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# Supporting document 3 - Consumer behaviours, understandings, risk perceptions, and information sources regarding caffeinated foods

P1056 – Caffeine review

## Executive summary


Food Standards Australia New Zealand undertook a rapid systematic review to examine the available evidence on consumer behaviour, understanding, risk perceptions, and information sources regarding caffeinated foods (including beverages). The review had a specific focus on the subpopulations of children, adolescents, athletes, and pregnant/lactating women as well as the broader population. No studies were found that examined caffeine-sensitive individuals. This report outlines the methodological approach to the review and summarises the available evidence.

Searches of electronic databases and hand-searching were used to identify 65 studies for this review. Findings across studies were narratively synthesised. The findings are in respect of the Australian/New Zealand populations except for the subpopulations of children and pregnant/lactating women, where the findings also draw on international literature to supplement a small number of available studies.

This review is not without limitations. Most studies examined did not use nationally representative samples from Australia/New Zealand. The findings may therefore not be generalisable to all Australians and New Zealanders, particularly those from ethnic minorities. Studies also commonly examined different caffeinated products and/or different consumption timeframes. This limits some prevalence and intake information, as caffeine may not have been measured across the entire diet, or in a way that can be compared across studies. Finally, not all 65 studies provided evidence relevant to every research question. Thus, in some instances, conclusions are based on only one or two studies – this is stated where relevant. Acknowledging these limitations, there are a number of conclusions that can be made based on the consistency of the evidence. The key findings are described below.

**Who consumes caffeinated food products, and are they being consumed within the recommended daily limits?**

- The majority of children, adolescents, pregnant women, and the general population consume caffeinated food and beverages. At least some athletes and military personnel use caffeinated sports supplements such as gels, gums, and capsules, however the prevalence varied widely across studies.

- Age was consistently associated with likelihood and level of caffeine intake, with older children, adolescents, and university students being more likely to consume caffeine and at higher levels. Sex only had an influence on the type of products that were consumed, with males more likely to consume formulated caffeinated beverages (energy drinks), and females more likely to consume tea, coffee, and chocolate. Lower socioeconomic status was associated with a higher level of caffeine consumption among children only.

- Sociodemographic factors associated with caffeine intake among pregnant women were generally mixed, although there was some evidence that greater caffeine consumption among pregnant women was associated with greater age, subsequent pregnancies, smoking, and/or consuming alcohol.

- The majority of the general population and each examined subpopulation appear to be consuming caffeine within the recommended daily limits (i.e. 400 mg/day for adults and athletes; 5.7mg/kg bw/day for adolescents; 3 mg/kg bw/day for children; and 200 mg/day for pregnant/lactating women).

- There is little evidence that children and adolescents are regularly exceeding the recommended daily limits of caffeine. One international study found that a very small proportion of children (less than 0.6%) reported exceeding the recommended daily limit by consuming cola and energy drinks. One South Australian study found that at least some 8-12 year olds exceed the recommended daily limit, however the exact proportion was not reported. There was no available evidence on caffeine consumption in children based on New Zealand studies[1]. One Australian study found that a subset of adolescents (less than 3.4%) exceed the recommended daily limit of caffeine in an average ‘session’ of energy drink consumption. However, the frequency of these sessions was not reported, so it is unclear whether adolescents are exceeding the recommended limits on a regular basis.

- There is some evidence that a subset of pregnant women (typically less than 15%) and the general population (14-33%) are exceeding the limits on a regular basis. No information was available regarding the amount of caffeine being consumed by athletes.

- Coffee was the major contributor to exceeding the daily recommended limits of caffeine for pregnant women and the general population. In addition, two studies found that a subset of individuals from the broader population (proportion not quantifiable) are either regularly reaching or exceeding the daily safe limit of caffeine solely by consuming energy drinks.
- Sports foods were not a major contributor to daily caffeine intake in children, adolescents or a sample of university students. No studies directly examined the

[1] The social science literature review that was published as a supporting document to the first CFS previously said: *There was no evidence of overconsumption of caffeine in children based on Australian/New Zealand studies.* Here, this sentence and the previous sentence have been revised to acknowledge the South Australian study.

contribution of sports foods products to total caffeine intake in athletes, pregnant women or the general population.

- One study found that a subset of individuals from the general population (proportion not quantifiable) may be exceeding the daily safe limit of caffeine solely by consuming caffeine tablets, medications, and/or sports supplements. It is not possible to determine which of these products contributed most to exceeding the daily limit as they were combined into one category.

- Five quantitative studies reported that athletes/military personnel consume multiple sports foods/supplements, however, it is unclear whether these are consumed within the same day (i.e., stacking behaviour). One qualitative study found that both active and sedentary consumers from the general population use multiple types of sports foods/supplements within the same day. In both cases it is not clear whether the products contained caffeine.

**What is consumers' understanding of caffeinated food products and their risks?**

- No studies investigated consumer awareness of the recommended maximum daily limits of caffeine. Although pregnant women typically sought information to assist with dietary changes, it is not clear they were aware of, or had received advice consistent with, the 200 mg/day limit.

- Most consumers from the broader population reported perceived negative side effects from consuming caffeinated food and beverage products. However, this did not always cause consumers to reduce their caffeine intake. In one study, coffee and energy drinks were still regularly consumed by New Zealand university students despite experiencing adverse symptoms.

- There was no information available on whether consumers are aware of the caffeine content associated with foods that naturally contain caffeine such as tea and coffee. However, there is evidence that consumers may not always be aware that caffeine has been added to beverages such as energy drinks and caffeinated ready-to-drink alcoholic beverages.

- Children, adolescents and consumers from the broader population had an awareness that 'health risks' were associated with energy drink consumption. However, there was evidence of a lack of understanding of the specific nature of any health risks, or which risks may be related to the caffeine content.

- No studies investigated consumers' risk perceptions of caffeinated food and beverage products more broadly. Pregnant women's tendency to reduce caffeine intake, and coffee in particular, may reflect a level of awareness of the associated health risks during pregnancy. However, other motivations – such as nausea – may also contribute to this behaviour.

**Why do consumers use caffeine?**

- Consumers' motivations for consuming caffeinated food and beverages varied across different food products and subpopulations, but common themes were: taste, desire for increased energy, and social considerations.

**Where do consumers get their information about caffeinated food products, and do they feel they have sufficient information?**

- No studies directly examined where consumers receive their information about caffeinated food products. However, advertising was a recurring theme in discussions of energy drinks among children, adolescents, and the broader population. Parents/carers or other significant adults also played an important role in discouraging or normalising energy drink consumption among children and adolescents. Advisory statements on energy drinks were not a prominent source of information among children, adolescents or the broader population.

- Athletes sourced information about sports foods/supplements from medical professionals, coaches, family/friends, and the internet. One Australian study of elite swimmers found they usually read the label of these products.

- One study found that, among pregnant women, midwives were the most common and trusted sources of dietary information during pregnancy. However during lactation, while midwives remained important, the internet and family friends became relatively more influential than they were during pregnancy.

- Four studies found that, when prompted, consumers desired clearer and more prominent labelling of energy drinks to convey caffeine content. However, these studies did not examine the potential effect of labelling changes on consumers' understanding and consumption behaviours, and this was beyond the scope of the current review.

- No studies examined whether consumers feel that they have sufficient information regarding other caffeinated foods or beverages.

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# Introduction

In August 2019, Food Standards Australia New Zealand (FSANZ) undertook a review and report to Australian Government Ministers regarding the safety of caffeine powders and high caffeine content products following the tragic death of a young man in New South Wales attributed to acute caffeine toxicity associated with the consumption of a caffeine powder. The review found that the retail sale of pure and highly concentrated caffeine products posed an unacceptably high risk to consumers and that there was a need to act quickly to protect public health and safety.

On the basis of this assessment, FSANZ prepared Urgent Proposal P1054 as an emergency interim response to prohibit the retail sale of pure and highly concentrated caffeine products. Under P1054, FSANZ approved a variation to the Australia New Zealand Food Standards Code ('the Code') to prohibit total caffeine present in a concentration of 1% or more for liquid foods and 5% or more for solid and semi-solid foods for retail sale. This prohibition came into force on 12 December 2019 in Australia and on 3 February 2020 in New Zealand.

FSANZ had 12 months to undertake a full assessment of the prohibition and decide whether to confirm, reject, or amend the approved variation. As part of this assessment, FSANZ called for submissions to help seek views on whether to reaffirm the variation or to prepare a proposal to amend or repeal the variation.

After considering all submissions received, FSANZ's preferred option was to prepare Proposal P1056 – Caffeine Review to consider whether additional measures are required in relation to caffeine in the Australian and New Zealand food supply in order to protect public health and safety; looking in particular at,

- caffeine in sports food, which may consider a maximum limit on caffeine for foods in the general food supply; and

- the extent of the risk posed to sensitive subpopulations and whether and how any such risk should best be managed.

To inform this work, FSANZ undertook a literature review to examine the evidence base on consumer behaviour, understanding, risk perceptions, and information sources regarding caffeinated foods, with a specific focus on the subpopulations of children, adolescents, athletes, pregnant and/or lactating women, and caffeine sensitive individuals as well as the broader population. The literature review considers all caffeinated foods and beverages that contribute to the overall diet, including those that naturally contain caffeine (e.g. tea, coffee, and chocolate) and those to which caffeine has been added (e.g. cola and formulated caffeinated beverages [energy drinks]). While caffeine tablets and caffeinated medication are out of scope of P1056, they are included in this literature review where studies have reported their contribution to overall caffeine intake.

The literature review investigated six research questions:

1. Who consumes caffeinated food products?
    a. What prevalence of use is found in the general population, athletes, and vulnerable subpopulations (e.g. children, adolescents, pregnant and/or lactating women, and caffeine sensitive individuals), and what products do they consume?
    b. Are there any sociodemographic factors associated with use?
2. How do consumers use caffeinated food products?

   a. Are they being consumed at the recommended levels? What products are contributing to people's overall caffeine intake, and in what proportions?
   b. What are the sociodemographic characteristics associated with higher levels of caffeine consumption?
3. Why do consumers use caffeinated food products?
4. What do consumers understand about caffeinated food products?
   a. To what extent do consumers understand the caffeine content of caffeinated food products?
   b. Do consumers understand the risks associated with caffeine consumption?
   c. Do consumers report perceived side effects?
   d. Do consumers understand what is a safe level of caffeine consumption?
5. Where do consumers get their information about the safety, recommended usage levels and/or performance benefits of caffeinated products, and how to use these products?
6. Do consumers feel they have sufficient information to enable them to make an informed choice regarding their caffeine intake? If they want further information, what is their preferred source?

# Methods

## Literature search strategy

FSANZ undertook a systematic search for literature on consumer behaviour, understanding, risk/benefit perceptions, and information sources in relation to caffeinated foods using a staged approach. It includes peer-reviewed articles published in academic journals, as well as grey literature, such as unpublished theses.

Literature was identified by:

- Searching six online databases for peer-reviewed studies published between January 2010 and February 2022;
- Searching for relevant studies in P1010 – Formulated Supplementary Sports Foods literature review; and
- Searching the reference lists and citing studies of obtained studies.

The literature search involved a staged approach focusing first on Australian/New Zealand studies, which provided sufficient information for the adolescent and broader subpopulations. However, the available Australian/New Zealand studies were deemed insufficient for the children and pregnant/lactating women subpopulations because they did not provide information relevant to every research question (e.g., no Australian or New Zealand studies examined why children consume caffeinated food products). Literature was therefore also drawn from international countries for the children and pregnant/lactating women subpopulations.

We deemed it inappropriate to draw on international literature for athletes, as both Australian/New Zealand and international studies tended to only examine consumption of caffeinated supplements. It was difficult to determine if the caffeinated supplements under investigation would be regulated as a formulated supplementary sports food under the Code (e.g., some could be regulated as a formulated supplementary food, or as a therapeutic good)[2]. In addition, as the international sports foods regulatory environment and market largely differs from that of Australia and New Zealand, incorporating the international literature for this particular subpopulation was deemed to have added little value to the review. No studies were found on caffeine-sensitive individuals in either context.

A total of 65 full-text documents (consisting of 64 unique studies) were included in the literature review. The literature search and screening process was conducted by three officers. More detail on the literature search strategy and research review process are available in Appendix 1.

## Evidence synthesis

The evidence from each study was collated thematically under the research questions in order to present a narrative overview of the available evidence. The quality of each individual study was not assessed using a standardised quality assessment tool, given the high number of included studies and the need to produce a timely evidence synthesis. Rather, the general strengths and limitations were considered in the narrative when describing each individual study.

When making conclusions for each research question, consideration was given to the general principles of the GRADE framework (Guyatt et al., 2011). That is, consideration was given to the strengths and limitations of the individual studies, the consistency of the findings across studies, and the directness of the evidence (e.g., relevance of the study's target sample)[3]. For example, confidence in the findings will be low if there are inconsistencies in the findings across studies, unless the inconsistencies can be explained (e.g., if studies examined different types of caffeinated products or samples).

Write-up and synthesis was conducted by three FSANZ officers. The draft literature review was internally reviewed by FSANZ staff members. The final draft was then externally peer reviewed by an independent academic, and peer review comments were considered and incorporated into the final version of the report.

# Findings

Findings have been reported separately for each of the following subpopulations: Children, adolescents, athletes and army/military personnel, pregnant/lactating women, and broader populations. 'Broader populations' included samples from the general population, or other specific subpopulations not covered by the previous subpopulations of interest (such as

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[2] A formulated supplementary sports food is a product that is specifically formulated to assist sports people in achieving specific nutritional or performance goals. Such foods are intended as supplements to a diet rather than for use as the sole or principal source of nutrition. These foods are regulated under Standard 2.9.4 of the Code. In comparison, a formulated supplementary food is specifically designed as a supplement to a normal diet to address situations where intakes of energy and nutrients may not be adequate to meet an individual's requirements. These foods are regulated under Standard 2.9.3 of the Code.

[3] Although the GRADE framework typically involves quantitatively grading the evidence (e.g., confidence in the findings is graded as high [on a scale from very low to high] when studies use randomised controlled trials), this was not appropriate for the current review given that it synthesises studies that used diverse designs, and addresses research questions where randomised controlled trials would not necessarily be of higher quality. Therefore, only a narrative approach was taken, with general considerations given to relevant GRADE principles.

university students or shift workers). Athletes and army/military personnel were included in the same category as studies examining both of these subgroups tended to solely focus on sports foods and/or supplements. Due to differing ways in which children and adolescents are defined across the different studies, no specific age ranges have been defined for these categories. However, children were approximately aged 0-13 years, and adolescents were approximately aged 13-21 years. No studies were found that examined caffeine-sensitive individuals.

## Overview of study characteristics

65 studies were eligible for inclusion. 53 studies were peer-reviewed published in academic journals, and 12 were grey literature (i.e. preprints, unpublished theses, and research produced by governmental agencies). 37 studies were based in Australia/New Zealand, and 28 studies drew on international contexts (see Table 1 below). 50 studies used quantitative methodologies, 11 used qualitative methodologies, and 4 used mixed methodologies (i.e., had both quantitative and qualitative components).

*Table 1: Number of included studies by subpopulation and geographic location.*

| Subpopulation | # of Studies in AU/NZ* | # of International Studies |
|---|---|---|
| Children | 2 | 14 |
| Adolescents | 14 | N/A |
| Athletes or Military Personnel | 7 | N/A |
| Pregnant or Lactating Women | 4 | 14 |
| Broader Populations | 11 | N/A |
| Caffeine-Sensitive Individuals | 0 | 0 |

* Some studies covered multiple subpopulations.

Studies commonly examined a different range of caffeinated products. For example, some studies focused only on energy drinks or caffeinated beverages, while others considered intake across various food and beverage types. This limits some prevalence and intake information as caffeine may not have been measured across the entire diet. In addition, a number of studies did not use samples representative to the Australian/New Zealand population. The findings may therefore not be generalisable to all Australians and New Zealanders, particularly those from ethnic minorities. There was a lack of studies that specifically examined First Nations Australian, Māori, or Pasifika communities.

Further information on limitations is available on page 110.

# Research Question 1: Who consumes caffeinated food products?

This section examines the proportion of each subpopulation consuming caffeinated food products, the type of food products they consume, and any sociodemographic factors associated with the likelihood of use. Note that this section does not examine how frequently products are used by those who consume them. Frequency of use information (in conjunction with the amount of caffeine present in all consumed products) is used to determine consumers' *overall caffeine intake* and is therefore discussed in Research Question 2. Similarly, it does not report on sociodemographic factors that are associated with the amount of caffeine consumed, which is also reported as part of Research Question 2.

All studies in this section were quantitative and relied on participant recall (or that of their proxy, in the case of young children).

## Overarching findings

*Proportion of the population using caffeine*

The majority of children (58.3% - 87%), adolescents (94.9%), pregnant women (42% - 95.3%) and the general population (99.1%) consume caffeinated food and beverage products across all different age groups. Prevalence of caffeine consumption among pregnant women appears to differ over the course of pregnancy, being lower in early pregnancy and rising as pregnancy progresses. Prevalence of use of caffeinated supplements such as gels, gums and capsules among athletes and military personnel varied widely across studies (10.8% to 49% for athletes; 1.4% to 73% for military personnel), likely due to the different range of supplements and timeframes of use examined.

*Prevalence of different caffeinated food products*

The most common type of caffeinated products consumed by children and athletes or military personnel is unclear, as studies that examined these subpopulations either did not report prevalence of use by product type, or only examined prevalence of use of a limited range of products (such as energy drinks). There is data available on the proportion of overall caffeine intake contributed by different caffeinated products for some of these subpopulations, which are reported in Research Question 2, however this may differ from prevalence of consumption.

Five studies reported prevalence of use for a broad range of different caffeinated food and beverage products. Three studies were based in New Zealand, with one examining adolescents, another examining university students, and the third examining the general population. Overall, the most prevalent caffeinated products consumed by both adolescents and university students was chocolate, followed (in order) by coffee, tea, cola drinks, and energy drinks. Conversely, in the sample of the general population, the most prevalent type of caffeinated products consumed was cola, followed by coffee, energy drinks, tea and caffeinated 'ready-to-drink' alcoholic beverages (RTDs). However, chocolate consumption was not examined in the study that examined the general population, and so this study is not directly comparable to the other two. Two international studies found that pregnant women most commonly consumed (in order) soda, coffee and tea, but rarely energy drinks (United States) and coffee, tea, chocolate and soda (Italy), noting the United States Study also did not capture chocolate consumption.

It is important to note that the most prevalent caffeinated products consumed in each subpopulation may not necessarily contribute the most to daily caffeine intake. The proportion that different caffeinated products contribute to overall caffeine intake is reviewed under Research Question 2.

*Sociodemographic factors associated with use of caffeinated products*

Some studies reported on sociodemographic factors associated with use of caffeinated products. Age was associated with caffeine consumption in both children and adolescents, with older children and adolescents being more likely to consume caffeinated products or beverages than younger children and adolescents. In the general population, age was associated with prevalence of consumption for energy drinks in particular, with younger people (those aged 18-49 years) being more likely to consume energy drinks than older people (those aged 50+ years). Conversely, age was not associated with consumption of any particular type of caffeinated product in university students.

Sex was also associated with likelihood of consumption of some products. Caffeinated soft drinks were more likely to be consumed among male adolescents than female adolescents, and energy drinks were also more likely to be consumed by males among children, adolescents, army personnel, and the general population. In adolescents and university students, females were more likely than males to consume tea, coffee, and chocolate.

Employed adolescents and university students (either part-time or full-time) were more likely to consume energy drinks and (for university students only) caffeine tablets than those who were unemployed. Whereas unemployed students were more likely to consume tea than employed students.  Perhaps related, one study found that energy drink consumption was associated with adolescents who had more discretionary money (at least $40/week) compared to those who had less (less than $10/week).

A more detailed description of the findings is provided below, grouped by the type of subpopulation.

## Children

Twelve studies reported on the proportion of children who consume caffeine.  Two were from Australia, five from Europe, and five from the United States of America (United States). No New Zealand studies were found. Six studies considered caffeine intake from general foods, such as tea, coffee, chocolate, and/or caffeinated soft drinks, three studies considered caffeine intake from caffeinated soft drinks and energy drinks, and three studies considered caffeine intake only from energy drinks.  In addition, two Australian studies that focused on adolescents asked at what age they first consumed energy drinks, and found that the mean age was under 12 years so are reported here.

*Australian Studies*

Only two Australian studies looked specifically at the proportion and sociodemographic characteristics of children consuming caffeinated food products.  One study (Beckford et al. 2015) used nationally representative data from 2007, whereas the other (Watson et al. 2017) was a smaller but more recent study based in South Australia.

In addition, two studies that asked adolescents at what age they first consumed energy drinks have findings relevant to children and are also reported here.

*Table 2: Comparison of Australian studies examining proportion of children who had consumed caffeine.*

| Study | Sample | Sample Size | Product | Timeframe | % Consumed |
|---|---|---|---|---|---|
| Beckford et al. (2015) | 2-3 year old Australians | 1,071 | Caffeinated soft drinks and energy drinks | Previous 24 hours | 4% |
| | 4-8 year old Australians | 1,216 | | | 9% |
| | 9-13 year old Australians | 1,110 | | | 18% |
| Watson et al. (2017) | 8-12 year old South Australians | 309 | Caffeine-containing food and beverages | Last 7 days | 87% |

As seen in Table 2, Beckford et al. (2015) found that 4% of 2-3 year olds and 9% of 4-8 year olds consumed caffeinated soft drinks and/or energy drinks in the previous 24 hours. In the data reported for comparable age groups across the two studies (9-13 year olds and 8-12 year olds), there was a striking difference: Beckford et al. (2015) found that 18% of 9-13 year olds had consumed caffeinated soft drinks and energy drinks in the previous 24 hours compared to Watson et al.'s (2017) finding that 87% of 8-12 year olds had consumed caffeine-containing food and beverages in the last week. However, the two studies use very different populations (one nationally representative and the other relatively small and geographically localised), time periods (previous 24 hours vs previous 7 days), and consider different products (Watson et al. includes caffeine-containing food such as chocolate as well as beverages that naturally contain caffeine such as tea and coffee). As a result, it is not possible to make clear comparisons between the two studies.

