63	-.24	-4.33	<.001		
Age group							.06	.804
<12 years	4	-.35	-.71	0	-1.94	.052		
18-24 years	3	-.3	-.56	-.03	-2.17	.03		
Intervention duration							.02	.903
<=105 days	5	-.31	-.56	-.06	-2.43	.015		
>105 days	2	-.34	-.75	.08	-1.6	.109		
Intervention type							2.78	.096
Dietary change	3	-.69	-1.17	-.21	-2.81	.005		
Supplementation	4	-.25	-.44	-.06	-2.63	.009		
	Outcome: Aggression Intervention: Omega-3 fatty acid supplementation							
	Within-group						**Between-group**	
	k	**g**	**95% CI - lower**	**95% CI - upper**	**z**	**p**	**Q**	**p**
Study design							.13	.714
Cross-over RCT	1	-.03	-1.71	1.65	-.04	.972		
Parallel RCT	8	-.36	-.94	.22	-1.22	.222		
Study population							.13	.938
Aggressive diagnosis	1	-.03	-1.78	1.72	-.03	.973		
Non-aggressive diagnosis	7	-.37	-1.02	.28	-1.12	.263		
Offender	1	-.3	-1.99	1.4	-.34	.731		
Proportion of males							1.15	.564
<80%	2	-.71	-1.51	.09	-1.74	.081		
>=80%	6	-.21	-.7	.28	-.83	.404		
Unknown	1	-.21	-1.57	1.14	-.31	.758		
Age group							<.01	.971
<12 years	8	-.33	-.93	.27	-1.07	.284		
18-24 years	1	-.3	-1.97	1.38	-.35	.729		
Intervention duration							.05	.831
<=105 days	4	-.26	-1.1	.58	-.6	.549		
>105 days	5	-.38	-1.1	.34	-1.03	.305		
	Outcome: Antisocial behavior Intervention: Broad-spectrum nutritional interventions							

	Within-group						Between-group	
	k	g	95% CI - lower	95% CI - upper	z	p	Q	p
Study design							.14	.708
Parallel RCT	10	-.52	-.87	-.17	-2.91	.004		
Observational	3	-.43	-.74	-.12	-2.75	.006		
Study population							4.74	.093
Aggressive diagnosis	3	-.13	-.4	.14	-.93	.352		
Non-aggressive diagnosis	5	-.86	-1.6	-.12	-2.29	.022		
Offender	5	-.41	-.62	-.2	-3.85	<.001		
Proportion of males							8.2	.004
<80%	6	-.17	-.29	-.04	-2.66	.008		
>=80%	7	-.8	-1.22	-.39	-3.77	<.001		
Age group							.38	.825
<12 years	8	-.57	-1.03	-.12	-2.48	.013		
12-17 years	3	-.43	-.74	-.12	-2.75	.006		
18-24 years	2	-.39	-.79	.01	-1.92	.055		
Intervention duration							1	.318
<=105 days	11	-.52	-.81	-.24	-3.65	<.001		
>105 days	2	-.31	-.63	.01	-1.91	.056		
Intervention type							5.18	.023
Dietary change	6	-.86	-1.36	-.35	-3.34	.001		
Supplementation	7	-.23	-.42	-.04	-2.4	.017		
	Outcome: Antisocial behavior Intervention: Omega-3 fatty acid supplementation							
	Within-group						**Between-group**	
	k	**g**	**95% CI - lower**	**95% CI - upper**	**z**	**p**	**Q**	**p**
Study design							.76	.682
Cross-over RCT	3	-.16	-.43	.11	-1.18	.237		
Parallel RCT	17	-.14	-.29	.02	-1.74	.082		
Observational	1	-.24	-.41	-.06	-2.68	.007		
Study population							1.6	.449
Aggressive diagnosis	1	-.23	-.4	-.07	-2.72	.007		
Non-aggressive diagnosis	18	-.12	-.26	.02	-1.7	.089		
Offender	2	-.33	-.74	.07	-1.62	.105		
Proportion of males							<.01	.979
<80%	11	-.15	-.31	.02	-1.72	.086		
>=80%	10	-.14	-.31	.03	-1.64	.102		
Age group							.86	.355
<12 years	20	-.14	-.26	-.01	-2.19	.028		
18-24 years	1	-.33	-.74	.07	-1.62	.105		
Intervention duration							4.65	.031
<=105 days	11	-.24	-.36	-.13	-4.19	<.001		
>105 days	10	-.01	-.19	.17	-.1	.922		
	Outcome: Antisocial behavior Intervention: Vitamin D supplementation							