In addition to these studies that looked specifically at children, two studies that looked at adolescents asked participants at what age they first consumed energy drinks. In Costa et al.'s (2016) survey of 399 students in secondary schools in regional Victoria, the mean age energy drinks were first consumed was 10.5 years (SD 2.97), and 52.8% of participants had consumed their first energy drink prior to age 12. Similarly, in Trapp et al.'s (2020) survey of Western Australian secondary school students, the average age of first energy drink consumption was 10.7 years (SD 2.93).

Beckford et al. (2015) found that, across the whole sample of children and adolescents aged 2-16 years, older children and children from a low socioeconomic status background were significantly more likely to consume caffeinated soft drinks and energy drinks than younger children or children from a high socioeconomic status background (both $p \leq 0.001$). Watson et al. (2017) did not examine sociodemographic characteristics associated with likelihood of caffeine consumption

*European Studies*

Five studies looked at the proportion of children consuming caffeine in Europe. Each of the studies was from a different country, but a few provided data covering similar populations of children aged 11-13 years, allowing for some comparison.

Table 3 below shows the findings for studies within Europe that had comparable age ranges (mostly aged 11-13 years). Across the three studies that assessed proportion of children aged 11-13 who had consumed energy drinks in their lifetime (Gallimberti et al. 2013, Galimov et al. 2019, and Martins et al. 2018), consumption ranged from a low of 35.9% in Italy to a high of 50.1% in Germany. It is not possible to provide an averaged proportion of the three lifetime usage studies via meta-analysis as Galimov et al. (2019) did not report the sample size for students aged 11-13 years old.

*Table 3: Comparison of European studies that analysed consumption of cola and/or energy drinks in children aged 10-12 or 11-13 years.*

| Study | Sample | Sample Size | Product | Timeframe | % Consumed |
|---|---|---|---|---|---|
| Kristjansson et al. (2014) | 10-12 year olds in Iceland | 11,132 (49.7% female) | Cola drinks | Typical daily consumption | 13.5% (19% of boys, 8% of girls) |
| | | | Energy drinks | Typical daily consumption | 5% (7% of boys, 3% of girls) |
| Wierzejska et al. (2016) | 11-13 year olds in Poland | 329 (50.2% female) | Cola drinks | "Several times a month" or more | 89.1% |
| | | | Energy drinks | | 23.8% |
| Gallimberti et al. (2013)* | 11-13 year olds in Italy | 916 (47.6% female) | Energy drinks | Lifetime | 35.9% |
| Galimov et al. (2019)* | 11-13 year olds in Germany | Not reported by age (overall n=6,902, % female unknown) | Energy drinks | Lifetime | 50.1% |
| Martins et al. (2018) | 11-13 year olds in Portugal | 263 (54% female) | Energy drinks | Lifetime | 43.3% |

* These studies provided proportions for a finer category of age ranges or grade (11 year olds, 12 year olds, and 13 year olds or Grade 6, Grade 7, and Grade 8). These were combined by taking a simple average to provide an overall figure comparable to other studies.

Across all European studies, energy drink consumption was found to be significantly more likely among boys than girls. There was also a significant association between older age and likelihood of energy drink consumption.

There were conflicting findings regarding consumption of cola drinks. Kristjansson et al. (2014) found that consumption of cola drinks was more common and frequent among boys than girls ($p<0.001$). In comparison, Wierzejska et al.'s (2016) study found that there was no statistically significant differences in the consumption of cola drinks between boys (90.2%) and girls (87.8%). This may relate to the different time periods considered in the studies. Kirstjansson et al. considered typical daily consumption of cola drinks, whereas Wierzejska et al. considered users who consumed cola "several times a month" or more.

*United States' Studies*

Three studies used National Health and Nutrition Examination Survey (NHANES) data from 2009-10 to analyse the proportion of children who consumed caffeine in a 24 hour recall period, although they used different techniques to sample the population available through the dataset. NHANES is a complex, stratified, multistaged probability survey of the US civilian, non-institutionalised population. The NHANES involves a dietary interview in which participants (or their proxies, for children aged ≤ 5 years) recall the type and quantity of all foods and beverages consumed in the preceding 24 hour period. However, it is important to note that this may not be reflective of usual consumption given that consumption patterns may change from day to day. In addition, the data is now approximately 12 years old, and caffeine consumption could have changed in the intervening years. The findings are compared below in Table 4. It is not possible to provide an averaged proportion of the three studies via meta-analysis as Branum et al. (2014) did not report the sample size for either the 2-5 year old or 6-11 year old age groups.

*Table 4: Comparison of studies using data from the 2009-2010 NHANES in the United States*

| Age Group | Study | Sample Size | % Consumed Caffeine within 24-hour Recall Period ± Standard Error |
|---|---|---|---|
| 2-5 years | Ahluwalia et al. (2014) | 861 | 58.3% ± 2.4 |
| | Branum et al. (2014) | Not reported | 62.7% ± 1.1 |
| | Caceres (2014) | 410 | 58.7% |
| 6-11 years | Ahluwalia et al. (2014) | 1,154 | 74.9% ± 1.7 |
| | Branum et al. (2014) | Not reported | 74.8% ± 0.9 |
| | Caceres (2014) | 779 | 74.9% |

The other two studies from the United States are not comparable because they use different age ranges and examine different sources of caffeine, and are thus described narratively below.

In Warzak et al.'s (2012) survey of parents of 201 children aged 5-12 years at an urban outpatient paediatric clinic, 75.5% of children had consumed caffeine from all food/beverage sources. This proportion was made up of 73% of children aged 5-7 (n=104) and 80% of children aged 8-12 (n=97).

In Lisdahl et al.'s (2021) prospective cohort study, 67.6% of the 11,857 children aged 9-10 years (of whom 47.8% were female) reported consuming at least one type of caffeinated beverage during the past six months.

Of the studies from the United States, three considered sociodemographic factors associated with caffeine consumption. These concerned sex, age, ethnicity, and socioeconomic status.

Ahluwalia et al. (2014) found that there was no statistically significant difference in caffeine consumption between males (70.6% ± 1.9) and females (71.5% ± 1.3) across the entirety of the sample population (2-19 years). This is in contrast to Lisdahl et al. (2021), which found that, at age 9-10 years, males (70.2%) were significantly more likely than females (64.7%) to report using caffeine ($p < 0.001$). The difference in these findings could be due to a range of different factors, including: the difference in products examined (all food/beverage sources of caffeine vs caffeine-containing beverages only), the different age ranges considered (2-19 years vs 9-10 years), and/or the different time periods in which data was collected (2009-10 vs 2016-18).

Ahluwalia et al. (2014) ($p < 0.01$) and Branum et al. (2014) ($p < 0.001$) found that there was a significant association between age and likelihood of caffeine consumption. The same authors also found that caffeine consumption was more likely in non-Hispanic White children compared to non-Hispanic Black or Mexican-American children ($p < 0.05$), with non-Hispanic Black children the least likely to consume caffeine.

There were conflicting findings regarding the influence of household income. Branum et al. (2014) found that higher-income children were significantly more likely to consume caffeine than children below the poverty threshold ($p < 0.01$). However, it is important to note that proportions of use were not largely different (72%-75%). Ahluwalia et al. (2014) found no statistically significant association.

*Summary*

Overall, the literature suggests that caffeine is being consumed by the majority of children around the world, at all different age ranges. However, the differences in populations, sampling methods, timeframes and products examined mean that, while cautious comparisons are possible, it is not possible to draw definitive conclusions beyond this point.

The 2009-10 NHANES studies found that the majority of children aged 2-5 years (58.3% to 62.7%) and 6-11 years (74.8% to 74.9%) in the United States had consumed caffeine from all food/beverage sources in the previous 24 hour period. Their nationally representative data source, as well as the fact that they examined caffeine from all food/beverage sources, gives a high level of confidence in these findings.

Three studies that looked specifically at energy drinks found that the proportion of children aged 11-13 years who had consumed energy drinks within their lifetime ranged from 35.9% in Italy to 50.1% in Germany. This is consistent with the findings in the Australian context that the average age of first energy drink consumption was around 10.5 years (Costa et al. 2016 and Trapp et al. 2020), and that 52.8% of children had consumed energy drinks before 12 years of age (Costa et al. 2016). The consistency in these findings suggest that a significant proportion (more than a third to half) of children aged 11-13 years may have consumed energy drinks at some point in their lifetime.

Three studies found that caffeine consumption was more likely among older children. There are conflicting findings around the influence of sex on caffeine consumption, which could be due to a range of different factors including: the difference in products examined, the different age ranges considered, and/or the different time periods in which data was collected. However, there appears to be an association between being male and consuming energy drinks in particular, although this could also be influenced by the tighter age range (11-13 years) in these studies.

There were also conflicting findings in respect of the influence of socioeconomic status on the likelihood of caffeine consumption. One study in the Australian context found that children from low socioeconomic backgrounds were significantly more likely to consume caffeine compared to those from high socioeconomic backgrounds, one study based on the US NHANES found that there was a small but significant trend in the reverse direction, and another US NHANES study found no statistically significant association. All studies used similar sampling methods from a similar time period, so there is no clear explanation for the variance in these findings, except for the different contexts in which the studies were conducted. As a result, there is not enough data available to draw a conclusion.

## Adolescents

*Proportion of Adolescents Consuming Caffeine*

Eight studies reported on the proportion of adolescents who use caffeinated food products; six in Australia, and two in New Zealand. Six looked specifically at energy drinks, one looked at caffeinated soft drinks and energy drinks, one looked at all caffeinated beverages, and one looked at caffeine from all sources, including pills and supplements. The results are summarised in Table 5 below.

*Table 5: Studies reporting on the proportion of adolescents who use caffeinated food products in Australia*

| Study | Sample (Mean age ± SD) | Sample Size | Product | Timeframe | % Consumed |
|---|---|---|---|---|---|
| Beamish et al. (2016) | 13-18 year olds in 12 Christian schools across Australia | 949 (51.8% female) | Caffeinated beverages | Previous week | 47% |
| Beckford et al. (2015) | 14-16 year olds across Australia | 942 (overall sample 49% female) | Caffeinated soft drinks and energy drinks | Previous 24 hours | 26% |
| Costa et al. (2016) | 12-18 year olds (14 ± 1.28) in regional Victoria | 399 (36% female) | Energy drinks | Lifetime | 56.1% |
| Nuss et al. (2021) | 12-17 year olds (14.7 ± 1.2) across Australia | 8,942 (52% female) | Energy drinks | Regular users (weekly or more) | 8% |
| O'Dea (2003) | 11-18 year olds from one high school in Australia (location unknown) | 78 (% female unknown) | Energy drinks | Prior two weeks | 42.3% |
| Trapp et al. (2014) | 18-22 year olds (20 ± 0.5) born in Perth | 1,565 (53.3% female) | Energy drinks | Regular users (monthly or more) | 48% |
| Trapp et al. (2020) | 12-18 year olds (13.6 ± 1.5) in Western Australia | 3,688 (55.1% female) | Energy drinks | Lifetime | 49.4% |
| Turner (2019) | 15-18 year olds (16.6 ± 0.82) in New Zealand | 216 (65.0% female) | Caffeinated food, beverages pills and supplements | Current | 94.9% |
| Utter et al. (2018) | Secondary school students in New Zealand | 8,304 (54.8% female) | Energy drinks | Previous week | 35% |

As shown in Table 5, two studies (Costa et al. 2016 and Trapp et al. 2020) examined the proportion of adolescents aged 12-18 years who had consumed energy drinks within their lifetime. They found that 56.1% and 49.4% of adolescents respectively had consumed energy drinks. In addition, two studies (O'Dea 2003 and Utter et al. 2018) looked at the consumption of energy drinks in the previous fortnight and week respectively. They found that 42.3% and 35% of adolescents had consumed energy drinks in that period, respectively. However, it is important to note that both Costa et al. (2016) and O'Dea (2003) have geographically limited populations (a regional Victorian town and a single high school), with relatively small sample size (n=399 and n=78 respectively) that, in Costa et al.'s case, is skewed male (only 36% were female). The other studies used varying products and timeframes and/or definitions of "users" that prevent comparison. However, it is relevant to note that, across subpopulations, studies that included food sources of caffeine, like Turner (2019), generally reported a much higher level of prevalence (in this case, of 94.9%).

One study (Turner 2019) provided a breakdown of the proportions of adolescents who consumed various categories of products. As shown in Table 6, the product with the highest proportion of consumption was chocolate (85.1%), followed by coffee (56.3%), tea (55.3%), and cola drinks (54.4%). Of note, 7% of adolescents reported consuming 'other' caffeine sources, such as sports supplements and caffeine tablets.

*Table 6: Percentage of 15-18 year olds (16.6 ± 0.82) in New Zealand (n=217) who had consumed various categories of caffeinated food products (data sourced from Turner 2019).*

| Product | % Consumed (n=217) |
|---|---|
| Chocolate | 85.1% |
| Coffee | 56.3% |
| Tea | 55.3% |
| Cola | 54.4% |
| Energy Drinks | 31.6% |
| Caffeinated 'ready to drink' alcoholic beverages | 21.9% |
| Other (Sports supplements and caffeine tablets) | 7% |
| No caffeine | 2.1% |

*Sociodemographic Characteristics Associated with Caffeine Consumption*

Of the above studies, seven reported sociodemographic characteristics associated with consumption. These were in respect of sex, age, ethnicity, socioeconomic status, and employment status.

Five of the studies found that caffeinated soft drink and/or energy drink consumption was more prevalent among males than females (Beckford et al. 2015, Costa et al. 2016, Nuss et al. 2014, Trapp et al. 2014, and Turner 2019). In addition, Turner (2019) found that girls were 2.25 times more likely than boys to consume tea (p=0.005), and that there was a non-significant trend for girls to consume more coffee (60.4% vs 47.3%, p=0.066) and chocolate (88.5% vs 79.7%, p=0.084) than boys.

Three studies found that age was significantly associated with caffeine consumption, with older adolescents being more likely to consume caffeinated drinks (Beamish et al. 2016, Beckford et al. 2015, Costa et al. 2014). In contrast, Nuss et al. (2021) found that energy drink consumption was not significantly associated with high school year level. The variance in findings may be due to the difference in products examined (Beamish et al. and Beckford et al. investigated a wider range of caffeinated beverages than Nuss et al.), as well as the fact that year level, while correlated with age, is not a perfect proxy for it.

Utter et al. (2018) found that energy drink consumption was more common among Māori and Pasifika young people in New Zealand.

Beckford et al. (2015) and Utter et al. (2018) found that children and adolescents from a low socioeconomic status background were more likely to consume caffeinated soft drinks and/or energy drinks compared to those from a high socioeconomic status background. In comparison, Trapp et al. (2014) found that family income was not a significant correlate for energy drink use, and Nuss et al. (2021) found that consumption of energy drinks was *not* associated with socioeconomic status. The variance in results could be partially due to the differing age ranges examined. Beckford et al. (2015) looked at both children and adolescents (2-16 years), whereas Trapp et al. (2014) and Nuss et al. (2021) looked at adolescents (18-22 years and 12-17 years respectively) who would have more ability to make their own purchasing decisions. However, this does not explain findings regarding socioeconomic status in Utter et al. (2018), who looked at secondary students (aged approximately 12-18 years). The variance could also relate to the different timeframes that were measured; both Trapp et al. (2014) and Nuss et al. (2021) investigated regular users, whereas Beckford et al. (2015) and Utter et al. (2018) examined discrete time periods (the previous 24 hours and previous week respectively).

Trapp et al. (2014) found that being in full- or part-time employment was significantly associated with being an energy drink user. Turner (2019) found that those who were in paid employment were more likely to drink coffee and caffeinated RTDs. Perhaps related, Nuss et al. (2021) found that energy drink consumption was associated with students who had more discretionary money (at least $40/week) compared to those who had less (less than $10/week).

In addition, Nuss et al. (2021) found that consumption of energy drinks was not associated with geographic location (metropolitan vs rural/regional).

*Summary*

Few clear comparisons can be made across studies examining adolescents' caffeine consumption in Australia and New Zealand as the studies varied in the products examined and the timeframe or measure (such as being a "regular user") analysed. Only one study, which examined New Zealand adolescents aged 15-18 years, considered caffeine consumption from all caffeinated food, beverages, pills, and supplements. This study found that 94.9% of adolescents consumed caffeine, with the most prevalent caffeinated foods and beverages being chocolate (85.1%), followed by coffee (56.3%), tea (55.3%), and cola drinks (54.4%). This study was conducted with a relatively small sample size (n=217) in a relatively limited age range, which limits its generalisability, however as it is the only study to examine all caffeinated food and beverage sources, it provides us with the best data available on adolescent caffeine consumption. The finding that the vast majority of adolescents are consuming caffeine is leant support by the finding that the majority of children consume caffeine, as it is likely that prevalence of caffeine consumption in childhood would be similar or less than the prevalence among adolescents.

Some comparisons can be made in respect of energy drinks. Across the two studies that examined lifetime energy drink consumption among 12-18 year olds, prevalence was found to be 49.4% (Trapp et al., 2020) and 56.1% (Costa et al., 2016). In addition, two studies (O'Dea, 2003; Utter et al., 2018) that looked at the consumption of energy drinks in the previous fortnight and week found that 42.3% and 35% of adolescents had consumed energy drinks in that period, respectively. The combination of these studies suggests that a significant proportion of adolescents – more than one-third – have consumed energy drinks. The consistency in the results across studies, including two that involved robust sample populations (Trapp et al. 2020 and Utter et al. 2018), lends confidence to these findings, even though two of the studies (Costa et al., 2016 and O'Dea, 2003) have significant limitations in respect of their geographically limited, relatively small samples (which also skewed male in Costa et al., 2016).

There was some consistency to the findings of sociodemographic characteristics associated with caffeine consumption in respect of gender and age. Five studies found that caffeinated soft drink and/or energy drink consumption was more prevalent among males than females, and three studies found that older adolescents were more likely to consume caffeinated beverages of different sorts. No clear conclusions could be made about socioeconomic status and caffeine consumption, and one study found that consumption of energy drinks was not associated with geographic location (metropolitan vs rural/regional). One study found that energy drink consumption was more common among Māori and Pasifika young people in New Zealand.

## Athletes/Military Personnel

Seven studies reported on the proportion of athletes (n = 4) or military personnel (n = 3) consuming caffeinated food products. Five studies were based on Australian samples, whereas two studies were based on New Zealand samples. The studies generally only asked participants about caffeinated tablets, gums, gels, energy drinks or 'caffeine supplements' more broadly, and therefore information is not provided on other potential sources of caffeine across the entire diet. Additionally, product information was very vague across these studies (e.g., broad descriptions such as "caffeine nutritional/ergogenic supplements" or "gels" without specifying brand). The findings are summarised below, grouped by subpopulation (athletes vs. military personnel).

*Athletes*

As shown in Table 7, prevalence of use of caffeine supplements in athletes ranged from 10.8% to 49%.

It is important to note that participants were asked about use for different timeframes across studies (i.e., in one study, proportions reflect use within the past 6 months, whereas in other studies, proportions reflect 'current' or 'ever' use; see fourth column in Table 7). Secondly, participants in Clancy (2020) Study 1 were specifically asked about use of caffeine supplements *to enhance performance*. It is possible that participants did not only take caffeine supplements for performance reasons, rather, they may take supplements for a variety of reasons (see also Research Question 3). This question wording in Clancy (2020) Study 1 differs from the other two studies where participants were not asked whether they use products for a particular reason. Thirdly, the specific type of caffeinated products participants were asked about differed across studies. That is, in one study, participants were asked about energy drinks, gels, gums and capsules, whereas in other studies participants were asked about caffeine 'nutritional' or 'ergogenic' supplements more broadly (see third column in Table 7).

For the above reasons, it is not possible to make robust comparisons across studies regarding prevalence of use in these groups.

*Table 7: Percentage of athletes reporting use of particular types of caffeine products for each study.*

| Study and Sample | Sample Size | Product | Timeframe | % Consumed Caffeine |
|---|---|---|---|---|
| Clancy (2020) Study 1<br>NZ; adolescent athletes | 1,298 | Caffeine supplements (including energy drinks, gels, gums, capsules) | In the past 6 months to enhance performance | 10.8% |
| Pumba (2007)<br>Australia; athletes | 497 | Caffeine nutritional supplements | Ever | 37% |
| Shaw (2012)<br>NZ; athletes<br>(Able bodied [AB] and Spinal cord injuries [SCI]) | 26 (AB = 11; SCI = 15) | Caffeine nutritional supplements | Currently using | 16% (AB = 27.3%; SCI = 7.1%) |
| Shaw (2013)<br>Australia; swimmers | 39 | Caffeine ergogenic supplements | In the past 12 months | 49% |

Only one of the studies in Table 7 examined sociodemographic factors associated with caffeine use. Shaw (2013) found no significant differences in prevalence of use based on gender, age (≤21 years vs. >21 years) or experience (<4 years vs. ≥4 years).

### *Military Personnel*

As shown in Table 8, prevalence of use of caffeine supplements in military personnel ranged from 1.4% to 49%. However, as with the studies that sampled athletes, the timeframes of use and types of products examined differed across studies. It is therefore not possible to make clear comparisons across studies regarding prevalence of use.

*Table 8: Percentage of army/military personnel reporting use of particular types of caffeine products for each study.*

| Study and Sample | Sample Size | Product | Timeframe | % Consumed |
|---|---|---|---|---|
| Baker et al. (2019)<br>Australia; Army | 2,162 | Caffeine tablets or gum | ≥1 times per week | 1.4% |

| Study and Sample | Sample Size | Product | Timeframe | % Consumed |
|---|---|---|---|---|
| Kullen et al. (2019)<br>Australia; Army | 667 | Energy drinks + 'caffeine' more broadly | Ever | Energy drinks: 58.5%<br>Caffeine: 73.0% |
| Van der Pols et al. (2017)<br>Australia; Military | 14,032 | Bodybuilding, energy and weight loss supplements that contain caffeine | Currently | 11.7% |

Only one of the studies in Table 8 examined sociodemographic factors associated with caffeine use. Kullen et al. (2019) found that younger army personnel were significantly more likely to use energy drinks ($p < 0.0005$), but significantly less likely to use other caffeinated products ($p = 0.0007$), compared to older personnel. There were no significant associations based on gender, level of education (high school vs. tertiary) or occupational group (officers vs. soldiers vs. physical training instructors vs. cooks).

*Summary*

At least some athletes and military personnel report consuming caffeinated supplements, such as gels, gums and capsules. Some also reported consuming energy drinks. The exact proportion of athletes and military personnel consuming caffeinated supplements varied widely across studies (10.8% to 49% for athletes; 1.4% to 73% for military personnel), likely due to the different range of supplements and timeframes of use examined.

Few studies examined sociodemographic factors associated with use of caffeine. One study found that younger army personnel were significantly more likely to use energy drinks, but significantly less likely to use other caffeinated products, compared to older personnel.

## Pregnant/Lactating Women

Eight studies reported on the proportion of pregnant or lactating women who consume caffeine. This included two Australian, two New Zealand, and four international studies. The studies varied significantly in the products examined, the consumption timeframe, sample size and characteristics, and the age of the data.

*Australian and New Zealand Studies*

Four studies were from Australia and New Zealand. As displayed in Table 9, a significant proportion of women consume caffeine during pregnancy. While the consumption timeframe measured differed across each study, proportions ranged from slightly less than 50% for daily consumption of a single beverage type, to 82.6% for any caffeine consumption across seven days. All four studies only considered caffeinated beverages, so do not provide insight into caffeine consumption across the total diet.

Rates of caffeine consumption appear to change across pregnancy. Peacock et al. (2018) found that the proportion of women reporting caffeine consumption declined once pregnancy had been recognised in trimester one, but rose again in trimester two and three.

Only one study (Brown et al., 2020) reported on caffeine consumption during lactation, with results indicating that consumption of caffeinated beverages like tea and coffee remain at similar levels to that consumed during pregnancy. However, the sample was not representative of the New Zealand population, including predominantly women of European descent, highly educated, food secure, and of good health status.

One study (Lain et al., 2010) found that fewer Australian women who were pregnant for the first time consumed caffeinated drinks, compared to those who had had prior pregnancies (76.9% vs 88.6%). No other studies reported on the sociodemographic factors associated with caffeine use.

*Table 9: Australian and New Zealand studies reporting on the proportion of pregnant or lactating women who use caffeinated food products*

| Study and Sample | Sample Size | Product | Timeframe | % Consumed |
|---|---|---|---|---|
| Brown et al. (2020) New Zealand | 458 | Coffee or tea | Pregnancy – Daily | Tea: 48% Coffee: 42% |
| | | | Lactation – Daily | Tea: 47% Coffee: 50% |
| Lain et al. (2010) Australia | 576 | Coffee, tea or cola | Any 7 day period during pregnancy post 20 weeks | 82.6% |
| Morton et al. (2010) New Zealand | 6,882 | Coffee, tea, energy drinks | During pregnancy | 62.1%* |
| Peacock et al. (2018) Australia | 1,232 | Caffeinated beverages | Trimester 1: Pre-pregnancy awareness | 89% |
| | | | Trimester 1: Post pregnancy awareness | 68% |
| | | | Trimester 2 | 79% |
| | | | Trimester 3 | 80% |

*Morton et al (2010) proportion consuming caffeine is calculated from the total sample, minus the number reporting they avoided caffeinated beverages during pregnancy (37.9%).

*International Studies*

Four international studies reported on the proportion of pregnant women who consume caffeine (see Table 10). These studies considered populations from the United States, Norway, Spain and Italy. Despite variations in study design, as in the Australian and New Zealand literature, caffeine was consistently consumed by a majority of pregnant women.

No international studies were found that reported the proportion of lactating women who consume caffeine.

*Table 10: International studies reporting on the proportion of pregnant or lactating women who use caffeinated food products*

| Study and Sample | Sample Size | Product | Timeframe (Gestation) | % Consumed |
|---|---|---|---|---|
| Castillo et al. (2016)<br>Spain | 1,175 | Coffee, cola, chocolate and chocolate biscuits | First half of gestation | 95.3% |
| Hinkle et al. (2021)<br>United States | 2,583 | Coffee, tea, soda, energy drinks | Week 10-13<br>In the past week | Any caffeinated beverage: 58.5% |
| | | | | Soft drinks: 32.2% |
| | | | | Coffee: 23.7% |
| | | | | Tea: 18.8% |
| | | | | Energy drinks: 0.3% |
| | | | Week 16-22 | Any caffeinated beverage: 76.4% |
| | | | Week 24-29 | Any caffeinated beverage: 71.9% |
| | | | Week 30-33 | Any caffeinated beverage: 69.8% |
| | | | Week 34-37 | Any caffeinated beverage: 69.6% |
| Sengpiel et al. (2013) | 59,123 | Caffeinated foods and beverages, caffeine supplements | Week 15-17 | 87.5% |
| | | | Week 22 | 76.3% |

| Study and Sample | Sample Size | Product | Timeframe (Gestation) | % Consumed |
|---|---|---|---|---|
| Norway | | | Week 30 | 83.4% |
| Stefanidou et al. (2011)<br>Italy | 312 | Coffee, tea, cola, chocolate | From 4 weeks before last menstrual period to the week before delivery. | Caffeine: 100% |
| | | | | Coffee: 87.8% |
| | | | | Tea: 69.9% |
| | | | | Chocolate: 49.4% |
| | | | | Cola: 27.6% |

Two studies reported the prevalence of caffeine consumption across different time periods throughout pregnancy. Hinkle et al. (2021) found that the prevalence of caffeine consumption in a United States sample increased between 10-13 weeks gestation and 16-22 weeks, from 58.5% to 76.4%. This aligns with the findings of the Australian study by Peacock et al. (2018). However, Sengpiel et al. (2013) found that the proportion of Norwegian women consuming caffeine followed a U shape across three time points during pregnancy. The differing results may have been influenced by the different scope of products covered, cultural differences or the age of the data (Sengpiel 1999-2009; Hinkle 2009-2013). The timing of pregnancy recognition was not captured by either study, so the potential effect cannot be analysed. Further analysis on changes in consumption patterns before and during pregnancy is covered in Research Question 2 and Research Question 4.

Two studies reported on the proportion of women consuming certain caffeinated products. In Italy, coffee and tea were most commonly consumed (Sengpiel et al., 2013), while in the United Sates, soft drinks were more common, followed by coffee (Hinkle et al., 2021).

*Summary*

Overall, across both Australian/New Zealand and international literature, a significant proportion of women (42% to 95.3%) were found to consume caffeine during pregnancy. This range is likely driven by differences in the types of products examined, the consumption timeframe, the study country, and/or the age of the data.

The prevalence of consumption appears to differ over the course of pregnancy. While the exact pattern of consumption differs across studies, the proportion of women consuming caffeine typically reduces in early pregnancy, before rising again as pregnancy progresses.

Two studies reported on the proportion of women consuming certain caffeinated products. In Italy, coffee and tea were most commonly consumed (Sengpiel et al., 2013), while in the United Sates, soft drinks were more common, followed by coffee (Hinkle et al., 2021).

Only one study considered the sociodemographic factors associated with consumption in general, finding that first time mothers were less likely to consume caffeine than those experiencing their second or subsequent pregnancy.  Given the high proportion of women consuming caffeine during pregnancy, more analysis focused on the factors associated with higher caffeine consumption, which is explored in Research Question 2.

## Broader Populations

*Proportion consuming caffeine*

Four studies reported on the proportion of individuals consuming caffeinated food products in the broader population, two from Australia and two from New Zealand. One New Zealand sample only included university students.

As shown in Table 11, while all four studies examined use of energy drinks, they measured use across different timeframes. The prevalence of energy drink use ranged from 13.4% (Pennay et al., 2015) to 80% (Peacock et al., 2016). It is unclear whether differences in proportions of use reflect the difference in timeframes used, or a combination of both the differences in timeframes and participant characteristics of the samples.

Two of the studies examined consumption of a broader range of caffeinated food products, not just energy drinks (Booth et al., 2020; Stachyshyn, 2017). These two studies used comparable timeframes (current use), but different samples (New Zealand general population vs. university students). Nevertheless, both studies found that 99.1% of their samples generally consume at least one caffeinated food product.

As shown in Table 11, the proportion of individuals consuming coffee was similar between the two studies (72% vs. 76.3%), however, there were some differences for other caffeinated food types. That is, cola drinks (81% vs. 49.2%), energy drinks (67.9% vs. 40.4%), and caffeinated RTDs (51.2% vs. 18.2%) were consumed by a higher proportion of individuals in the general population sample (Booth et al., 2020) than in the university sample (Stachyshyn, 2017). Conversely, tea was consumed by a higher proportion of individuals in the university sample (71.6% vs. 52.5%). However, it should be noted that Booth et al. (2020) used a non-representative sample of the general population (e.g., females were overrepresented), therefore the differences in findings may not necessarily be driven by whether consumers are university students.

Chocolate was also commonly consumed by university students (81.7%), however, chocolate was not directly examined in the study that sampled the general population. A small proportion of university students also reported consuming sports supplements (6.6%) and caffeine tablets (3.5%), however, these products were also not directly examined in the general population sample. Although participants in the general population study had the option to specify some ‘other’ food product that was not provided in the list of options, products that were not specifically prompted by the researchers may not have as readily come to mind. The researchers in this study reported caffeine pills and sports supplements as examples from the ‘other’ category (selected by 19.5% of participants), however it is unknown what other products may be included in this category.

*Table 11: Percentage of individuals reporting use of particular types of caffeinated products*

| Study and sample | Sample size | Time-frame | Energy drinks | Coffee | Tea | Choco-late | Cola | RTDs | Other |
|---|---|---|---|---|---|---|---|---|---|
| **Peacock et al. (2016)** Australian general population (median age = 24 years, 42% female) | 2953 | In lifetime and past year | 80% had consumed an energy drink in their lifetime; 59% in the past year | - | - | - | - | - | - |
| **Pennay et al. (2015)** Australian general population (Mean age = 48.9 years, 56% female) | 2000 | Past 3 months | 13.4% | - | - | - | - | - | - |
| **Booth et al. (2020)** NZ general population (median age = 21 years, 65% female) | 2379 | Current | 67.9% | 72% | 52.5% | - | 81% | 51.2% | 19.5% (“e.g., sports supplements and caffeine pills”) |
| **Stachyshyn (2017)** NZ university students (74.4% aged 19-30 years, 53% female) | 317 | Current | 40.4% | 76.3% | 71.6% | 81.7% | 49.2% | 18.3% | 6.6% Sports supplements; 3.5% caffeine tablets |

*Sociodemographic characteristics associated with caffeine consumption*

Only two of the four studies reported on sociodemographic factors associated with caffeine consumption (Pennay et al., 2015; Stachyshyn, 2017). Pennay et al. (2015) found that males were significantly more likely to be energy drink users than females (17.75% vs. 6.02%, p<0.001). Pennay et al. also found that younger participants (those aged 18-49 years, 29.95%; 25-39 years, 21.20%; 40-49 years, 10.95%) were significantly more likely to be energy drink users than older participants (those aged 50+ years; 2.88%).

In Stachyshyn (2017), female university students were significantly more likely than male university students to consume tea (79.9% vs. 62.2%, p < 0.001), coffee (81.1% vs. 76.3%, p = 0.034) and chocolate (87.6% vs. 75.0%, p = 0.004). Age was not significantly associated with consumption of any caffeinated food product or beverage in university students. Employed university students (part-time or full-time) were significantly more likely to consume energy drinks (50.0% vs. 35.5%, p = 0.013) and caffeine tablets (8.5% vs. 0.9%, p < 0.001) than those who were unemployed. Unemployed students were more likely to consume tea than employed students (75.4% vs. 64.2%, p = 0.037).

*Summary*

The vast majority of people from broader populations (adults from the Australian and New Zealand general population, university students) consume caffeinated food and beverages. In a sample of university students, the most prevalent type of caffeinated product consumed was chocolate, followed by coffee, tea, cola and energy drinks. Conversely, in a sample of the general population, the most prevalent type of caffeinated product consumed was cola, followed by coffee, energy drinks, tea and RTDs. However, it is important to note that chocolate consumption was not examined in the study that examined the general population, and so this study is not directly comparable to the study that examined university students.

Few studies examined sociodemographic factors associated with use of caffeine. One study found that males and younger people (those aged 18-49) are more likely to report energy drink consumption than older people (those aged 50+). Furthermore, a second study found that female university students are more likely to consume tea, coffee and chocolate than male university students. Employed university students are more likely to consume energy drinks and caffeine tablets than those who are unemployed, whereas unemployed university students are more likely to consume tea.

## Research Question 2: How do consumers use caffeinated food products?

This section seeks to examine how consumers use caffeinated food products. Specifically, are they being consumed at the recommended levels and in the recommended way? What products are contributing to people's overall caffeine intake, and in what proportions? And what are the sociodemographic factors associated with higher caffeine consumption?

The studies included in this section used quantitative surveys. For the studies that reported overall caffeine intake, the authors generally calculated this by combining frequency of consumption information with caffeine content information for all consumed products. The reference caffeine content information differed across studies, which typically developed reference values to reflect caffeine content in their specific markets.

The recommended caffeine intake levels used to assess whether caffeinated food products are being consumed at the maximum recommended levels follows that described in SD1 – Safety Assessment, with mg/day calculated using the current Australian National Health and

Medical Research Council's reference ranges for bodyweight (2017). This results in the following recommended levels:

- 400 mg/day for the adult population, excluding pregnant and lactating women, including athletes/military personnel (5.7 mg/kg bw/day based on a 70 kg bodyweight);
- 3 mg/kg bw/day for children:
    - 39 mg/day for children aged 1-3 (based on 13 kg bodyweight);
    - 66 mg/day for children aged 4-8 (based on 22 kg bodyweight); and
    - 120 mg for children aged 9-13 (based on 40 kg bodyweight);
- 5.7 mg/kg bw/day for adolescents; and
- 200 mg/day for pregnant and/or lactating women.

## Overarching Findings

*Are caffeinated food products being consumed at the recommended levels?*

The majority of the general population and each examined subpopulation appear to be consuming caffeine within the recommended daily limits.

There is little evidence that children and adolescents are exceeding the recommended daily limit of caffeine on a regular basis. One international study found that a very small proportion of children (less than 0.6%) exceed the recommended daily limit of caffeine by consuming cola and energy drinks. One South Australian study found that at least some 8-12 year olds exceed the recommended daily limit, however the exact proportion was not reported. There was no available evidence on caffeine consumption in children based on New Zealand studies. One Australian study found that a subset of adolescents (less than 3.4%) exceed the recommended daily limit of caffeine in an average session of energy drink consumption. As 'session' was undefined in this study, it is unclear whether any consumers had multiple sessions per day, and this could therefore be an under-estimate.

There is evidence that a subset of pregnant women and consumers from the general population are exceeding the recommended daily limits of caffeine on a regular basis:

- Eight studies in comparable populations to Australia/New Zealand found that the proportion of pregnant women who exceed the recommended daily intake of caffeine of 200 mg/day ranged from 0.8% to 15.6%.
- Two studies found that 14% and 17% of the broader population may be regularly exceeding the recommended daily limit of 400 mg/day of caffeine. One study found that this percentage may be even higher in those who do shift work (up to 33%). One study found that coffee consumers were 16.29 times more likely to exceed the safe limit than those who do not consume coffee (18.6% vs. 1.3%; $p<0.001$).

No information was available regarding the amount of caffeine being consumed by athletes, and it is therefore unknown whether they are exceeding the recommended daily limit. However, five studies reported that athletes/military personnel consume multiple sports foods products, although it is unclear whether these are consumed within the same day (i.e. stacking behaviour). In addition, one qualitative study found that consumers from the general population use multiple types of sports food products within the same day. Although it is unclear whether these studies examined consumption of *caffeinated* sports foods in particular, they still provide insight into how consumers use sports foods more broadly. This is of relevance should caffeinated sports foods become more prominent in the market.

*What are the top sources of caffeine intake?*

The top contributors to caffeine intake differ according to the subpopulations examined. However, with the exception of children, coffee was consistently one of the major contributors to overall caffeine intake. As noted above, and in line with this finding, two studies (one in adolescents and one in university students) found that coffee consumers were significantly more likely to exceed the safe limit of caffeine than those who do not consume coffee.

For children and adolescents, soft drinks, tea, coffee and/or chocolate contributed the highest proportion of caffeine to their overall intake. However, one study found that a subset of adolescents (less than 3.4%) report exceeding the daily safe limit of caffeine in an average 'session' of energy drink consumption. As the frequency of these sessions was not reported, it is unclear whether adolescents are exceeding the recommended limits on a regular basis.

For pregnant women, tea and coffee were consistently the top two sources of caffeine, although the order differed between studies, with the exception of Spain, where coffee and soft drinks were the top two contributors (in order).

In the broader population, coffee was consistently the highest contributor to caffeine intake. The proportions contributed by other products varied between the two studies, with energy drinks, caffeinated 'ready to drink' alcoholic beverages, and tea the other major contributors. One study found that some consumers (exact proportion unquantifiable) reported exceeding the recommended daily limit solely by consuming medications and sports supplements combined. Additionally, some consumers (exact proportion unquantifiable) reported either reaching or exceeding the recommended daily limit of caffeine by consuming energy drinks alone.

*What are the sociodemographic characteristics associated with higher caffeine consumption?*

Increased age was consistently associated with increased caffeine consumption in children and adolescents. One study found that daily caffeine consumption was also significantly higher in older than younger university students (31-50 years vs. 16-18 years).

There were inconsistent findings about the influence that sex has on caffeine consumption. Three studies found that males had higher caffeine consumption among children, however, two other studies did not find a significant association. There were no significant associations between sex and caffeine intake among adolescents, and one study in the broader population found that daily caffeine consumption was significantly higher in female than male university students. It is likely, however, that sex has an impact on the proportion of caffeine obtained from different sources among adolescents, with females having higher intake from tea and males having higher intakes from soft drinks and energy drinks.

Among children, there was some evidence that socioeconomic status may influence total caffeine consumption, with higher socioeconomic status correlated with lower total caffeine consumption.

Among pregnant women, the sociodemographic factors associated with caffeine intake were mixed. Some studies found that those who had higher caffeine intake were significantly more likely to have had a previous pregnancy, to be older, and to also smoke tobacco or consume alcohol, whereas other studies found that these factors were not significantly associated with caffeine intake.

One study found that cigarette smoking was also associated with increased likelihood of exceeding the safe daily caffeine limit among the broader population.

A more detailed description of the findings is provided below, grouped by the type of subpopulation.

## Children

Eleven studies reported data for children's average caffeine intake and/or children's caffeinated food sources. Two were from Australia, three from Europe, and six from the United States of America. No New Zealand studies were found. Nine studies examined caffeine intake from all food sources, one study examined caffeine intake specifically from soft drinks and energy drinks, and two studies examined caffeine intake only from energy drinks.

*Australian and New Zealand Studies*

Two Australian studies looked at children's average caffeine intake, and the proportion of different foods that contributed. Both available studies suggest that Australian children's average caffeine intake is well under the recommended daily limits of 3 mg per kilogram of bodyweight (for children aged 9-13 years, this is about 120 mg/day), as summarised in the table below. However, standard deviation was high in Watson et al.'s study (SD 17.4), with reported intake ranging from 0 to 150 mg/day. This latter figure is over the recommended daily maximum of 120 mg/day for 9-13 year olds, suggesting that at least some 8-12 year old South Australians were consuming caffeine over the recommended daily maximum. It is also important to note that participants in Beckford et al. (2015) were required to report consumption over a 24-hour period, which may not be reflective of *usual* intake.

*Table 12: Comparison of Australian studies reporting mean caffeine intake (mg/day)*

| Study | Sample | Sample Size | Mean Caffeine Intake (mg/day ± standard deviation) | Mean Caffeine Intake (mg/day ± SD) –Consumers |
|---|---|---|---|---|
| Beckford et al. (2015) | 2-3 year old Australians | 1,071 | 3 mg (95% CI: 2.9-3.8mg) | Not reported |
| | 4-8 year old Australians | 1,216 | 8 mg (95% CI: 7.2-9.0mg) | Not reported |
| | 9-13 year old Australians | 1,110 | 19 mg (95% CI: 17.1-21.4mg) | Not reported |
| Watson et al. (2017) | 8-12 year old South Australians | 309 | 10.2 mg ± 17.4 (Range: 0-150 mg) | Mean: 11.8 mg ± 18.1 (Range not reported) |

Beckford et al. (2015) found that the majority of caffeine for the entire sample population (aged 2-16 years) was consumed through beverages (81%), and the remainder (19%) from food sources. The highest proportion of caffeine intake came from soft drinks and flavoured mineral waters (31%), followed by coffee and coffee substitutes (21%), tea (17%), milk beverages (5%), other beverages (4%), and energy, electrolyte and fortified beverages (3%).