	Within-group						Between-group	
	k	**g**	**95% CI - lower**	**95% CI - upper**	**z**	**p**	**Q**	**p**
Proportion of males							.81	.368
<80%	3	-.4	-.72	-.09	-2.51	.012		
>=80%	1	-.66	-1.14	-.19	-2.75	.006		

Appendix D: Percentage change calculations

Broad-spectrum diet change and supplementation for criminal reoffending

Odds in control group = $\frac{\text{Number of individuals with reoffending}}{\text{Number of individuals without reoffending}}$.

In the control group, the occurrence of reoffending is assumed to be 50 out of 100 individuals (as all study participants had already offended). Therefore,

odds of reoffending in control group = $\frac{50}{100-50} = \frac{50}{50} = 1$.

The Hedges's g value in the meta-analysis was -1.25, which corresponds to an odds ratio of 0.10 (calculation based on https://www.escal.site/). This means that the odds of reoffending in the treatment group are 0.10 times the odds in the control group. Therefore, the odds in treatment group = 1*0.10 = 0.10. Probability of aggression in the treatment group is calculated as

$\frac{\text{Odds in treatment group}}{1+\text{odds in treatment group}} = \frac{0.10}{1+0.10} = 0.091$.

Consequently, the probability of reoffending in the treatment group is 9.1%.

The percentage change in reoffending is calculated as the difference in probabilities between the control and treatment groups, divided by the control group's probability, and then multiplied by 100. Given that the probability of reoffending in the control group is assumed to be 50%,

percentage change = $\frac{50-9.1}{50} * 100 = 81.8$.

Consequently, the effectiveness of the intervention in terms of percentage reduction in reoffending is approximately 82%.

If we assume, that the reoffending rate is only 10% in the control group, then using the above algorithm, the percentage change would be 88.6%. In case of a 25% reoffending rate in the control group, the relative reduction would change to 86.6%.

Broad-spectrum diet change and supplementation for aggression

Odds in control group = $\frac{\text{Number of individuals with aggression}}{\text{Number of individuals without aggression}}$.

In the control group, the occurrence of aggression is assumed to be 25 out of 100 individuals. Therefore,

odds of aggression in control group = $\frac{25}{100-25} = \frac{25}{75} = 0.33$.

The Hedges's g value in the meta-analysis was -0.31, which corresponds to an odds ratio of 0.57 (calculation based on https://www.escal.site/). This means that the odds of aggression in the treatment group are 0.57 times the odds in the control group. Therefore, the odds in treatment group = 0.33*0.57 = 0.19. Probability of aggression in the treatment group is calculated as

$\frac{\text{Odds in treatment group}}{1+\text{odds in treatment group}} = \frac{0.19}{1+0.19}$ = 0.1597.

Consequently, the probability of aggression in the treatment group is 15.97%.

The percentage change in aggression is calculated as the difference in probabilities between the control and treatment groups, divided by the control group's probability, and then multiplied by 100. Given that the probability of aggression in the control group is assumed to be 25%,

percentage change = $\frac{25-15.97}{25}$ * 100 = 36.12.

Consequently, the effectiveness of the intervention in terms of percentage reduction in aggression is approximately 36%.