19% came from other caffeine sources, such as chocolate and baked products containing chocolate or cocoa powder.

Beckford et al. considered the proportion of caffeine intake contributed by caffeinated soft drinks and energy drinks according to age group. Caffeinated soft drinks and energy drinks contributed 17% of caffeine intake in children aged 2-3 years, 28% in children aged 4-8 years, and 38% in children aged 9-13 years. The majority of this was consumed in the form of caffeinated soft drinks (75-80% among all age groups).

Watson et al. (2017) found that the largest contributor to caffeine consumption among 8-12 year olds was coffee and tea (41% of total caffeine intake), followed by soft drinks (40%). Although foods and drinks containing chocolate were consumed by 79% of the sample, they only contributed 6% to the overall caffeine intake. Energy drinks contributed 13% to overall caffeine intake.

Table 13 on the following page shows the top three contributors to caffeine for the two studies, as well as the contribution that energy drinks made towards the total caffeine intake for the sample. As shown in Table 13, soft drinks, coffee and/or tea, and food sources (such as chocolate and cocoa-containing products) were the key contributors to caffeine intake for both studies, although the proportions by which they contributed to caffeine intake differed. There was also a notable difference in the proportion of caffeine intake that was contributed by energy drinks across the two studies (3 vs 13%). This may reflect in part the different age ranges of the two studies – Beckford et al. (2015) studied children from 2-16 years of age, whereas Watson et al. (2017) studied children in a tighter age range of 8-12 years old.

Beckford et al. (2015) found that males had significantly higher intakes of caffeinated soft drinks and energy drinks than females across the whole sample population (2-16 years), while Watson et al. (2017) found that there were no significant differences in caffeine consumption between males and females among 8-12 year olds. The difference in these findings could be due to the different age ranges (2-16 years vs 8-12 years), and/or the different products examined (caffeinated soft drinks and energy drinks vs caffeine from all food/beverage sources).

Watson et al. (2017) found that there were significant associations between level of caffeine consumption and age, and socioeconomic status. Increased age was correlated with increased total caffeine consumption ($p=0.004$), while higher SES was correlated with decreased total caffeine consumption ($p=0.004$).

*Table 13: Comparison of Australian studies analysing food/beverage contributions to caffeine intake*

| Study | Sample | Size | Products | Top Sources of Caffeine (Percentage/Amount Contributed to Daily Caffeine Intake) | | | Energy Drinks |
|---|---|---|---|---|---|---|---|
| | | | | #1 | #2 | #3 | |
| Beckford et al. (2015) | 2-16 year old Australians | 4,487 | Caffeinated soft drinks and energy drinks | Soft drinks and flavoured waters (31%) | Coffee/coffee substitutes (21%) | Food sources (19%) | 3% |
| Watson et al. (2017) | 8-12 year old South Australians | 309 | Caffeine-containing food and beverages | Coffee and tea (41%) | Soft drinks (40%) | Food sources (13%) | 13% |

*European Studies*

Three European studies looked at children's caffeine intake. Very little information was available on caffeine sources.

Children's Caffeine Intake

Three studies looked at children's average caffeine intake. As they did not use comparable populations or units of analysis, and are thus described narratively.

In Wierzejska et al.'s (2016) study of cola and energy drink consumption among 329 primary school children aged 11-13 years in Poland, caffeine intake from both cola and energy drinks ranged from 0 to 224 mg/day. The upper limit of this range is above the recommended daily limit of 120 mg for children aged 9-13 years. The median of daily caffeine intake for the entire study group was 4.0 mg/day. When limited only to consumers of cola and energy drinks it was slightly higher at 5.71 mg/day. Median intake in terms of kilogram of bodyweight (kg bw) was 0.09 mg/kg bw/day across the entire study population and 0.12 mg/kg bw/day among consumers, measured according to participants' body weight. This accounts for 3% and 4% of the recommended maximum daily caffeine intake, respectively. The authors reported that a very small proportion (0.6%) of children had a caffeine intake that exceeded 2.5 mg/kg bw/day. This indicates that less than 0.6% of children in this study exceeded the safe daily limit of caffeine of 3.0 mg/kg bw/day.

In Galimov et al.'s (2019) study of energy drink consumption among 9-19 year olds in Germany, among past 30-day users, 12.10% drank less than one can in a typical day, 61.66% drank 1 can, 23.17% drank 2-3 cans, and 3.07% drank 4 cans or more.

In Martins et al.'s (2018) cross-sectional study of energy drink consumption among students aged between 11-17 years old (n=1,404) in northern Portugal, 87.5% of users across the entire sample reported consuming only one unit of energy drinks in a single day (87.5%), and 5.4% of students consumed three or more units.

Based on an average caffeine content of 80mg per 250mL can (as reported by the Australian Food Composition Database (2022)), consuming two cans or more of energy drinks in a day would cause children aged 9-13 years to exceed the recommended daily limit of 120 mg. However, given the wide age range in both of these studies, it is not possible to ascertain if any children aged 13 years or less were exceeding the maximum daily recommended limit.

Sources of Caffeine

Very little information was found in the European studies on the sources of food that contribute to caffeine intake, due to the studies' focus on cola and/or energy drinks. Martins et al.'s (2018) study of students aged between 11-17 years old, found that coffee consumption was reported in 46.6% of energy drink users, with 12.5% consuming more than one cup per day.

*United States Studies*

Children's Average Caffeine Intake

All studies that analysed children's caffeine intake using NHANES data found that mean and median caffeine intake among children was well below the recommended daily maximum of caffeine intake for children in Australia, as summarised in the table below. Ahluwalia et al. (2014) and Caceres (2014) also provided an analysis based on kilograms of bodyweight (kg bw) per day. These were also well below the Australian recommended daily maximum of 3 mg/kg bw/day.  However, it is important to note that NHANES data is based on report of caffeine intake in a 24-hour recall period, which may not be reflective of *usual* intake.

*Table 14: Comparison of studies using data from the NHANES in the United States*

| Age Group | Study | NHANES Cycle | Sample Size | Caffeine Intake in 24 hour recall period (mg/day) |
|---|---|---|---|---|
| 2-5 years | Ahluwalia et al. (2014) | NHANES 2009-10 | 861 | 4.7 mg (median)<br>($75^{th}$ percentile: 10.3 mg)*<br>Or 0.11 mg/kg bw/day<br>($75^{th}$ percentile: 0.36mg)* |
| | Branum et al. (2014) | NHANES 2009-10 | Not reported | 15.9 mg ± 1.2 (mean) |
| | Caceres (2014) | NHANES 2009-10 | 410 | 9.8 mg (mean)<br>Or 0.558 mg/kg bw/day |
| 6-11 years | Ahluwalia et al. (2014) | NHANES 2009-10 | 1,154 | 9.1 mg (median)<br>($75^{th}$ percentile: 31.4mg)<br>Or 0.15 mg/kg bw/day<br>($75^{th}$ percentile: 0.62 mg) |
| | Branum et al. (2014) | NHANES 2009-10 | Not reported | 31.8 mg ± 1.6 (mean) |
| | Caceres (2014) | NHANES 2009-10 | 779 | 23.0 mg (mean)<br>Or 0.704 mg/kg bw/day |
| 4-8 years | Drewnowski and Rehm (2016) | NHANES 2011-12 | Not reported | 15 mg (mean) |
| 9-13 years | | | Not reported | 26 mg (mean) |

* The study authors did not report the $25^{th}$ percentile, which makes up the first number in the IQR, although for mg/kg bw/day, they noted that it was "essentially zero".

Three other studies also explored average daily consumption of caffeine among children.  In Warzak et al.'s (2012) survey of parents of 201 children aged 5-12 years in the United States, children aged 5-7 years consumed approximately 52 mg of caffeine per day, and children aged 8-12 years consumed approximately 109 mg, on the basis of parental report. These values are just below Australia's recommended maximum daily caffeine intake for children aged 4-8 years (66 mg/day) and 9-13 years (120 mg/day).

Lisdahl et al.'s (2021) analysis of the Adolescent Brain Cognitive Development (ABCD) study of children aged 9-10 years in the United States of America (n=11,857), found that participants on average consumed around two standard doses of caffeine per week.  A small minority (7.4%) reported consuming one standard dose of caffeine per day on average.  A standard dose of caffeine was defined as one 8oz (237 mL) cup of coffee or tea (48-62.4 mg caffeine), 1 shot of espresso (63.6 mg caffeine), 12oz (355mL) of soft drink (cola: 33.5 mg), or 8oz (237ml) of energy drink (71.9 mg).[4] Given that all of these values are below the Australian recommended daily maximum of 120 mg caffeine for children aged 9-13 years (based on 40 kg bodyweight), this suggests that the vast majority of children are consuming caffeine within the recommended daily limits.

Sources of Caffeine

Four studies examined the proportion of the caffeine intake contributed by different food/beverage sources. Table 16 below summarises the top three contributors to caffeine intake among American children, either as a percentage of caffeine intake or in terms of the number of 'doses' that source provides. Tea and soft drinks account for the first and second contributors (in varying order) across every study.[5] Third contributors varied across studies, and were flavoured dairy (i.e. chocolate milk), food (e.g. chocolate/cocoa-containing products) and coffee. Energy drinks contributed very little or not at all to caffeine intake across all of these studies.

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[4] Caffeine amounts were not provided in the original study, and were determined using the reference values from the Survey Foods in the US FoodData Central nutrient database.

[5] It is important to note that "tea" in these American studies includes both hot tea as traditionally consumed in Australia and New Zealand, and sweetened iced tea (which we would classify as a sugar sweetened beverage).

*Table 15: Comparison of American studies analysing food/beverage contributions to caffeine intake*

| Study | Sample | Sample Size | Products | Top Sources of Caffeine (Percentage/Amount Contributed to Daily Caffeine Intake) | | | Energy Drinks |
|---|---|---|---|---|---|---|---|
| | | | | #1 | #2 | #3 | |
| Branum et al. (2014) | 2-5 years | Not reported | All foods and beverages | Tea* (29.4% ± 5.0) | Soft drink (26.8% ± 3.7) | Flavoured dairy (17.0% ± 2.3) | 0.0% |
| | 6-11 years | Not reported | | Soft drink (39.1% ± 3.8) | Tea* (29.7% ± 5.9) | Flavoured dairy (9.6% ± 0.9) | 0.0% |
| Caceres (2014) | 2-5 years | 410 | All foods and beverages | Soft drinks (27.8%) | Tea* (27.6%) | Flavoured dairy (17.5%) | 0.0% |
| | 6-11 years | 779 | | Soft drinks (39.1%) | Tea* (29.8%) | Flavoured dairy (9.6%) | 0.0% |
| Drewnowski and Rehm (2016) | 4-8 years | Not reported | All foods and beverages | Tea* (36%) | Soft drinks (33%) | Food (15%) | 0.0% |
| | 9-13 years | Not reported | | Soft drinks (41%) | Tea* (32%) | Food (11%) | 4% |
| Lisdahl et al. (2021) | 9-10 years | 11,857 | Caffeinated beverages | Soft drinks (1.18 doses; SD 4.56) | Tea* (0.56 doses; SD 2.81) | Coffee (0.15 doses; SD 1.56) | Least (0.02 doses; SD 0.36) |

* “Tea” in the United States’ context includes both hot tea as traditionally consumed in Australia and New Zealand, and sweetened iced tea (which we would classify as a sugar sweetened beverage).

Sociodemographic Characteristics Associated with Caffeine Intake

Of the above studies, five considered sociodemographic factors associated with caffeine consumption. These concerned sex, age, ethnicity, and parental education levels.

Branum et al. (2014) and Lisdahl et al. (2021) found that males had a significantly higher consumption of caffeine than females ($p \leq 0.001$). However, Ahluwalia et al. (2014) found no significant association between sex and caffeine intake.

Ahluwalia et al. (2014) and Branum et al. (2014) found that there was a statistically significant linear trend between age and caffeine consumption, with more caffeine being consumed by older children ($p \leq 0.001$). Lisdahl et al. (2021) similarly found that being older (10 year olds vs 9 year olds) was significantly associated with greater total average caffeine dosage per week ($p=0.03$).

Ahluwalia et al. (2014), Branum et al. (2014) and Drewnowski and Rehm (2016) found that non-Hispanic Black children consumed the least amount of caffeine across the whole sample of children. Branum et al. (2014) found that caffeine consumption was highest in non-Hispanic White children, compared to both non-Hispanic Black or Mexican American children ($p < 0.001$). This aligns with the finding from Warzak et al.'s (2012) survey of children aged 5-12 years, in which children from Spanish-speaking families were found to drink less caffeine than their English-speaking peers, although this finding was not statistically significant. However, this is in contrast to Ahluwalia et al. (2014), which found that there were no significant differences in consumption between non-Hispanic White and Mexican-American children, and Lisdahl et al. (2021), which found that, after statistically controlling for other demographic variables, Hispanic youth had significantly greater total average caffeine dosage per week compared to Caucasian youth ($p=0.03$). The difference in these findings could be due to a range of different factors, including: the different age ranges considered (2-9 years vs 5-12 years vs 9-10 years), and/or the different time periods in which data was collected (2009-10 vs 2016-18).

Lisdahl et al. (2021) also found that coming from families with lower parental education was significantly associated with greater total average caffeine dosage per week ($p < 0.001$).

*Summary*

All but one study that examined caffeine intake in children reported levels of caffeine intake that are within, and often well under, the daily recommended limit for children in Australia. These studies used robust sample populations and most examined caffeine intake from all food/beverage sources. Although one internationally-based study found that some children may be exceeding the daily recommended limit of caffeine by consuming cola and energy drinks, this was only the case for a very small proportion (less than 0.6% of children).

There were consistent findings regarding the top sources of caffeine. Soft drinks and tea/coffee were the top two sources of caffeine across both Australia and the United States, although the order in which these two sources contributed varied between studies. Across all studies, soft drinks contributed from 26.8% to 41% of children's total caffeine intake, and tea and/or coffee contributed from 21% to 41%. Energy drinks consistently contributed the least amount to children's caffeine intake, ranging from 0.0% to 13%, with the highest figure reported in an Australian study of 8-12 year olds.

Increased age was consistently associated with increased caffeine consumption, however there was inconsistent findings related to the influence of sex on caffeine consumption. Three studies (Beckford et al., 2015; Branum et al., 2014; and Lisdahl et al. 2021) found that males had significantly higher consumption of caffeine than females, while two studies

(Watson et al., 2017 and Ahluwalia et al., 2014) found that there were no significant differences. Beckford et al., Branum et al, and Lisdahl et al. all used large, nationally representative data sources, which gives greater confidence in their finding of a significant association in comparison to the smaller and non-representative sample in Watson et al. However, the reason for Ahluwalia et al.'s divergent finding is unclear, as they used the same dataset (the US NHANES 2009-10) as Branum et al. There was some evidence that socioeconomic status, or its components, may influence total caffeine consumption. Watson et al. (2017) found that higher SES was correlated with decreased total caffeine consumption, while Lisdahl et al. (2021) found that lower parental education was significantly associated with children's greater total average caffeine dosage per week.

## Adolescents

Five studies reported consumption data for adolescents' use of caffeinated food products; four in Australia, and one in New Zealand. Three studies looked at all caffeinated food and/or beverages, and two studies looked specifically at energy drinks.

*Average Caffeine Intake*

Three studies, two of which looked at all caffeinated food and beverages, found that overall caffeine consumption is well below the recommended adolescent limit of 400 mg/day (see Table 17).

*Table 16: Studies that reported average caffeine intake as mg/day.*

| Study | Sample (Mean age ± SD) | Sample Size | Products | Caffeine Intake (mg/day) | Caffeine Intake (mg/day) - Consumers |
|---|---|---|---|---|---|
| Beamish et al. (2016) | 13-18 year olds in Christian schools across Australia | 949 (51.8% female) | Caffeinated beverages | 36.6 mg/day (mean) | 67.6 mg/day (mean) |
| Beckford et al. (2015) | 14-16 year olds across Australia | 942 | Caffeinated food and beverages | 42 mg/day (mean) (range: 37.3-46.1 mg) | Not reported |
| Turner (2019) | 15-18 year olds (16.6 ± 0.82) in New Zealand | 216 (65% female) | Caffeinated food and beverages | Not reported | 68.3 mg (median) (IQR: 24.9-158.9 mg) |

Two studies examined the number of energy drinks adolescents consumed; one looked at the number of 250mL cans consumed in an average session, and the other the maximum number of cans (not defined) consumed in a single day (Table 18). Costa et al. (2016) found that consumers of energy drinks usually drink 2 energy drinks (defined in this study as a 250 mL can) or less per session. Similarly, Trapp et al. (2020) found that most adolescents who had ever consumed energy drinks had consumed a maximum of 2 cans in one day. The Australian Food Composition Database (2022) lists a value of 80-85 mg per 250 mL can of energy drink, suggesting a total caffeine content of up to 170 mg per session for these consumers, which is within the recommended daily limit. However, the range given by Costa et al. (2016) for average cans per session is quite large (0-7 cans), suggesting that a subset of adolescent energy drink consumers (less than 3.4%) are exceeding the daily recommended limit of caffeine solely from the number of energy drinks consumed in an average session. It is important to note that 'session' was not defined in this study ,and it is unclear whether consumers had more than one session of energy drink consumption per day. The percentage of the sample exceeding the daily recommended limit of caffeine solely by consuming energy drinks could therefore be higher than 3.4%, but this information was not reported in this study.

*Table 17: Studies that reported on energy drink consumption.*

| Study | Sample (Mean age ± SD) | Sample Size | Usual or Maximum Energy Drink Intake | Percentage of Sample |
|---|---|---|---|---|
| Costa et al. (2016) | 12-18 year olds (14 ± 1.28) in regional Victoria | 399 (36% female) | Non-consumers | 47.8% |
| | | | 1-2 cans per average session (250 mL cans) | 48.8% |
| | | | ≥ 3 cans consumed per average session (250 mL cans) | 3.4% |
| | | | 1.43 ± 0.92 cans consumed per average session (range: 0-7 cans) | Average across consumers |
| Trapp et al. (2020) | 12-18 year olds who had “ever consumed” energy drinks in Western Australia | 1,889 (overall sample 55.1% female) | “Don’t know” or missing | 24.1% |
| | | | 1-2 cans maximum in one day | 58.2% |
| | | | 3-4 cans maximum in one day | 11.5% |
| | | | 5 or more cans maximum in one day | 6.2% |

This is supported by Trapp et al.’s (2020) study of 12-18 year olds in Western Australia. Of the 1,889 respondents who had ‘ever consumed’ energy drinks (that is, they responded affirmatively to the question “Have you ever tried an energy drink, even a few sips?”), 6.2% reported consuming five or more energy drinks in a single day. Based on the Australian Food Composition Database, five 250 mL cans of energy drink contain the daily recommended limit of 400 mg of caffeine, suggesting that 6.2% of respondents reached or exceeded the safe daily recommended limit of caffeine solely by consuming energy drinks. However, it is important to note that Trapp et al. (2020) did not define energy drinks using a millimetre amount in their study, and one quarter of their respondents who had ever consumed energy drinks reported that they had, at some point, consumed a 710 mL can. This suggests that this figure could be an underestimate. However, it is also important to note that Trapp et al.’s (2020) finding does not reflect consumption on an average day. Rather, participants in this study were asked about the most they have *ever* consumed in one day. Therefore it is unclear whether 6.2% (or more) of adolescents are exceeding or reaching the safe daily limit via energy drink consumption *on a regular basis.*

*Sources of Caffeine*

Three studies reported on the food sources that contributed to caffeine intake. Table 20 outlines the top three contributors to average caffeine intake by the proportion of caffeine they contributed, as well as the proportion contributed by energy drinks.

The top sources of caffeine for adolescents were generally soft drinks, coffee and/or tea, and food sources. However, the products examined and the order in which these sources contributed to overall caffeine intake differed between studies. This variance could be a result of different food products, age ranges, and country examined, which make it difficult to compare findings.

Beckford et al. (2015) and Turner (2019) both considered all caffeinated food and beverages. Beckford et al. found that the top three sources for caffeine were soft drinks, coffee and coffee substitutes, and food sources. In comparison, Turner found that the top three sources were coffee, chocolate, and tea. Soft drinks contributed a comparatively small proportion of overall caffeine intake in Turner's study (cola was the fourth highest contributor, at 2.25 mg), compared to Beckford et al, which may be a result of Turner's comparatively higher age range (15-18 years vs 2-16 years). It could also be impacted by local differences between Australia and New Zealand, as the studies were conducted in different countries.

Beamish et al. (2016) only looked at caffeinated beverages, and found that soft drinks, tea and coffee, and energy drinks were the top three sources of caffeine.

The proportion of caffeine intake contributed by energy drinks differed significantly between the three studies. Two reported relatively low caffeine contributions by energy drinks (3% and an average of 0 mg), while the other reported that energy drinks made up 17.8% of average caffeine intake. The outlying study examined only caffeinated beverages (compared to both caffeinated food and beverages), and also utilised a non-representative sample in the form of students aged 13-18 years at Christian schools, which was non-representative in terms of both the proportion of adolescents who are Christian (78% of the sample were Christian, vs 60% of the Australian population) and who speak English at home (14% of the sample spoke a language other than English at home, vs 25% of the Australian population). In comparison, Beckford et al. (2015) utilised a nationally representative sample with a much wider age range (2-16 years), and Turner (2019) recruited their female-skewed (65%) and older (15-18 years) sample from a broader range of secondary schools. These differences make it difficult to draw clear conclusions from the studies.

*Table 18: Comparison of studies analysing food/beverage contributions to caffeine intake in adolescents.*

| Study | Sample | Size | Products | Top Sources of Caffeine (Percentage/Amount Contributed to Daily Caffeine Intake) | | | Energy Drinks |
|---|---|---|---|---|---|---|---|
| | | | | #1 | #2 | #3 | |
| Beamish et al. (2016) | 13-18 years Australia | 949 (51.8% female) | Caffeinated beverages | Caffeinated soft drinks (47.5%) | Tea and coffee (34.7%) | Energy drinks (17.8%) | 17.8% |
| Beckford et al. (2015) | 2-16 years Australia | 942 | Caffeinated food and beverages | Soft drinks (31%) | Coffee and coffee substitutes (21%) | Food sources (19%) | 3% |
| Turner (2019) | 15-18 years New Zealand | 216 (65% female) | Caffeinated food and beverages | Coffee (10.7 mg median) (IQR: 0-88.6) | Chocolate (6.28 mg median) (IQR: 2.56-11.4) | Tea (3.71 mg median) (IQR: 0.00-25.2) | 0.00 mg (median) (IQR: 0.00-3.18) |

*Sociodemographic Characteristics Associated with Caffeine Intake*

Four studies considered sociodemographic characteristics associated with caffeine intake. These were in respect of age and sex.

Beamish et al. (2016) found that caffeine consumption was significantly associated with age, with greater consumption as age increased. Similarly, Beckford et al. (2015) found that older children had significantly higher intakes of caffeinated soft drinks and energy drinks although he did not analyse this in respect of the amount of caffeine consumed.

Although sex was found to be significantly associated with the likelihood of consuming energy drinks (see Research Question 1), there were no significant sex differences found in the amount of caffeine consumed (Beamish et al. 2016 and Turner 2019).

There were, however, sex differences to be found in the sources of caffeine. Turner (2019) found that the average daily intake of caffeine from tea was higher in females than males, whereas intake from cola drinks and energy drinks was higher in males than females. Beckford et al. (2015) similarly found that males had a significantly higher intake of caffeinated soft drinks and energy drinks than females (a mean of 475g/day vs 400g/day), however did not analyse this in respect of the amount of caffeine consumed or in respect of other sources of caffeine (such as tea or coffee).

*Summary*

The literature shows that, on average, adolescents are consuming caffeine within the recommended daily limits, with no evidence that adolescents are regularly exceeding the recommended daily caffeine intake. Soft drinks, coffee, tea, and/or chocolate were the greatest contributors to adolescent caffeine intake.

However, there is also evidence that a minority of adolescents may be reaching or exceeding the recommended daily intake of caffeine solely by consuming energy drinks. One study (Costa et al., 2016) found that a proportion of adolescents (less than 3.4%) are exceeding the recommended daily limit of caffeine in an average session of energy drink consumption. In addition, Trapp et al.'s (2020) study of 12-18 year olds in Western Australia found that, 8.2% of sampled adolescents reported reaching or exceeding the daily recommended limit of caffeine solely by consuming energy drinks. However, these findings do not reflect consumption on an average day. Therefore it is unclear whether these individuals are exceeding or reaching the safe daily limit via energy drink consumption *on a regular basis.*

Age played a significant role in caffeine consumption, with increased age being associated with greater consumption. No other factors were found to influence caffeine intake.

Sex was not associated with the amount of caffeine consumed. However, sex did have an influence on the proportion of caffeine that was consumed from different sources, with females having higher caffeine intakes from tea and males having higher intakes from soft drinks and energy drinks.

## Athletes and Military Personnel

No studies examined the amount of caffeine being consumed by athletes or military personnel. However, there was some evidence regarding frequency of consumption of caffeine, and also whether consumers are using more than one sports food product at the same time (referred to as stacking).

*Frequency of caffeine consumption*

One study reported frequency of caffeine use in Australian army personnel (Kullen et al., 2019).

In this study, army personnel were asked to indicate how often they used energy drinks and ‘caffeine’ more broadly (response options were daily, weekly, monthly, rarely or never). Nearly one half of participants (48.5%) reported using caffeine daily, whereas 62.5% reported using caffeine ≥ once per week. However, it is unclear exactly what type of caffeinated products participants reported using in response to this question. When asked specifically about energy drinks, 6.7% reported using daily, whereas 28.2% reported using ≥ once per week.

Overall, this study indicates that army personnel may be frequently using caffeinated products. However, it is unclear from this information whether they are exceeding the safe recommended limit of 400 mg/day of caffeine..

*Stacking of sports foods*

Six studies examined the number of sports food products participants consume. These findings are relevant to the question of whether consumers are using more than one sports food product at the same time (stacking). Although it is unclear whether these studies examined consumption of *caffeinated* sports foods in particular, they still provide insight into how consumers use sports foods more broadly. This is of relevance should caffeinated sports foods become more prominent in the market.

Five of these studies examined this question in athletes/military personnel (Baker et al., 2019; Kullen et al., 2019; Shaw, 2012; Shaw, 2013; Van der Pols et al., 2017), whereas one additional study examined this question within the broader population (FSANZ, 2013). Although this section is primarily concerned with how athletes/military personnel consume caffeinated food products, the study on the broader population is also included here given that this study primarily examined consumption of sports foods. It is also important to note that all of the studies described in this section examined this question in relation to sports foods more broadly (not necessarily caffeinated sports foods). The evidence if further reviewed below, grouped by the type of subpopulation examined.

<u>Athletes</u>

Two of the studies examined the number of sports foods products consumed by athletes (Shaw, 2012; Shaw, 2013). Both studies used quantitative surveys. However, in both studies, the relative timing of consumption was not examined (e.g., whether consumers alternated products each day/month, etc., or consumed them at the same time). Additionally, participants were asked about supplements more broadly, which likely consisted of products that would be regulated as a formulated supplementary sports food under the Code as well as products that would not be regulated as such under the Code (including products that may be regulated as a therapeutic good).

Shaw (2012) found that just over half of the athletes in their sample (both able-bodied [55%] and those with spinal cord injuries [SCI; 53%) reported that they currently consume more than one supplement. The group mean number of supplements consumed was approximately 2, with no significant differences between the two groups (able-bodied athletes M = 2.4, SD = 2.1; SCI athletes M = 1.8, SD = 1.8). However, the large standard deviations (SD) relative to the means indicate a high degree of variability across participants, and thus the mean may not accurately represent the group.

Shaw (2013) found that elite swimmers also reported use of more than one type of sports food, with a group mean of 3.3 (SD=4.3). However, as with the previous study, the relatively large standard deviation indicates variability within the sample, and that the mean does not accurately represent the group. In this study, 'sports foods' products were categorised as bars, liquid meals, and protein powders. Participants also reported use of a range of different products that were categorised as 'ergogenics', which included products such as sports gels, electrolyte replacements, and vitamins, the latter of which is not regulated under the Code (group mean number of ergogenics = 4.0, SD = 1.7).

Military personnel

Three of the studies examined the number of sports foods products consumed by military personnel (Baker et al., 2019; Kullen et al., 2019; Van der Pols et al., 2017). All studies used quantitative surveys. However, as with the previous studies that sampled athletes, the relative timing of consumption was not examined in these studies (e.g., whether consumers consumed different products at the same time, or whether consumption was spaced out by a number of hours). Additionally, participants were asked about supplements more broadly, which consisted of both in-scope and out-of-scope products.

In Baker et al. (2019), army soldiers reported using multiple dietary supplements per week (group mean number = 4.0, SD = 4.6), with notable variability within the sample for the number consumed. In contrast to the previously described studies, Baker et al. (2019) reported additional findings that provided further insight into the source of this variability. That is, higher numbers of supplements per week were reported by younger soldiers (those aged 23-37 years vs. those aged 43-62 years), and also by those with higher Body Mass Index (BMI) ranges (BMI ranges of 25-30 vs. <25). Those who undertook more hours of cardio exercise per week and a higher number of strength training sessions per week also tended to report use of a higher number of supplements.

Similarly, Kullen et al. (2019) generally found that army personnel reported consuming multiple supplements. In this study, the mean number of dietary supplements used daily, once per week, or "ever" (monthly or rarely) were 1.34 (SD = 1.62), 2.52 (SD = 2.02), and 5.01 (SD=3.08), respectively, indicating that participants who consumed supplements less frequently may consume a higher number of products. However, the large standard deviations indicate a high degree of variability across participants, and this study did not statistically compare the number of supplements consumed among the different frequencies of use. The maximum number of supplements used either daily, at least once per week or "ever" by any participant was 9, 10, and 18, respectively. Of the participants who reported using multiple supplements, 17.3% reported using at least five supplements at least once per week.

Van der Pols et al. (2017) also found that, based on a sample of military personnel, the number of different products used per person ranged from 1-5, 1-4, and 1-2 products for bodybuilding, energy, and weight-loss products, respectively. Additionally, 11.6% of the sample reported using supplements from more than one product category.

Broader population

Only one study examined the number of sports foods products consumed using a sample beyond that of athletes or army/military personnel. Colmar Brunton (2010) conducted focus groups consisting of both physically-active and sedentary consumers of sports foods. Both physically-active and sedentary consumers reported consumption of multiple products. No consumers reported eating multiple sports foods on the same eating occasion, but some (both physically-active and sedentary) had multiple eating occasions throughout a single day (e.g., protein shake in the morning, protein bar during the day).

*Summary*

Overall, the evidence suggests that some consumers (whether they be athletes, army soldiers/military personnel, or physically-active/sedentary consumers from the broader population) *may* consume multiple sports foods products. However, across all of these studies, participants considered both products that would be regulated as a formulated supplementary sports food in the Code, and products that would not be. Thus any conclusions regarding sports foods in particular are tentative. Furthermore, the studies that sampled athletes or army/military personnel did not report on the relative timing of consumption of multiple products. It is therefore unknown whether multiple products were consumed simultaneously, or spread out over a number of days or weeks, for example. However, in one study that sampled army personnel (Kullen et al., 2019), some participants reported using more than one product within a day. There was generally a high degree of variability in the number of supplements consumed across participants.

The one study that sampled a broader population beyond that of athletes/military personnel (Colmar Brunton, 2010) found that when consumers (both physically-active and sedentary) consumed multiple products in a day, these were generally spaced out (e.g., one product consumed in the morning, and another in the evening).

## Pregnant/Lactating Women

Twelve studies considered how pregnant women consumed caffeine, including the total caffeine intake across the diet, excess consumption, caffeine sources and sociodemographic factors associated with high caffeine intake. One study was from Australia, while other studies considered samples from Poland, Norway, Ireland, Japan, Italy, the United States and Spain. The studies varied significantly in the products examined, the consumption timeframe, sample size and characteristics, and the age of the data.  No studies were found on lactating women.

*Average Caffeine Intake*

Twelve studies presented an average and/or a distribution of total caffeine intake across the diet in mg/day (see Table 22).

In their study of 1,232 Australian mothers, Peacock et al. (2018) reported the median typical and median maximal daily intake of caffeine, including the change following pregnancy recognition and across each trimester. Similar to the prevalence of caffeine consumption (as reported in Research Question 1), the median typical caffeine consumption dropped following pregnancy recognition (from 107 mg/d to 60 mg/d) before rising to below pre-pregnancy levels in trimester two and three (80 mg/d). Maximal intake also fell after pregnancy recognition, from a median of 187 mg/d to 12 0mg/d, before rising slightly to 132 mg/d in trimester three. However, as this study only considered caffeine from beverages, these figures may underestimate total intake. The sample was also not representative, being slightly older, more socio-economically advantaged, more likely to be born overseas, more highly educated, more likely to have no prior children, and less likely to be living in single-parent households than the general Australian population.

In addition to Peacock et al. (2018), seven international studies considered the change in caffeine intake from before pregnancy to during pregnancy. Across the three studies measuring caffeine intake change in mg/day, average caffeine intake declined, with the magnitude of decline ranging from 22% of pre-pregnancy intake in Japan (Kobayashi et al., 2019) to 51% and 64% of pre-pregnancy intake in Spain (Castillo et al., 2016; Roman Galvez et al., 2021).

Four other studies reported the direction of caffeine intake changes during pregnancy (not reported in Table 22, for further detail see Table 28 under Research Question 4). Chen et al. (2014) and Stefanidou et al. (2011) identified that most women in their American and Italian samples consumed caffeine before pregnancy, with a substantial majority (78% and 66% respectively), reducing or stopping caffeine intake during pregnancy. Similarly, 77% of 379 pregnant Canadian women reported decreasing or stopping their caffeine intake (Forbes et al., 2018). Castillo et al. (2016) found that while 95.3% of their Spanish sample consumed caffeine while pregnant, 64.9% decreased consumption. Both Castillo et al. (2016) and Stefanidou et al. (2011) identified that a small proportion of women increased their caffeine intake during pregnancy (8.3% and 2.9% respectively), while 28.6% and 30.8% maintained their pre-pregnancy consumption.

Two further international studies considered the change in consumption patterns across pregnancy. As in Peacock et al. (2018), Hinkle et al. (2021) report that caffeine consumption increased as gestational age increased, with most women moving from consuming nothing at 10-13 weeks, to consuming between 1-100 mg/day at 16-22 weeks. Sengpiel et al. (2013) however found that consumption followed a U shape, with a median intake of 126 mg/day at gestational week 15-17, dropping to 44 mg/day at week 22, and rising again to 60 mg/day at week 30. Pregnancy recognition timing was not collected by Hinkle et al. (2021) or Senpiel et al. (2013), so the impact of this cannot be analysed. However Sengpiel's result may indicate that it can take some time for pregnant women to make changes to their caffeine intake.

Taken together, these results suggest that a significant proportion of women decrease or stop caffeine intake during pregnancy (64.9% - 78%), with only a small minority (2.9% - 8.3%) increasing their intake.  During pregnancy, caffeine intake appears to decline once pregnancy is recognised, before rising to below pre pregnancy levels as the pregnancy progresses.

*Excess Consumption*

Table 22 also highlights ten studies that reported the proportion of pregnant women who exceed the recommended daily intake of caffeine of 200 mg/day. This proportion was generally below ~15% of women, ranging from 0.8% (Hinkle et al., 2021) to 15.6% (Chen et al., 2019). The exception to this was seen in studies from Japan, where 25.8% (Kobayashi et al., 2019) and 67.3% (Okubo et al., 2015) of women consumed over 200 mg of caffeine per day. This may be attributable to Japan not currently issuing guidance on caffeine intake for pregnant women, or the high caffeine intake from tea not seen in other countries (Okubo et al., 2015).

Excess caffeine consumption also declined as gestational age increased (Peacock et al., 2018; Roman-Galvez et al., 2021). Peacock et al. (2018) found that those who exceeded the guidelines at some point during pregnancy (8.1%) were more likely to change their consumption during pregnancy than those who were abstinent (21.5%) or consumed consistently within the guidelines (70.3%). The women exceeding 200 mg/d generally reduced their use to adhere to the guideline rather than stopping entirely.

*Table 19: Studies reporting pregnant women caffeine intake and proportion exceeding recommended daily intake.*

| Study and Sample | Products | Timeframe/Cohort | Caffeine intake (mg/day) | % Exceeding 200 mg/day |
|---|---|---|---|---|
| **Peacock et al. (2018)**<br>Australia<br>(n = 1,232) | Caffeinated beverages | Trimester 1: Pre-pregnancy awareness | 107 mg/day<br>(median; IQR 60-147) | NB: Typical or maximal intake<br>30% |
| | | Trimester 1: Post pregnancy awareness | 60 mg/day<br>(median; IQR 40-107) | 10% |
| | | Trimester 2 | 80 mg/day<br>(median; IQR 40-107) | 4% |
| | | Trimester 3 | | 5% |
| **Hinkle et al. (2021)**<br>United States<br>(n = 2,583) | Coffee, tea, soft drink, energy drinks | 10-13 weeks | 0 mg/day: 41.5% | 0.8% |
| | | | 1-100 mg/day: 51.0% | |
| | | | 101-200 mg/day: 6.7% | |
| | | 16-22 weeks | 0 mg/day: 23.6% | 0.8% |
| | | | 1-100 mg/day: 68.3% | |
| | | | 101-200 mg/day: 7.3% | |
| **Patti et al. (2021)**<br>United States<br>(n = 389) | Coffee, tea, soft drink, chocolate | EARLI* Cohort (n=120) | 20 mg/day<br>(median; IQR: 8-65) | Not reported |
| | | HOME* Cohort (n=269) | 18 mg/day<br>(median; IQR: 5-48) | |

| Study and Sample | Products | Timeframe/Cohort | Caffeine intake (mg/day) | % Exceeding 200 mg/day |
|---|---|---|---|---|
| **Kobayashi et al. (2019)**<br>Japan<br>(n = 94,876) | Coffee, tea | Year prior to pregnancy | 161.6 mg/day (median) | 25.8%** |
| | | During pregnancy | 125.5 mg/day (median) | |
| **Okubo et al. (2015)**<br>Japan<br>(n = 858) | Tea | Past month, measured between 5-39 weeks | 258 mg/day<br>(median; IQR 176-371) | 67.3% |
| **Blaszczyk-Bebenek et al. (2018)**<br>Poland<br>(n =140) | Coffee, tea, soft drinks, energy drinks, chocolate | Trimester 2 or 3 | 49.6 mg/day<br>(mean; SD: 59.15) | 1.4% |
| | | | 33.48 mg/day<br>(median; range: 0 – 498) | |
| **Jarosz et al. (2011)**<br>Poland<br>(n = 509) | Coffee, tea, cola, energy drinks, chocolate | During pregnancy | 91 mg/day (mean) | >300mg/d: 1.6% |
| **Castillo et al. (2016)**<br>Spain<br>(n = 1,175) | Coffee, cola, chocolate and chocolate biscuits | Pre-pregnancy | 150.1 mg/day<br>(mean; SD: 141.1; range: 0.1 – 872) | 31.2% |
| | | First half of gestation | 72.6 mg/day<br>(mean; SD: 92.7; range: 0.1 – 650) | 9.9% |
| **Roman-Galvez et al. (2021)**<br>Spain<br>(n = 463) | Coffee, tea, cola, energy drinks, chocolate | Pre pregnancy | 120.05 mg/day (mean; SD 117.85) | N/A |
| | | Trimester 1 | 42.76 mg/day (mean; SD 63.90) | 13.8% |
| | | Trimester 2 | 42.00 mg/day (mean; SD 59.76) | 3.9% |
| | | Trimester 3 | 39.30 mg/day (mean; SD 50.9) | 2.3% |

| Study and Sample | Products | Timeframe/Cohort | Caffeine intake (mg/day) | % Exceeding 200 mg/day |
|---|---|---|---|---|
| **Sengpiel et al. (2013)**<br>Norway<br>(n = 59,123) | Caffeinated food and beverages and caffeine supplements | Week 15-17 | 126 mg/day (median; IQR 40-254) | 10.8% |
| | | Week 22 | 44 mg/day (median; IQR 13-104) | |
| | | Week 30 | 60 mg/day (median; IQR 21-130) | |
| **Chen et al. (2019)**<br>Ireland<br>(n = 558) | Coffee, tea, soft drinks, chocolate containing foods and beverages | Week 12-16 | <50 mg/day: 19.3% | 15.6% |
| | | | 50-100 mg/day: 30.6% | |
| | | | 100-200 mg/day: 34.4% | |
| | | | >200 mg/day: 15.6% | |
| **Stefanidou et al (2011)**<br>Italy<br>(n = 312) | Coffee, tea, cola, chocolate and hot chocolate | From 4 weeks before last menstrual period to the week before delivery. | 177.4 mg/day<br>(weighted mean***) | Not reported |

*Patti et al. (2020) examines two cohorts – the Early Autism Risk Longitudinal Investigation (EARLI) and the Health Outcomes and Measures of the Environment (HOME) study.
**Calculated from Kobayashi et al. (2019) supplementary eTable 2.
***Stefanidou et al. (2011) weighted mean calculated from two subpopulations: recurrent miscarriage and controls

*Sources of Caffeine*

Six studies reported on the sources of caffeine in mg per day for pregnant women (outlined in Table 23). While these studies varied in the products they covered, the results suggest there are cultural differences in the main sources of caffeine. For example, green tea is a significant contributor to caffeine intake in Japan, while black tea was a more prominent source in Poland. Coffee was a consistently high contributor to pregnant women's caffeine intake across all the studies reviewed. Changes in the source of caffeine during pregnancy are examined further in Research Question 4.