If we assume, that the aggression rate is only 10% in the control group, then using the above algorithm, the percentage change would be 40.6%. In case of a 50% aggression rate in the control group, the relative reduction would change to 27.5%.

Omega-3 fatty acid supplementation for aggression

Odds in control group = $\frac{\text{Number of individuals with aggression}}{\text{Number of individuals without aggression}}$.

In the control group, the occurrence of aggression is assumed to be 25 out of 100 individuals. Therefore,

odds of aggression in control group = $\frac{25}{100-25} = \frac{25}{75}$ = 0.33.

The Hedges's g value in the meta-analysis was -0.33, which corresponds to an odds ratio of 0.55 (calculation based on https://www.escal.site/). This means that the odds of aggression in the treatment group are 0.55 times the odds in the control group. Therefore, the odds in treatment group = 0.33*0.55 = 0.183. Probability of aggression in the treatment group is calculated as

$\frac{\text{Odds in treatment group}}{1+\text{odds in treatment group}} = \frac{0.183}{1+0.183}$ = 0.1547.

Consequently, the probability of aggression in the treatment group is 15.47%.

The percentage change in aggression is calculated as the difference in probabilities between the control and treatment groups, divided by the control group's probability, and then multiplied by 100. Given that the probability of aggression in the control group is assumed to be 25%,

percentage change = $\frac{25-15.47}{25}$ * 100 = 38.12.

Consequently, the effectiveness of the intervention in terms of percentage reduction in aggression is approximately 38%.

If we assume, that the aggression rate is only 10% in the control group, then using the above algorithm, the percentage change would be 42.5%. In case of a 50% aggression rate in the control group, the relative reduction would change to 29.1%.

Amino acid supplementation for aggression

Odds in control group = $\frac{\text{Number of individuals with aggression}}{\text{Number of individuals without aggression}}$.

In the control group, the occurrence of aggression is assumed to be 25 out of 100 individuals. Therefore,

odds of aggression in control group = $\frac{25}{100-25} = \frac{25}{75}$ = 0.33.

The Hedges's g value in the meta-analysis was 0.37, which corresponds to an odds ratio of 1.96 (calculation based on https://www.escal.site/). This means that the odds of aggression in the treatment group are 1.96 times the odds in the control group. Therefore, the odds in treatment group = 0.33*1.96 = 0.653. Probability of aggression in the treatment group is calculated as

$\frac{\text{Odds in treatment group}}{1+\text{odds in treatment group}} = \frac{0.653}{1+0.653}$ = 0.395.

Consequently, the probability of aggression in the treatment group is 39.5%.

The percentage change in aggression is calculated as the difference in probabilities between the control and treatment groups, divided by the control group's probability, and then multiplied by 100. Given that the probability of aggression in the control group is assumed to be 25%,

percentage change = $\frac{25-39.5}{25}$ * 100 = -58.0.

Consequently, the effect of the intervention is a 58% increase in aggression, meaning treatment harm.

If we assume, that the aggression rate is only 10% in the control group, then using the above algorithm, the percentage change would be 78.9%. In case of a 50% aggression rate in the control group, the relative increase would change to 32.5%.

Broad-spectrum diet change and supplementation for antisocial behavior

Odds in control group = $\frac{\text{Number of individuals with aggression}}{\text{Number of individuals without aggression}}$.

In the control group, the occurrence of antisocial behavior is assumed to be 25 out of 100 individuals. Therefore,

odds of antisocial behavior in control group = $\frac{25}{100-25} = \frac{25}{75}$ = 0.33.

The Hedges's g value in the meta-analysis was -0.49, which corresponds to an odds ratio of 0.41 (calculation based on https://www.escal.site/). This means that the odds of antisocial behavior in the treatment group are 0.41 times the odds in the control group. Therefore, the odds in treatment group = 0.33*0.41 = 0.1367. Probability of antisocial behavior in the treatment group is calculated as

$\frac{\text{Odds in treatment group}}{1+\text{odds in treatment group}} = \frac{0.1367}{1+0.1367} = 0.1203.$

Consequently, the probability of antisocial behavior in the treatment group is 12.03%.