*Table 20: Studies reporting top sources of caffeine consumed by pregnant women.*

| Study and Sample | Products | Measure | Top Source of Caffeine | | |
|---|---|---|---|---|---|
| | | | #1 | #2 | #3 |
| **Kobayashi et al. (2019)** Japan n=94,876 | Green tea, Coffee, Black tea, Oolong tea | % of caffeine intake | Green tea: 37.0% | Coffee: 26.5% | Black tea: 17.6% |
| **Okubo et al. (2015)** Japan n=858 | Caffeinated beverages and confectionary | % of caffeine intake | Japanese and Chinese tea: 73.5% | Coffee: 14.3% | Black tea: 6.6% |
| **Blaszczyk-Bebenek et al. (2018)** Poland n=140 | Coffee (instant/ground), tea, soft drinks, energy drinks, chocolate | % of caffeine intake | Black tea: 43.5% | Coffee: 30.8% | Green tea: 16.4% |
| **Jarosz et al. (2011)** Poland n=509 | Coffee, tea, soft drinks, chocolate | % of caffeine intake | Black tea: 58.9% | Coffee: 26.6% | Soft drinks: 4.9% |
| **Roman-Galvez et al. (2021)** Spain n=463 | Coffee, tea, soft drinks, chocolate | Trimester 3 average intake (mg/d) | Coffee: 63.99 mg/d | Cola: 15.93 mg/d | Chocolate: 14.76 mg/d |
| **Sengpiel et al. (2013)** Norway n=59,123 | Caffeinated food and beverages and caffeine supplements, | % of caffeine intake | Coffee: 56% | Black tea: 22% | Soda: 14% |

*Sociodemographic Characteristics Associated with Caffeine Intake*

Nine studies considered the sociodemographic characteristics associated with high caffeine use during pregnancy. These studies considered populations from Australia, Norway, Ireland, Poland, Japan, the United States and Spain. All studies considered different potential sociodemographic characteristics, and generally used different statistical methods to determine the association with caffeine use (including T tests, Chi Square, logistic regression, odds ratios, relative risk reduction etc.) Given the broad range of characteristics considered, the below analysis only reports on sociodemographic factors found to be associated with caffeine intake across more than three studies. Overall there was some inconsistency in the findings across studies, which could not be clearly explained by differences in the analytical methods used, sources of caffeine measured, study country, or sample size and characteristics.

Nine studies considered the relationship between caffeine intake and parity. Seven of these found that having had previous pregnancies was significantly associated with higher caffeine consumption during pregnancy (Castillo et al., 2016; Chen et al., 2019; Hinkle et al., 2021; Okubo et al., 2015; Patti et al., 2021; Peacock et al., 2018; Sengpiel et al., 2013). Higher consumption in those with previous pregnancies reflects comments made by women in a New Zealand study, who reported being more "relaxed about food safety and dietary choices during consecutive pregnancies because of limited time with multiple children, fatigue, or finding recommendations hard to adhere to" (Brown et al., 2020, pg. 8). This also aligns with Lain et al.'s (2010) finding that fewer Australian women who were pregnant for the first time consumed caffeinated drinks, compared to those who had had prior pregnancies. Of the two studies showing no statistically significant relationship between parity and caffeine intake, one did not report the P value (Jaroz et al., 2011), while the other reported a p=0.067, only slightly above the 0.05 cut off (Roman & Galvez et al., 2021).

Nine studies also considered the association between the mother's age and caffeine intake. Four of those studies found that being older was significantly related to higher intake (Chen et al., 2019; Hinkle et al., 2021; Jaroz et al., 2011; Sengpiel et al,. 2013). One further study provided weaker evidence for this relationship; Patti et al. (2021) found that age was significantly related to caffeine intake in one of the two cohort studies they considered. Four studies showed no statistically significant relationship between age and caffeine intake (Castillo et al., 2016; Okubo et al., 2015; Peacock et al., 2018; Roman & Galvez et al., 2021). Where reported, age ranges examined appeared to be similar across studies.

Of the six studies considering the relationship between alcohol and caffeine intake, four studies found that caffeine intake was higher among those consuming alcohol either during pregnancy (Castillo et al., 2016; Hinkle et al., 2021; Peacock et al., 2018), during the peri-conceptional period of 14 weeks before and 10 weeks after conception (Chen et al., 2019) and prior to pregnancy (Hinkle et al., 2021). Two studies did not find a statistically significant association between caffeine intake and alcohol use (Okubo et al., 2015; Sengpiel et al., 2013). Of the nine studies that considered tobacco smoking, six found that higher caffeine intake was related to active smoking during pregnancy (Castillo et al., 2016; Jaroz et al., 2012; Patti et al,. 2021; Peacock et al., 2018; Roman Galvez et al., 2021; Sengpiel et al., 2013), and one found it was related to cotinine in the blood (proxy for nicotine) (Hinkle et al., 2021). Two studies did not find an association between tobacco smoking and caffeine intake (Chen et al., 2019; Okubo et al., 2015). While there is some inconsistency in these results, taken together they suggest that there may be value in combining any caffeine education efforts for this subpopulation with information on the risks of alcohol and tobacco use during pregnancy.

*Summary*

While the majority of women consume caffeine during pregnancy, a significant proportion decrease or stop their intake (64.9 – 78%), with only a small minority (2.9 - 8.3%) increasing their intake. This reduction in caffeine intake is often quite substantial, on average ranging from 22%-64% of pre-pregnancy average intake. Caffeine consumption also changes throughout pregnancy, with intake declining once pregnancy is recognised, before rising to below pre-pregnancy levels as the pregnancy progresses.

The proportion of pregnant women consuming caffeine in excess of the recommended daily intake was generally below 15%, ranging from 0.8% to 15.6%. The exception to this was two Japanese studies where intake was significantly higher. The median caffeine intake of pregnant women did not exceed the recommended daily limit of 200 mg/day in all studies, with the exception of one Japanese study.

Despite clear cultural differences in the main source of caffeine, coffee was a consistently high contributor to caffeine intake across all studies.

The evidence regarding sociodemographic factors associated with higher caffeine intake during pregnancy was generally mixed. Some studies found that those who had higher caffeine intake were more likely to have had previous pregnancies, to be older, and to also smoke tobacco or consume alcohol. However, confidence in these findings is low, given the degree of inconsistency across studies.

## Broader Populations

Five studies examined caffeine consumption in broader populations (Booth et al., 2020; Centofanti et al., 2018; Shaw, 2019; Stachyshyn, 2017; Trapp et al., 2014). The findings are further summarised below, grouped by the type of information that was reported (studies that reported average caffeine intake from a range of products vs. studies that only reported on energy drink consumption).

*Average caffeine intake and excess consumption*

Table 24 summarises the findings of four studies that reported the mean (or median) caffeine intake (mg/day) across participants, and/or the proportion of the sample that exceeded the recommended limit of 400 mg/day.

*Table 21. Amounts of caffeine consumed by participants across studies that sampled broader populations*

| Study and Sample | Sample Size | Products Examined | Caffeine intake (mg/day) | % exceeding 400 mg/day |
|---|---|---|---|---|
| **Booth et al. (2020)**<br>NZ general population<br>Median age: 21 years<br>65% female | 2379 | Coffee, tea, energy drinks, cola, RTDs, Other ("e.g., NoDoz, medications, sports supplements") | 221 (mean)<br>(SD 265) | 17.4% |
| **Stachyshyn (2017)**<br>NZ university students<br>74.4% aged 19-30 years<br>53% female | 317 | Coffee, tea, energy drinks, cola, RTDs, sports supplements, caffeine tablets, chocolate | 146.73 (median)<br>(Range 0.07-1988.14)<br>Where bodyweight known:<br>2.25 mg/kg bw/day (median)<br>(IQR: 1.01-4.31) | 14.2% |
| **Centofanti et al. (2018)**<br>Nurses + midwives who do shift work<br>Mean age: 43 years<br>89% female | 97 | Coffee, tea, cola | N/A | Before starting shift work: 15%<br>Since starting shift work: 33% |
| **Shaw (2019)**<br>Shift workers<br>Mean age: 42 years<br>17% female | 22 | Participants generally asked to report all food and beverages | 178.0 (mean)<br>(SD 160.3) | N/A |

As shown in Table 24, two of these studies examined the amount of caffeine consumed from a variety of specified food sources (Booth et al., 2020; Stachyshyn, 2017). However, there were some differences in the types of food sources examined (e.g., Stachyshyn, 2017 examined chocolate, whereas Booth et al., 2020 did not). The samples examined also differed across the two studies (New Zealand general population vs. university students). Across these two studies, the group mean (or median) caffeine intake was generally below the recommended daily limit of 400 mg/day. However, the standard deviation and range of values reported indicated that at least some individuals may still be exceeding the limit. Indeed, the authors reported that this was the case in 14.2% to 17.4% of the samples. It is important to note that caffeine intake may have been underestimated in the study that examined the New Zealand general population (Booth et al., 2020), as products that were consumed less than daily were not included, and the participants could only report consumption of up to 5 portions of a product per day. Conversely, in Stachyshyn (2017), all consumed caffeinated products were included, and participants could report consumption of up to 6+ portions of a product per day.

As also shown in Table 24, the remaining studies examined caffeine intake in shift workers (Centofanti et al., 2018; Shaw, 2019). Centofanti et al. (2018) examined caffeine intake in nurses and midwifes who do shift work, and participants were only asked about their average daily intake of coffee, tea and cola. The percentage of the sample found to be exceeding the recommended daily limit of caffeine (400 mg/day) increased from 15% to 33% since beginning shift work. Participants also reported consuming energy drinks, however, this was identified during a later qualitative component of the study, and therefore may not have been considered when calculating the proportion exceeding the recommended daily limit of caffeine[6]. It is therefore possible that the reported proportion is an underestimation.

Shaw (2019) examined shift workers more broadly (not limited to nurses and midwives), and participants were asked to record all food and beverages that they consumed over a four-day period. The mean daily caffeine intake was below the recommended daily limit (Mean = 178.0, SD= 160.3), although the standard deviation indicates high levels of variability in the sample. This indicates that at least some participants may have exceeded the recommended limit, however, the proportion of these participants was not reported in the study. It is also important to note that participants in this study were required to report consumption over a particular four-day period, which may not be reflective of *usual* intake.

*Sources of Caffeine*

Only two of the above studies indicated how much each type of food contributed to participants' caffeine intake (Booth et al., 2020; Stachyshyn, 2017). The way in which this information was conveyed differed between these two studies. That is, one reported the proportion that each product contributed to daily caffeine intake, whereas the other reported the median daily caffeine intake for each product. Table 25 presents the information that was available across both studies.

Stachyshyn (2017) reported the proportion that each food product contributed to total daily caffeine intake in New Zealand university students. Coffee was the top contributor to total daily caffeine intake (61.4%), followed by tea and energy drinks, which made notably smaller contributions (14.4% and 8%, respectively). Additional analyses showed that coffee consumers were 16.29 times more likely to exceed the safe limit than those who do not consume coffee (18.6% vs. 1.3%; $p<0.001$). This is not surprising given that coffee was the greatest contributor to total daily caffeine intake. Additionally, alcoholic RTD consumers were

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[6] This is unclear based on the information provided in Centofanti et al. (2018)

2.26 times more likely to exceed the safe limit than those who do not consume alcoholic RTDs (24.1% vs. 12.4%; p=0.025). However, exceeding the safe limit was not caused by consuming RTDs (given that RTDs only contributed to 0.8% of total daily caffeine intake). Rather, RTD consumers were more likely to exceed safe limits (compared to non-RTD consumers) by consuming other sources. No other sources of caffeine were associated with exceeding the daily safe limit (p>0.05).

Booth et al. (2020) reported the group median caffeine intake (and range) for different food products using a sample of the New Zealand general population. These results provide further insight into whether consumers are exceeding their total daily caffeine limit via one food source alone. Although the group median daily caffeine intake was below the recommended limit for each type of food, both espresso coffee and 'other' sources (a category in which caffeine tablets, medications, and sports supplements were combined) had an upper range that exceeded 400 mg, indicating that at least some participants are exceeding the safe daily limit of caffeine by consuming these products alone. However, the exact proportion of participants exceeding 400 mg/day was not reported by product type in this study, only in terms of overall caffeine intake (which was 17.4% of the sample, as previously described). The upper range of 400 mg/day for both energy drinks and other types of coffee also indicate that some consumers (exact proportion not quantifiable) *reach* their safe daily limit from these products alone. Thus, if these individuals were to consume additional caffeinated products within the same day, they would exceed the safe limit. However, it is unknown whether these particular individuals were consuming multiple caffeinated products in a day. As noted previously, caffeine intake may have been underestimated in this study, given that products that were consumed less than daily were not included.

*Excess consumption from energy drinks*

One study only examined consumption of energy drinks within the Australian general population (Trapp et al, 2014), rather than consumption of a broader range of caffeinated food products. In this study, 18-22 year olds were asked to report the usual amount (total number of cans, volume not specified) they would drink per day on a day that they consume an energy drink. For those who reported consuming energy drinks on a regular basis (3-6 days per week; which represented 8% of participants in the study), the mean number of cans consumed per day was 1.53 (SD = 0.93), with a range of 1-6. As noted previously, the Australian Food Composition Database (2022) lists a value of 80-85 mg of caffeine per 250 mL can of energy drink. Based on this, consuming more than five cans would cause consumers to exceed the recommended daily limit of caffeine (400 mg). The upper range in number of cans consumed therefore indicates that at least some participants (proportion not quantifiable) are exceeding the recommended daily limit of caffeine solely by consuming energy drinks on a regular basis. However, it is important to note that, as Trapp et al. (2014) did not specify a volume for energy drink 'cans' in their study, a greater range of reported cans per day could potentially be associated with overconsumption. For those who reported consuming energy drinks monthly (which represented 24% of participants in the study), there was also evidence of overconsumption (mean number of cans consumed per day = 1.26; SD = 0.77; Range = 1-10).

*Sociodemographic Characteristics Associated with Caffeine Intake*

Only one of the four studies also reported on sociodemographic factors associated with the amount of caffeine consumed (Stachyshyn, 2017).

Stachyshyn (2017) found that overall daily caffeine consumption was significantly higher in female than male university students (p=0.041), but only when expressed on a per kg of body weight basis. However the median daily caffeine consumption from cola drinks (15.31

vs. 9.94 mg/day), RTDs (6.10 vs. 3.00 mg/day) and energy drinks (32.20 vs. 11.54 mg/day) was significantly higher in males than females. Stachyshyn also found that age was associated with the amount of caffeine consumed, but again, only when expressed on a per kg of body weight basis. Overall, older age groups (31-50 year olds) had significantly higher daily caffeine consumption than younger age groups (16-18 year olds; p=0.008). Daily caffeine consumption from coffee in particular was also significantly higher in the 19-30 year old age group (median 109.35 mg/day) than in the 16-18 year old age group (median 38.07 mg/day; p = 0.01). There was no association between age group and daily consumption of caffeine from any other caffeine sources (p> 0.05). There was also no association between overall daily caffeine consumption and working status (paid employment vs. no paid employment), however, median daily caffeine intake from cola drinks was significantly higher in those with paid employment (14.29 mg/day) than those with no paid employment (10.87 mg/day; p = 0.029). Cigarette smoking was the only participant demographic that increased the likelihood of exceeding 400 mg/day (p = 0.001).

*Table 22: Amounts of caffeine consumed for each product type across studies that reported consumption from broader populations.*

| Study and sample | Measure | Sources of Caffeine | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Coffee | Tea | Energy drinks | Chocolate | Cola | Other | RTDs |
| **Booth et al. (2020)**<br>NZ general population<br>Median age: 21 years<br>65% female | Median caffeine intake in mg/day (range) | **Espresso:** 290 (145-725)<br>**Instant:** 160 (80-400)<br>**Other:** 160 (80-400) | 100 (50-250) | 160 (80-400) | - | 90 (45-225) | **"Other (e.g., Nodoz, medications, sports supplements)":** 100 (100-500) | 113 (45-225) |
| **Stachyshyn (2017)**<br>NZ university students<br>74.4% aged 19-30 years<br>53% female | % contribution to total daily caffeine consumption | 61.4%* | 14.4% | 8% | 7.3% | 5.3% | **Sports supplements:** 2.4%<br>**Caffeine tablets:** 0.5% | 0.8% |

**'Coffee' in this study consisted of instant coffee, plunger/drip coffee, espresso coffee, decaffeinated coffee and iced coffee. However, % contribution to total daily caffeine consumption was not reported separately for each sub-type.*

*Summary*

On average, people from broader populations are consuming caffeine within the recommended daily limits (400 mg/day). However, there is some evidence to suggest a significant minority of consumers (14-17%) may be regularly exceeding the recommended daily limit of 400 mg/day of caffeine. This percentage may be even higher in those who do shift work (up to 33%).

The top contributor to caffeine intake in a sample of New Zealand university students was coffee (61.4% of daily caffeine intake), followed by tea (14.4%) and energy drinks (8%). Coffee consumers were 16.29 times more likely to exceed the recommended daily limit of caffeine than those who do not consume coffee. Similarly, in a sample of the New Zealand general population, average daily caffeine intake was highest for coffee. Second to coffee was energy drinks, followed by RTDs, tea, and a category for which caffeine tablets, medications and sports supplements were combined. Some consumers (exact proportion unquantifiable) reported exceeding the recommended daily limit of caffeine (400 mg/day) by consuming espresso coffee alone. This was also the case for medications and sports supplements combined. Additionally, some consumers (exact proportion unquantifiable) reported either reaching or exceeding the recommended daily limit of caffeine by consuming energy drinks alone.

Few studies examined sociodemographic factors associated with the amount of caffeine consumed. One study found that daily caffeine consumption was significantly higher in female than male university students. Daily caffeine consumption was also significantly higher in older than younger university students (31-50 years vs. 16-18 years). However, cigarette smoking was the only participant demographic associated with increased likelihood of exceeding 400 mg/day.

## Research Question 3: Why do consumers use caffeinated food products?

This section seeks to examine what motivates consumers to use caffeinated food products.

### Overarching Findings

The primary motivations for consuming caffeinated food and beverage products included taste, energy and social considerations. However, the key motivators varied by subpopulation and beverage type. The majority of the research in this area focused on motivations for consuming energy drinks, particularly for children, adolescents and military personnel. No studies were found that examined why athletes or pregnant women consume caffeinated products. However, pregnant women commonly reported eliminating or reducing caffeine intake due to safety risks, particularly for coffee.

Children were motivated to consume energy drinks or caffeinated sugary drinks by taste, followed by a desire for increased energy. Adolescents were also motivated to drink energy drinks by function and taste. However, while social concerns influenced adolescent consumption, this was not a major factor for children, although this may have been affected by social desirability bias.

Some studies also looked at the reasons why children and adolescents did not consume energy drinks. There is some evidence that children and adolescents were deterred from energy drink consumption when aware of the risks associated with their sugar and/or caffeine content (see also Research Question 4). Parents also played a role in either discouraging or normalising the consumption of energy drinks for children and adolescents, although the latter waned as adolescents grew older. The taste of energy drinks was also a key deterent for adolescents, further highlighting the importance of this factor in consumption decisions. No studies considered adolescent motivations to consume other caffeinated food and beverages.

Army personnel reported using energy drinks and caffeinated beverages primarily because they 'liked it' and also for energy. It is unclear exactly why they 'like it', but it is possible that this response is referring to taste.

In the broader population, motivations to drink energy drinks were primarily for taste, physiological benefit, and social image, particularly for younger age groups. Reasons for coffee, sports supplements and caffeine tablet consumption were primarily due to functional effects (e.g. for energy). This motivation was particularly relevant in a sample of nurses and midwives undertaking shift work. Young men also see sports supplements as a status symbol, using them to fit into a "gym goer" image. Reasons for tea, chocolate and cola drink consumption were primarily hedonic (e.g., for warmth, for the taste, to relax), while caffeinated RTDs were consumed socially, and for the alcohol content. Advertising was also a factor driving consumption among the general population, particularly of energy drinks and caffeinated RTDs. However, advertising was not a prominent factor among university students. Caffeinated RTDs were also consumed due to peer pressure among the general population, but this motivator was less prominent among university students, noting these results may be influenced by social desirability bias. Some females also reported replacing food with tea, coffee or energy drinks to control calorie intake, or because of lack of money or time.

A more detailed description of the findings is provided below, grouped by the type of subpopulation.

## Children

Four studies were found that examined children's motivations for consuming caffeinated food products. No studies were found from Australia or New Zealand. Two studies are from Europe and concerned children's consumption of energy drinks, and two studies are from the Washington DC area in the United States and concerned children's consumption of caffeinated sugary drinks.

Visram et al. (2017) conducted a series of focus groups with 37 students (48.6% female) from four schools in low socio-economic status areas in northern England that investigated why children and young people choose to consume or abstain from energy drinks. The study involved 20 students from Year 6 (aged 10-11 years) and 17 students from Year 9 (aged 13-14 years). Across the focus groups, taste was one of the main influences in the decision to consume energy drinks, with needing a physical or mental 'boost' the next most popular reason. The relatively low price of energy drinks in the United Kingdom and their wide availability were also key factors in participants' purchasing decisions. These factors were confirmed through a mapping exercise carried out after the focus groups, which highlighted the wide range of products available and the low cost of some brands (cheaper than water or soft drink).

The children also perceived that energy drinks were widely consumed among their peer group. A number of participants believed that their peers drank energy drinks in order to enhance their image or identity, with boys described as wanting to appear tough or attractive to girls, and girls described as having a preference for "expensive-looking" brands in smaller cans, which they associated with being sophisticated. However, these influences were generally described as affecting *other* children and young people, rather than being reported as important factors in their *own* consumption decisions.

Parents, carers, and other significant adults (like sports coaches) had limited influence over children and young people's decisions to purchase and consume energy drinks. They played a role in either facilitating or limiting children's access to energy drinks, and normalising their consumption or not. However, much of the children's consumption of energy drinks occurred outside of the home and with their own lunch or pocket money, so adults may not have been aware of the behaviour, and parents and carers were not generally identified by children and young people as important influences.

In Martins et al.'s (2018) cross-sectional study of students aged between 11-17 years old (n=1,404) in northern Portugal, individuals were asked why they drank energy drinks. The most commonly reported reasons for energy drink consumption across the entire sample were the pleasant taste (48.8%), desire to increase global energy (34.5%), and to increase sports performance (33.0%). Less common reasons were to decrease sleep (16.8%), and increase academic performance (11.7%). Peer pressure was the least commonly reported reason, at 4.6% ("Other" was 5.2%). These motivations were not broken down by the age of the participant.

Sylvetsky et al. (2020) conducted a focus group study with 37 children (41% female) aged 8-14 years (mean age 10.5 ± 1.9 years) from community organisations primarily serving low-income, minority populations in Washington, D.C. in the United States to evaluate the contextual factors surrounding children's sugar drink consumption. Participants were limited to children aged between 8-14 years who spoke English fluently and whose parents reported that they consumed ≥ 12 ounces (355 mL) of caffeinated, sugary, non-diet drinks per day, but did not consume caffeine-containing coffee, hot tea, or energy drinks ≥ 1 time per week. 81% of the sample was Black/African American, 11% was Hispanic, 3% was Asian, 3% was mixed race, and 3% was of unknown ethnicity.

Of the 33 participants who completed the pre-focus group survey, 94% reported liking caffeinated sugary drinks. 79% said they liked caffeinated sugary drinks because of the taste, and 67% because they gave the participant energy. In the focus group discussions, five key themes emerged as reasons for sugary drink consumption, which the authors categorised as follows:

- Perceived physical and cognitive benefits (such as providing energy, reducing sleepiness, enhances performance, and improving attention);

- Perceived need (such as satisfying cravings, quenching first, being part of a routine, and fostering a feeling of "normalcy");

- Perceived emotional and interpersonal benefits (such as relieving anger, reduce negative emotions, inducing happiness, and facilitating socialising);

- Enjoying sensory properties (such as taste, different flavours, burping, and refreshment when hot); and

- Perceived external cues of influence (such as being modelled by others, other options being unavailable, being encouraged by environmental cues, being provided by family members, or being provided by adults at school).

The researchers noted that the influence of caffeinated sugary drinks on mood regulation, including relieving anger, fostering a feeling of "normalcy", and reducing negative emotions was a novel finding. They speculated that "reported reliance on sugary drinks for emotional well-being may reflect a withdrawal-like symptom", however they also noted that physical symptoms of withdrawal, such as headaches or stomach-aches in the absence of sugary drinks, was not reported by participants.

This study had an non-representative sample consisting predominantly of African American children and adolescents from low-income backgrounds, limiting its generalisability to the broader population. In addition, the study authors note that younger participants were more likely to be shy, and were less likely to clarify or elaborate on their responses. The study is also unable to differentiate between drivers of consumption specific to sugar, caffeine, or both ingredients in combination.

Halberg et al. (2021) conducted a mixed-methods study to examine the reasons for caffeinated sugary drink intake among children aged 8-14 years old in Washington, D.C. in the United States. They used group concept mapping, conducted in three parts: brainstorming reasons for drinking caffeinated sugary drinks (n=51), sorting these reasons into conceptual categories (n=71), and rating the relative importance of the reasons for their consumption of caffeinated sugary drinks on a 5-point Likert-style scale (n=74) to produce cluster maps. 121 reasons reported during the initial brainstorming phase were condensed into 58 independent reasons using participants' original wording that were then used for the sorting and rating activities.

The study found that children consume caffeinated sugary drinks for a variety of reasons, with the most influential being related to the drinks' taste and mouth-feel. Children reported liking their taste, sweetness, sugar, fizziness, and acidity. Another key finding was that children perceived the drinks as capable of increasing their energy levels. Their reasoning evidenced the deliberate use of caffeinated sugary drinks to achieve a functional outcome, such as helping to stay awake or prepare for a hard day. A third influential cluster concerned seeing consumption of caffeinated sugary drinks as "something to do", which included children reporting that they liked to consume them on road trips, because they are bored, or because caffeinated sugary drinks are good for parties. Although a more distant reason, emotional and mood regulation was also found as a reason for caffeinated sugary drink consumption, echoing findings found in Sylvetsky et al. (2020), as noted above.

This study was limited in its geographic scope and sample, which consisted primarily of non-Hispanic Black and Hispanic participants, and is therefore not representative of all American children who consume caffeinated sugary drinks. Similar to the above study, this study is also unable to differentiate between drivers of consumption specific to sugar, caffeine, or both ingredients in combination.

*Summary*

Across the four studies that examined children and adolescents' motivations for consuming energy drinks or caffeinated sugary drinks, taste was consistently reported as the most influential reason, followed by a desire for increased 'energy'. This suggests children's deliberate use of caffeinated drinks in order to achieve a functional outcome. Peer pressure, although thought by participants in one study (Visram et al. 2017) to be a factor in *other* people's consumption of energy drinks, was consistently found to be one of the least reported motivations. This is, however, likely to be affected by self-reporting biases such as social desirability.

Although only a small number of studies covering two different types of caffeinated beverages, the consistency between them gives a reasonable degree of confidence in these findings. It is important to note, however, that these findings are on the basis of self-report and may be subject to participants' inaccurate interpretations of motivation, as well as social desirability bias.

In the two studies that looked at caffeinated sugary drinks, mood and/or emotional regulation were found to be novel motivations for consumption. The study authors considered that this could reflect a withdrawal-like symptom, although physical symptoms of withdrawal were not reported. These studies were, however, unable to differentiate between drivers of consumption specific to sugar, caffeine, or both ingredients in combination.

## Adolescents

Six studies examined adolescents' reasons for consuming energy drinks. Four of these were qualitative studies using focus groups, and two were quantitative surveys. Five were from Australia, and one from New Zealand.

In addition, two studies looked at factors that deterred adolescents from consuming energy drinks. Both studies were from Australia.

*Motivations for Consuming Energy Drinks*

As Table 27 shows, function and taste were the most common motivations for consumption of energy drinks among adolescents, with social concerns the third most common motivation.

Four studies found that function was the most common motivation for consuming energy drinks. This includes the desire to increase energy, boost sports performance, or stay/feel awake or relieve fatigue. For example, one participant in O'Dea (2003) said "I drink it before soccer and I don't lose energy as fast."

Taste was listed as one of the top two motivations for consuming energy drinks by four of the studies. The combination of bitter and sweet flavours in energy drinks was seen to compare favourably to soft drinks for some participants.

Social concerns was the third most common motivation, with three out of the six studies finding that social concerns were in the top three motivations. This includes peer pressure, image, and social norms. For example, one male Year 7 participant in Costa et al.'s (2014) study said, "I was like, ah, I don't really want it. But then he said, have another one. It doesn't taste as bitter the next time. So I had it and then it tasted a lot sweeter. However, it is important to note that many participants in the qualitative focus groups were reluctant to impute this motivation to themselves, instead suggesting that this may be a reason for *other* people's consumption. This may be influenced by participants' self-image, and therefore may not accurately reflect the degree to which social concerns influence adolescents' decision to consume energy drinks.

*Table 23: Top three motivations for consumption of energy drinks in adolescents.*

| Study (Design) | Sample | Size | Top Motivations for Consumption | | |
|---|---|---|---|---|---|
| | | | #1 | #2 | #3 |
| Costa et al. (2014) (Focus Groups) | 12-15 year olds from two high schools in regional Victoria | 40 (20% female) | Taste | Function* | Social^ |
| O'Dea (2003) (Focus Groups) | 11-18 year olds from one high school in Australia | 78 | Function* | Taste | Soft drink substitute |
| Brownbill et al. (2020) (Focus Groups) | 18-25 (mean age 20.3) year olds studying at one uni and one TAFE in South Australia | 32 (53.1% female) | Function* | Not reported | |
| Francis et al. (2017) (Focus Groups) | 12-25 year olds attending one youth group and/or two independent high schools in Western Australia | 41 (59% female) | Function* | Taste | Social^ |
| Trapp et al. (2020) (Survey) | 12-18 year olds (13.6 ± 1.5) in Western Australia | 3,688 (55.1% female) | Taste (36%) | Social^ (25%) | Function* (18%) |
| Turner (2019) (Survey) | 15-18 year olds (16.6 ± 0.82) in New Zealand | 216 (65% female) | Function* (72.6-85.0%) | Cooling (73.9%) | Taste (72.6%) |

* Function incorporates: to increase energy, to boost sports performance, to wake up or stay awake/alert, to relieve fatigue/stress, and to help study.
^ Social incorporates: "because it was given to me", peer pressure, image, and social norms.

*Deterrents to Consuming Energy Drinks*

The two studies that looked at factors that deterred adolescents from consuming energy drinks were consistent in finding the following as deterrent factors:

- knowledge of the high sugar/caffeine content of the drinks;
- knowledge of the physiological risks associated with them (potential negative side effects); and
- influence from parents and other significant adults (e.g. coaches) or peers.

Parental or other adult influence included both advising adolescents not to consume energy drinks, and modelling behaviour that doesn't normalise the consumption of energy drinks (e.g. by not consuming energy drinks themselves, or purchasing them as a matter of course).

In addition to the factors noted above, Trapp et al. (2020) found that the most common factor determining energy drink consumption among adolescents was taste (not liking the taste, or preferring other drinks). This highlights the strong role that taste plays in adolescents' decision-making around energy drink consumption, and that taste can be a deterrent as well as a motivation for energy drink consumption.

*Summary*

Function and taste were the key motivations identified for adolescents' consumption of energy drinks. Social concerns were a significant third concern, however participants' reluctance to impute this motivation to their own energy drink consumption may have artificially lowered the importance of this motivation in the literature.

Key deterrents to energy drink consumption were knowledge of the sugar and caffeine content of energy drinks and the side effects associated with them, and parental/adult influence. Taste was an important determinant noted by Trapp et al. (2020), which highlights the strong role that taste plays in adolescents' decision-making around energy drink consumption.

## Athletes and military personnel

Only one study examined why army personnel use caffeinated products (Kullen et al., 2019). No studies that sampled athletes examined this question.

In Kullen et al. (2019), Australian army personnel were asked to indicate their reason(s) for using caffeinated products (described to participants as 'energy drinks' and 'caffeine' more broadly), and could select as many reasons as applied from a list provided. The most common reasons for using caffeinated products were "I like it" (57.8%) and "Energy" (37.6%). It is unclear exactly why they 'like it', but it is possible that this response is referring to taste. Other less common reasons were for "Convenience" (5.9%) and "Endurance" (4.6%).[7] However, findings were not reported separately for the different types of caffeinated products examined (energy drinks vs. caffeine more broadly).

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[7] The proportion of consumers selecting all other response options were: "General Health" 1.7%; "Weight Loss" 0.9%; "Hydration" 0.9%; "Muscle Gain" 0.8%. Participants in this study were also able to specify some 'Other' reason for use.

## Pregnant/Lactating Women

No studies examined pregnant or lactating women's motivations for consuming caffeinated food products. However, one study (Forbes et al., 2018) examined the reasons behind pregnant women's decision to decrease or eliminate caffeinated food products from their diet. The top reasons cited for reducing or eliminating coffee and tea were:

- Concern around caffeine's safety risk (51.4% of coffee drinkers; and 20.4% of tea drinkers);
- Concern about the effect on the baby (33.0% of coffee drinkers);
- Aversion (26.0% of coffee drinkers); and
- Nausea (23.3% of coffee drinkers)

The distinction between concern around caffeine's safety risk and its effect on the baby was not clearly distinguished in the study. However, this study suggests that awareness of caffeine recommendations may play an important role in pregnant women's decisions around their caffeinated beverage consumption. This data is discussed further in Research Question 4, in respect of pregnant women's perceptions of the caffeine content of and risks associated with caffeinated food products.

## Broader Populations

Six studies examined why consumers from the broader population consume caffeinated food products (Bunting et al., 2013; Caruso, 2019; Centofanti et al., 2018; Stachyshyn, 2017; Wham et al., 2017; Zhu, 2021). The findings are further summarised below, grouped by the type of subpopulations that were examined.

*Energy drink consumers*

Three studies examined motivations for consuming energy drinks in particular (Bunting et al. 2013; Carso, 2019; Zhu, 2021).

Both Caruso (2019) and Zhu (2021) used the same quantitative survey and examined similar samples (individuals aged 18-39 years who consumed at least one energy drink in the past 3 months). In both of these studies, participants were provided with a list of reasons to select from, including an option to specify their own reason that was not provided on the list. Across both studies, the most prevalent response was 'to stay awake or to help concentrate for work/study' (selected by 90.8% of participants in Caruso 2019, and 81.34% of participants in Zhu, 2021). Other commonly selected reasons were 'to feel awake in general (not for a specific activity)' (76.8% and 69.70%) and taste (61.6% and 66.18%).

Bunting et al. (2013) conducted focus groups with New Zealanders who consume energy drinks at least twice per month, aged 16-35. Across all age groups (16-21 years, 22-28 years, 29-35 years), participants reported primarily consuming energy drinks for their taste. Other important motivational factors were social image/peer pressure (particularly for the younger age group) and perceived physiological effects (i.e., for energy).

*Shift workers*

One study examined caffeine consumption in nurses and midwives who do shift work (Centofanti et al., 2018). This study involved focus groups where participants were asked to discuss a typical night shift and how they cope with shift related fatigue. Participants reported consuming coffee, tea, cola, energy drinks and caffeinated “pre-workouts” to promote alertness when on shift or when driving home. For example, one participant stated: “..I have a pre-workout which I take with me just in case, and it’s got guarana and caffeine in it and stuff, but I’ll only drink that if we’re having a really busy night and I can’t go and have my half hour break. It tastes disgusting, but it works.” This particular quote suggests that taste is not a primary factor for consuming caffeinated products in shift workers. However, it is important to note that this study focused on how participants cope with shift related fatigue, therefore it is possible that shift workers may consume caffeinated products for different reasons when they are outside of this context.

*University students across a range of products*

One quantitative study examined why consumers use caffeinated food products using a sample of New Zealand university students, where the majority (75%) were aged 19-30 years (Stachyshyn, 2017). In this study, participants were provided with a list of statements about the reasons for consuming various types of caffeinated food and beverage products, and were asked to rate on a scale (from ‘strongly agree’ to ‘strongly disagree’) how much they agreed with each statement. The author reported the percentage of participants that agreed with each reason for each product. Overall, motivations for consumption differed according to the type of caffeinated product.

Reasons for coffee consumption, energy drinks, sports supplements and caffeine tablets were primarily due to functional effects (e.g., to wake up and for energy – 80-90% of participants agreed with these statements for these products).

Reasons for tea, chocolate and cola drink consumption were primarily hedonic (e.g., for warmth, for the taste, to relax – 80-90% of participants agreed with these statements for these products).

Tea and coffee were also consumed for social reasons (e.g., when with friends and family – 70-80% of participants agreed with these statements for these products).

Caffeinated RTDs were consumed primarily for social reasons (e.g., when with friends [91.8%], because others are drinking them [78.7%]), and also for the alcohol content (85.2%). Peer pressure was a less common motivating factor for consuming RTDs (40%).

Overall, consuming caffeinated products to replace other foods or meals was not a prominent motivating factor (6-35% of participants agreed with this statement across different products). However, the most common caffeinated foods that were used for this purpose were sports supplements (approx. 35%), coffee (approx. 30%) and energy drinks (approx. 20%).[8]

Advertising was also a less prominent reason for caffeine consumption in university students (10-40% of participants agreed with this reasoning across different products).

*General population across a range of products*

One study examined why consumers from the general population consume caffeinated food and beverage products (Wham et al., 2017). In this study, New Zealanders aged 15-51 years participated in focus groups where they viewed pictures of different caffeinated products and were asked what influences them to consume these products. Similarly to the study that examined university students, consumers from the general population reported consuming caffeinated products for a variety of reasons, depending on the type of product.

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[8] These percentages are approximate estimates taken from graphs available in the paper. Exact percentages were not reported in the paper.

Coffee, tea, energy drinks, soft drinks and caffeine tablets were used for functional effects (to wake up, to stay awake and/or to improve performance). Coffee, pre-workout sports supplements, sports gels and caffeine tablets were used to improve athletic performance and endurance. Sports supplements and caffeine tablets were perceived to be more suitable for competitive athletes, whereas coffee and energy drinks were deemed more appropriate for recreational athletes. Coffee, energy drinks and caffeine tablets were also consumed for mental stimulation and enhanced concentration while studying and at work.

Reasons for consuming some products (chocolate, coffee, tea, RTDs) were also hedonic (as these provided comfort and relaxation and regulated mood).

Female participants (proportion not quantified) reported replacing food with tea, coffee or energy drinks to control calorie intake or because of lack of money or time.

Tea and coffee were also consumed for social reasons (e.g., offering these beverages to visitors was seen as a social norm).

Peer pressure and a need to feel accepted were further motivational factors driving RTD consumption, as well as their alcohol content and ease of drinking. In older individuals (aged <30 years), taking a caffeinated RTD to social events was seen as more socially acceptable than taking a bottle of spirits, so that they wouldn't be "seen as a drinker." Young men also saw sports supplements as a status symbol, using them to fit into a "gym goer" image. When consumed in conjunction with resistance training, peer influence, advertising, and social acceptance were more important motivational factors than physiological need.

Caffeine tablets were consumed with alcohol as an alternative to taking illegal drugs, as this was perceived as a "legal high."

Advertising was another factor driving consumption of caffeinated products, particularly energy drinks and RTDs. Energy drinks were seen as being marketed towards teenagers, whereas RTDs were seen as being marketed towards young adults.

*Summary*

Overall, consumers from the broader population are motivated to consume caffeinated food products for a variety of reasons, depending on the type of food product. This also likely depends on the context in which the product is consumed, and possibly other sociodemographic factors (e.g., occupation).

In New Zealand energy drink consumers, the primary motivation for consuming energy drinks was for the taste. Social image (particularly for younger age groups) was the second most important motivator, followed by psychological or physiological benefit ('energy'). In Australian energy drink consumers, the primary motivator for consumption was physiological benefit (to stay awake), followed by taste.

In a sample of Australian nurses and midwives who do shift work, caffeine (including coffee, tea, cola, energy drinks and caffeinated "pre-workouts") were used to promote alertness while on shift or when driving home.

For New Zealand university students, as well as the general population, motivations for consumption differed across different caffeinated food and beverage products. Reasons for coffee consumption, energy drinks, sports supplements and caffeine tablets were primarily due to functional effects (e.g., to wake up and for energy). Young men may also see sports supplements as a status symbol, using them to fit into a "gym goer" image. Reasons for tea, chocolate and cola drink consumption were primarily hedonic (e.g., for warmth, for the taste, to relax).

Tea and coffee were also consumed for social reasons (e.g., when with friends and family). Caffeinated RTDs were consumed primarily for social reasons (e.g., when with friends, because others are drinking them), and also for the alcohol content.

Peer pressure was another factor driving RTD consumption in the New Zealand general population. However, this was a less prominent motivator for New Zealand university students.

Advertising was another factor driving consumption of products in the New Zealand general population, particularly energy drinks and RTDs. Energy drinks were seen as being marketed towards teenagers, whereas RTDs were seen as being marketed towards young adults. However, advertising was not cited as a prominent reason for caffeine consumption in university students.

Finally, some consumers (particularly females) may consume caffeinated products (particularly coffee, tea, sports supplements and energy drinks) to replace other foods and meals. This may be to reduce calorie intake or because of lack of money or time.

# Research Question 4: What are consumer understandings and risk perceptions of caffeinated food products?

This section seeks to examine the following areas: To what extent do consumers understand the caffeine content of caffeinated food products? Do consumers understand the risks associated with caffeine consumption?  Do consumers report perceived side effects?  Do consumers understand what is a safe level of caffeine consumption? It is important to note that controlled medical research examining the *actual* risks/side effects of caffeine goes beyond the scope of this literature review. Rather, these studies examined consumer *perceptions* of the risks/side effects, which may or may not reflect the *actual* risks or side effects associated with caffeine consumption.

## Overarching Findings

*What is the level of consumer understanding of the caffeine content of caffeinated food products?*

Few studies examined consumer awareness of the caffeine content of caffeinated products. However, the available evidence suggests that consumers may not always be aware that a product contains caffeine. Specifically, there was evidence to suggest that younger adolescents may not be aware that energy drinks contain caffeine. Additionally, consumers from the broader population may be unaware that caffeinated ready-to-drink alcoholic beverages (RTDs) contain caffeine. Consumer awareness of the caffeine content of other products was not directly examined, however, findings from one study indicate that older consumers from the general population are at least aware that energy drinks contain caffeine.

*Do consumers understand what is a safe level of caffeine consumption?*

No studies examined consumer awareness of the recommended daily limit of caffeine (i.e., 400 mg/day for adults, adolescents and athletes; 3 mg/kg bw/day for children; 200 mg/day for pregnant women).The limited evidence available regarding consumer understanding of the health risks associated with caffeinated food products is further reviewed below.

*What is the level of consumer understanding of the risks associated with caffeinated food products?*

For children, adolescents and consumers from the broader population, there was an awareness that health risks were associated with energy drink consumption. However, there was some evidence that children and adolescents may not understand the specific nature of the health risks, and many of the health risks associated with energy drinks are not related to their caffeine content. For example, consumers from the broader population acknowledged specific health risks such as tooth decay, heart problems, high blood pressures, and weight gain. In children and adolescents, awareness of 'health risks' tended to discourage energy drink consumption. In comparison, although consumers from the broader population had a greater understanding of the health risks, it is unclear whether they viewed the risks as being applicable to them, or whether this had an impact on their consumption. There was a general view that the risks are associated with overconsumption of energy drinks. However, as noted above, it is unclear whether consumers know what constitutes as 'overconsumption.' No studies examined consumer awareness of the risks associated with caffeinated food products beyond that of energy drinks for these subpopulations.