The percentage change in antisocial behavior is calculated as the difference in probabilities between the control and treatment groups, divided by the control group's probability, and then multiplied by 100. Given that the probability of antisocial behavior in the control group is assumed to be 25%,

percentage change = $\frac{25-12.03}{25} * 100 = 51.88.$

Consequently, the effectiveness of the intervention in terms of percentage reduction in antisocial behavior is approximately 52%.

If we assume, that the aggression rate is only 10% in the control group, then using the above algorithm, the percentage change would be 56.3%. In case of a 50% aggression rate in the control group, the relative reduction would change to 41.7%.

Omega-3 fatty acid supplementation for antisocial behavior

Odds in control group = $\frac{\text{Number of individuals with aggression}}{\text{Number of individuals without aggression}}.$

In the control group, the occurrence of antisocial behavior is assumed to be 25 out of 100 individuals. Therefore,

odds of antisocial behavior in control group = $\frac{25}{100-25} = \frac{25}{75} = 0.33.$

The Hedges's g value in the meta-analysis was -0.15, which corresponds to an odds ratio of 0.76 (calculation based on https://www.escal.site/). This means that the odds of antisocial behavior in the treatment group are 0.76 times the odds in the control group. Therefore, the odds in treatment group = 0.33*0.76 = 0.2508. Probability of antisocial behavior in the treatment group is calculated as

$\frac{\text{Odds in treatment group}}{1+\text{odds in treatment group}} = \frac{0.2508}{1+0.2508} = 0.2005.$

Consequently, the probability of antisocial behavior in the treatment group is 20.05%.

The percentage change in antisocial behavior is calculated as the difference in probabilities between the control and treatment groups, divided by the control group's probability, and then multiplied by 100. Given that the probability of antisocial behavior in the control group is assumed to be 25%,

percentage change = $\frac{25-20.05}{25} * 100 = 19.80.$

Consequently, the effectiveness of the intervention in terms of percentage reduction in antisocial behavior is approximately 20%.

If we assume, that the aggression rate is only 10% in the control group, then using the above algorithm, the percentage change would be 21.8%. In case of a 50% aggression rate in the control group, the relative reduction would change to 13.4%.

Vitamin D supplementation for antisocial behavior

Odds in control group = $\frac{\text{Number of individuals with aggression}}{\text{Number of individuals without aggression}}$.

In the control group, the occurrence of antisocial behavior is assumed to be 25 out of 100 individuals. Therefore,

odds of antisocial behavior in control group = $\frac{25}{100-25}$ = $\frac{25}{75}$ = 0.33.

The Hedges's g value in the meta-analysis was -0.48, which corresponds to an odds ratio of 0.42 (calculation based on https://www.escal.site/). This means that the odds of antisocial behavior in the treatment group are 0.42 times the odds in the control group. Therefore, the odds in treatment group = 0.33*0.42 = 0.1386. Probability of antisocial behavior in the treatment group is calculated as

$\frac{\text{Odds in treatment group}}{1+\text{odds in treatment group}}$ = $\frac{0.1386}{1+0.1386}$ = 0.1217.

Consequently, the probability of antisocial behavior in the treatment group is 12.17%.

The percentage change in antisocial behavior is calculated as the difference in probabilities between the control and treatment groups, divided by the control group's probability, and then multiplied by 100. Given that the probability of antisocial behavior in the control group is assumed to be 25%,

percentage change = $\frac{25-12.17}{25}$ * 100 = 51.32.

Consequently, the effectiveness of the intervention in terms of percentage reduction in antisocial behavior is approximately 51%.

If we assume, that the aggression rate is only 10% in the control group, then using the above algorithm, the percentage change would be 55.6%. In case of a 50% aggression rate in the control group, the relative reduction would change to 41.0%.

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