One New Zealand study found that pregnant and/or lactating women were aware of caffeine recommendations and had changed their consumption behaviour. However, the recommendations they were aware of did not align with the 200 mg/day caffeine limit, as the New Zealand Food and Nutrition Guidelines for Healthy Pregnant and Breastfeeding Women recommend a limit of 300 mg/day. Furthermore, the exact proportion of those who were aware of the recommendations, or the risks underpinning them, was not reported. One Canadian-based study indicated that at least some pregnant women may be aware of the safety risk of caffeine, as one-half and one-fifth of women cited the safety risk of caffeine as a motivation for reducing coffee and tea consumption, respectively. In addition, there is circumstantial evidence that pregnant women may be aware that there are risks associated with caffeine use during pregnancy due to a strong trend towards reducing their caffeine intake noted across multiple studies. However, this could occur due to other reasons (e.g. nausea), and it is unclear whether pregnant women are aware either of specific risks associated with caffeine or (as noted above) the safe recommended limit of 200 mg/day.

*Do consumers report perceived side effects?*

Some children and adolescents reported perceived negative side effects from consuming energy drinks and/or caffeinated sugary drinks. No studies examined whether children and adolescents report perceived negative side effects from other caffeinated products.

Most consumers from the broader population report perceived negative side effects from consuming caffeinated food and beverage products. Additionally, some perceived themselves as being "addicted" or "dependent" on caffeine, particularly for coffee and energy drinks. In the New Zealand general population, negative side effects caused consumers to reduce their caffeine intake. Conversely, coffee and energy drinks were still regularly consumed by New Zealand university students despite adverse symptoms. This finding, coupled with the finding that some individuals regularly exceed the recommended daily limit of caffeine (as discussed under Research Question 2: 'How do consumers use caffeinated food products'), indicate that some consumers are unable to self-regulate their caffeine intake. It is also unclear whether consumers view their perceived negative side effects as a high risk to their health.

A more detailed description of the findings is provided below, grouped by the type of subpopulation.

## Children

Five studies were found that examined children's perceptions and understanding of caffeinated food products. No studies were found from Australia or New Zealand. Four studies were from Europe and concerned children's risk perceptions of energy drinks, and one study was from the United States and concerned children's risk perceptions of caffeinated sugary drinks.

*What is the level of consumer understanding of the caffeine content of caffeinated food products?*

In Visram et al.'s (2017) qualitative focus group study with 37 students from low socio-economic areas in northern England, they reported that participants in both age groups (10-11 years and 13-14 years) appeared to have a good level of knowledge about key ingredients (undefined) in energy drinks.

*What is the level of consumer understanding of the risks associated with caffeinated food products?*

Three studies inquired into children's understanding of the risks associated with energy drinks. One study was based on focus groups, while two were survey-based. It is important to note that, in all of these studies, no distinction was made between perceived health effects stemming from the consumption of caffeine and other ingredients in energy drinks.

In focus groups, Visram et al. (2017) found that students were aware that there were potential health risks associated with energy drink consumption, but were not certain precisely how their health could be affected.

In Gallimberti et al.'s (2013) survey of energy drink consumption among 913 students aged 11-13 years in north-eastern Italy, they asked students "In your opinion, are [energy drinks] bad for your health?". 18.8% of respondents to this question answered "No", 56.7% answered "Yes", and 24.4% answered "I do not know". Students who were "less than weekly" drinkers (n=850) were more likely to answer "Yes" (60.4%), with 15.2% in this cohort answering "No" and 24.4% answering "I do not know". Students who were "at least weekly" drinkers (n=62) were more likely to answer "No" (69.3%; compared to 6.4% "Yes" and 24.2% "I do not know"). Students were not asked specifically about the health risks associated with the caffeine content of energy drinks.

In Martins et al.'s (2018) cross-sectional study of students aged between 11-17 years old (n=1,404) in northern Portugal, awareness of potential health risks associated with energy drinks were assessed by asking "What do you think about energy drink use effects on your health?" Respondents were able to select from four responses: "They are good because they increase my energy", "No harm in sporadic consumption", "May have some consequences for my health" and "No opinion." Almost half of the sample (48%) answered that there was no harm in sporadic energy drink consumption, about one third (32%) of the sample answered that it may have some consequences for their health, 7% believed that energy drinks had positive health effects, and the remainder (13%) had no opinion.

*Do consumers report perceived side effects?*

Two studies, one survey and one focus group study, asked children about perceived side effects from energy drinks or caffeinated sugary drinks. As above, it is important to note that no distinction was made between perceived side effects from caffeine and other ingredients in energy drinks or caffeinated sugary drinks.

Students in Martins et al. (2018) were also asked if they perceived any discomfort or symptoms after energy drink consumption. Respondents were able to select from the following list of symptoms: “Agitation or anxiety”, “Insomnia or trouble to sleep”, “Accelerated heart beat”, “Headache”, “Tremors” and “Other”. 30.5% of the energy drink users within the total sample claimed to have some symptom or discomfort after consumption, with the most common complaints being agitation or anxiety (36.2%) and insomnia (31.9%). Less common symptoms were accelerated heart beat (tachycardia) (17.3%), and headache (9.6%), with peripheral tremors and “other” scoring the least at 2.5% each.

In Sylvetsky et al.’s (2020) focus group study of 37 children aged 8-14 years (mean age 10.5 ± 1.9 years) from low-income minority populations in Washington, D.C. in the United States, children reported adverse effects relating to consumption of caffeinated sugary drinks. These included gastrointestinal consequences, headaches, fatigue, chronic disease, and hyperactivity.

*Do consumers understand what is a safe level of caffeine consumption?*

Students in Visram et al. (2017) expressed confusion and uncertainty about what constituted high levels of caffeine in the context of energy drinks.

*Summary*

Each of the four studies inquired into children’s perceptions of the risks associated with energy drinks or caffeinated sugary drinks in a different way, which makes comparison between the studies challenging.

Three studies found that children were aware of health risks being associated with energy drinks, but did not make a distinction between health effects associated with caffeine and other ingredients in energy drinks. One study (Visram et al. 2017) suggested that, while children may have a good level of knowledge of the ingredients and potential risks of energy drinks, they were uncertain about what constituted safe levels of consumption.

In two studies (Martins et al. 2018 and Sylvetsky et al. 2020), children reported adverse effects from consuming energy drinks or caffeinated sugary drinks, although the reported symptoms differed between studies.

## Adolescents

Five studies looked at adolescents’ understanding and risk perceptions concerning caffeinated food products, all of which focused specifically on energy drinks. Four were conducted in Australia, and one was conducted in New Zealand.

*What is the level of consumer understanding of the caffeine content of caffeinated food products?*

Three studies examined adolescents’ understanding of the content of energy drinks.

In focus group studies with adolescents, both Costa et al. (2014) and Francis et al. (2017) found that some participants (some of the youngest, according to Costa et al.) were not aware that energy drinks contained caffeine. Costa et al. (2014) found that these participants instead attributed the stimulant effect of energy drinks to their sugar content. Francis et al. (2017) found that the participants who *were* aware that energy drinks contained caffeine and sugar were not sure how much they contained. In contrast, Brownbill et al. (2020) found that participants were aware of the high caffeine content of energy drinks. The variance in findings is likely due to the much higher age range of participants in Brownbill et al.'s study, who were 18-25 years old compared to 12-15 year olds and 12-25 year olds in the other two studies. This suggests that younger adolescents may be less well informed about the caffeine content of energy drinks, although this is in contrast to the findings from Visram et al. (2017), which found that children were aware of the 'key ingredients' (undefined) in energy drinks.

Costa et al. (2014) and Francis et al. (2017) found that there was some confusion about the difference between energy drinks and other sorts of drinks such as non-caffeinated sports drinks, and other soft drinks (both caffeinated and non-caffeinated), with these other drinks often believed to also be 'energy drinks' due to their perceived sugar and/or caffeine content.

*What is the level of consumer understanding of the risks associated with caffeinated food products?*

Three studies looked at adolescents' understanding of the risks associated with energy drinks. It is important to note, however, that no distinction was made between perceived risks associated with caffeine and other ingredients in energy drinks.

Although a proportion of their sample was unaware of the caffeine content of energy drinks, most participants in Costa et al.'s (2014) study were found to be aware of the potential negative health effects of energy drink consumption. Participants believed that energy drinks were "bad for you", that "they can be hurtful to your system… you can get heart attacks from them" and that they can "keep you awake". In addition, most participants considered energy drinks to be addictive, but the mechanism of addiction was poorly understood, with some participants attributing it to the sugar content.

Francis et al. (2017) found that some adolescents had heard about the potential negative health effects of energy drinks on the news or on social media, although some questioned the legitimacy of the warnings.

In contrast, O'Dea (2003) found that none of the participants in her focus groups discussed any negative or potentially dangerous effects of the nutritional supplements she studied (including energy drinks). She suggested that this could either be because of a poor knowledge of these issues, or that the potential risks were ignored in favour of the perceived benefits (such as improved energy or sports performance). The lack of discussion of negative side effects could be a result of the time period in which this study was done, 10 years earlier than that conducted by Costa et al. (2014). Over the intervening years, energy drinks have become more common with their potential side effects perhaps more widely known as a result.

*Do consumers report perceived side effects?*

Four studies (three focus groups [Costa et al. 2014, 2016, and Francis et al. 2017] and one quantitative survey [Turner 2019]) found that adolescents reported perceived side effects from energy drink consumption. As above, it is important to note that in all of these studies no distinction was made between perceived side effects from caffeine and other ingredients in energy drinks.

Costa et al. (2016) found that 53.2% of participants had experienced at least one negative side effect. Francis et al. (2017) reported that 79.5% of participants had experienced at least one perceived effect, but this included beneficial effects such as "increased energy".

Perceived negative side effects that were consistent across studies included heart-related side effects (racing heart, irregular heartbeat, heart pains and/or palpitations), insomnia, nausea, tremors, stress or anxiety, and restlessness or inability to concentrate.

In contrast, O'Dea (2003) found that none of the participants in her focus groups discussed any negative or potentially dangerous effects from nutritional supplements, which included energy drinks. This may be due to the different time periods in which the research was undertaken – the studies that found adolescents reporting perceived side effects were all conducted more than ten years later, when energy drinks have become more common with their potential side effects perhaps more widely known as a result.

*Do consumers understand what is a safe level of caffeine consumption?*

Three studies investigated consumers' understanding of safe levels of energy drink consumption. These studies were not comparable in their measures, and hence are narratively described below.

Costa et al. (2016) found that 9.7% of participants perceived it to be appropriate for children aged less than 12 years to consume two or more energy drinks per day, which would be in excess of the recommended daily maximum of 120 mg/day for children aged 9-13 years.

Brownbill et al. (2020) found that, although caffeine was of concern to their participants, they did not know what quantity of caffeine in beverages should be considered harmful to health. For example, one 20 year old male participant said, "I saw the caffeine content [in the energy drink] is still 13, it's actually pretty like, in milligrams, is that high or is that low?"

*Summary*

The literature suggests that adolescents, particularly younger adolescents, often do not understand the caffeine content of energy drinks – with some not realising that they contain caffeine at all. However, most participants were aware of or had personally experienced negative side effects associated with the consumption of energy drinks, such as a racing heart, insomnia, nausea, and tremors. The consistency in findings across studies, with the exception of one study that was conducted more than ten years earlier than the other studies (when energy drinks were less common or well-known), lends a good degree of confidence to these findings.

Brownbill et al. (2020) found that consumers did not understand how to interpret milligrams of caffeine in terms of its effects on their health.

## Athletes and army/military personnel

No studies examined athletes' or army/military personnel's understanding of caffeinated food products.

## Pregnant/Lactating Women

One New Zealand study considered pregnant and lactating women's understanding of the risks associated with caffeine consumption. The study, which evaluated the dietary choices of 458 women during pregnancy and lactation reported that women "were aware of caffeine recommendations and commonly reported avoiding caffeine entirely or choosing decaf versions, rather than limiting intake" (Brown et al., 2020, pg. 7). However, the exact proportion of women who were aware of the recommendations, or the risks underpinning them, was not reported. It is also noted that the recommendations outlined in the New Zealand Food and Nutrition Guidelines for Healthy Pregnant and Breastfeeding Women, which Brown et al. (2020) refer to, do not align with the 200 mg per day limit utilised in this review. Rather they suggest, "caffeinated beverages should be limited; for example, no more than six cups of tea or instant coffee". The New Zealand Food Composition Database lists a 250 mL cup of tea as having a caffeine content of 57.5 mg and a 250 mL cup of instant coffee as having a caffeine content of 82.5 mg. Six cups of tea or instant coffee would therefore equate to 345 – 495 mg of caffeine.

More broadly, the fact that pregnant women typically reduce their caffeine intake and generally adhere to the recommended daily intake of 200 mg/day (see Research Question 2), suggests some understanding of the risks associated with caffeine use during pregnancy. Table 28 provides further detail on the six studies that reported on the change in consumption of caffeinated products, before and during pregnancy.

As outlined in Table 28, the majority of pregnant women studied either decreased or stopped caffeine consumption across all sources during pregnancy (64.9% – 77%), while only a small proportion were found to have increased their intake across all sources (2.8% - 8.3%).

Change in consumption during pregnancy varied more when looking at specific product types however, with 16.5% - 84% decreasing or stopping caffeine intake from a single source, and 1.2% - 10.5% increasing intake from a single source. While each study measured or reported the change in slightly different ways, coffee was consistently the most commonly ceased or reduced source, with only a very small proportion (1.2% to 1.6%) increasing their intake. Tea and soda intake were also consistently decreased during pregnancy, with the exception of Roman-Galvez et al. (2021) who found that caffeine intake from soda increased during pregnancy in their Spanish sample. This study also reported an increase in caffeine intake from chocolate during pregnancy, which aligns with Castillo et al.'s (2016) finding that a higher proportion increased intake of chocolate (10.5%) compared with coffee (1.2%) or soda (5.1%). Castillo et al. (2016) also found that while the majority (64.9%) of their sample reported reducing their intake of caffeinated products overall, most women reported maintaining their intake from coffee (62.5%) soft drinks (73.1%) and chocolate (72.9%), individually. This may suggest that pregnant women are also reducing caffeine from other sources not measured by Castillo et al (such as tea or energy drinks), or that participants found it difficult to estimate caffeine intake across the whole diet.

In addition to these studies, one Japanese study (Okubo et al., 2015) found a striking difference between the proportions of total caffeine intake contributed by coffee and Japanese and Chinese tea between pregnant women (14.3% and 73.5%, respectively) and non-pregnant women (46.8% and 43.0%, respectively). The study authors speculate that many pregnant women are advised by clinical practitioners to avoid caffeine in the form of coffee and black tea. However, a lack of awareness of the caffeine content in Japanese and Chinese tea may have resulted in many pregnant women not reducing their intake of this form of caffeine, and in fact they may have increased it as a substitute for coffee consumption.

Only one study (Forbes et al., 2018) examined the reasons behind pregnant women's decisions to decrease or eliminate caffeinated food products. As reported in Research Question 3, the top reasons cited for reducing or eliminating coffee and/or tea were:

- Concern around caffeine's safety risk (51.4% of coffee drinkers; and 20.4% of tea drinkers);
- Concern about the effect on the baby (33.0% of coffee drinkers);
- Aversion (26.0% of coffee drinkers); and
- Nausea (23.3% of coffee drinkers).

This data shows that concern about caffeine risk is a key motivator for reducing the consumption of coffee among approximately half of mothers, whereas there is less concern about caffeine-related risks associated with tea, perhaps due to its lesser caffeine content. No data was collected concerning motivations for reducing soft drink consumption.

The consistent pattern in overall decreased consumption of caffeinated beverages, combined with half of women citing caffeine-related risks as a motivation, suggest that there is a level of awareness of the risks associated with caffeine consumption. However, there is no data investigating whether pregnant women are specifically aware of, or have received advice consistent with, the 200 mg recommended daily limit for caffeine.

*Table 24: Studies reporting the change in caffeine consumption by caffeine source, before and during pregnancy*

| Study & Sample | Coffee | Tea | Soft drinks/ Cola | Chocolate |
|---|---|---|---|---|
| **Browne et al (2011)** United States (n=9,988) | Increased or no change: 16% | Increased or no change: 35% | Increased or no change: 25% | Not reported |
| | Decreased or stopped: 84%^ | Decreased or stopped: 65%^ | Decreased or stopped: 75%^ | |
| **Chen et al. (2014)** United States (n=8,347) | Increased: 1.6% | Increased: 4.8% | Increased: 4.4% | Not reported |
| | No change: 11.9% | No change: 19.8% | No change: 15.3% | |
| | Decreased or stopped^^: 65.7% | Decreased or stopped^^: 56.0% | Decreased or stopped^^: 62.2% | |
| **Forbes et al. (2018)** Canada (n=379) | Increased or no change (all sources): 23% | | | |
| | Decreased or stopped caffeine intake (all sources): 77% | | | |
| **Castillo et al. (2016)** Spain (n=1,175) | Increased (all sources): 8.3% | | | |
| | No change (all sources): 26.8% | | | |
| | Decreased (all sources): 64.9% | | | |
| | Increased: 1.2% | Not reported | Increased: 5.1%* | Increased: 10.5% |
| | No change: 62.5% | | No change: 73.1%* | No change: 72.9% |
| | Decreased: 36.2% | | Decreased: 21.6%* | Decreased: 16.5% |
| **Roman-Galvez et al. (2021)** Spain (n=463) average daily caffeine intake by source | Pre-pregnancy: 69.9 mg/day | Pre-pregnancy: 6.2 mg/day | Pre-pregnancy: 13.4 mg/day | Pre-pregnancy: 6.2 mg/day** |
| | Trimester 3: 64.0 mg/d | Trimester 3: 3.3 mg/d | Trimester 3: 15.9 mg/d | Trimester 3: 14.8 mg/d** |
| **Stefanidou et al. (2011)** Italy (n=260) | Increased caffeine consumption: 2.8% | | | |
| | No change in caffeine: 30.8% | | | |
| | Decreased or stopped caffeine consumption: 66.3% | | | |

^ Calculated based on the proportion of mothers who reported drinking more or the same level of caffeine.
^^ Calculated by combining percentages for 'decreased' and 'stopped' in order to derive a comparable figure.
*Combines reported values for cola and light cola
**Combines reported values for milk and dark chocolate

*Summary*

The proportion of mothers reducing their caffeine intake from caffeinated beverages such as coffee, tea, and soft drink during pregnancy *may* suggest an awareness of both the caffeine content of these products and the risks associated with their consumption during pregnancy. This was supported by a Canadian finding that around half of women and one-fifth of women cited the safety risk of caffeine as a motivation for reducing coffee and tea reduction respectively. However, there are other reasons (such as aversion or nausea, or concerns around other ingredients such as sugar) that could contribute to the decision to make these dietary changes. It is unclear whether pregnant women are specifically aware of the safe recommended caffeine limit of 200 mg/day.

## Broader Populations

Seven studies examined consumer perceptions and understanding of caffeinated food products in broader populations (Booth et al., 2020; Bunting et al., 2013; Caruso, 2019; Peacock et al., 2016; Stachyshyn, 2017; Wham et al., 2017; Zhu, 2021). The evidence is further summarised below, grouped by the sub question that was addressed.

*What is the level of consumer understanding of the caffeine content of caffeinated food products?*

Only one study reported findings relevant to consumer understanding of the caffeine content of food products (Wham et al., 2017). In this study, New Zealanders aged 15-51 years participated in focus groups where they were asked a series of questions about caffeinated food products, including what products they perceive as having caffeine in them. The authors reported that those who consumed RTDs were unaware of their caffeine content. Consumer awareness of the caffeine content of other food products was not directly reported on. However, findings by Bunting (2013) indicate that consumers are at least aware that energy drinks contain caffeine (this study is further discussed under the next section below).

*What is the level of consumer understanding of the risks associated with caffeinated food products?*

Three studies reported findings relevant to consumer understanding of the risks associated with energy drink consumption (Bunting et al., 2013; Caruso, 2019; Zhu, 2021).

Two of these studies (Caruso, 2019; Zhu, 2021) used quantitative surveys and examined similar samples (individuals who consumed at least one energy drink in the past 3 months, aged 18-39 years). These studies found that most of these consumers reported awareness of the health effects associated with drinking energy drinks. In Zhu (2021), most consumers (69.39%) responded ‘yes’ to the question: ‘Do you know of any illnesses or health effects associated with drinking energy drinks?’. In Caruso (2019), participants were asked to rate, from a prompted list, the potential health risks associated with energy drink consumption (1=not at all; 3 = somewhat; 5 = a great deal). The authors reported the proportion of the sample that showed some awareness (i.e., those who selected 3 or above). Knowledge of tooth decay (93.33% of participants), heart or cardiovascular complications/disease (86.90%), type 2 diabetes (85.52%), high blood pressure (85.06%) and weight gain (82.76%) was highly prevalent among consumers. However, knowledge of depression (44.60%) and cancer (39.77%) was less common. It is unclear whether participants in these studies had an understanding of the amounts of energy drinks that could result in these health effects, and whether they believed that they were personally at risk.

Further insights into consumer awareness of the risks associated with energy drink consumption is provided by Bunting (2013). This study involved focus groups with individuals aged 16-35 years, who consumed energy drinks at least twice per month. Participants in the youngest age group (16-21 years) were aware that energy drinks can induce potential health problems, however, they generally believed that energy drinks were safe because they thought they would not be on sale if the caffeine levels were too high. Conversely, participants in the older age groups showed scepticism about the safety of energy drinks. They were concerned about the level of caffeine in energy drinks, and associated this with negative health consequences such as palpitations and vomiting. Across all age groups, negative health effects of energy drinks were associated with overconsumption, as opposed to general consumption of energy drinks.

*Do consumers report perceived side effects?*

Three studies reported on consumers' perceived side effects from caffeinated food and beverage products (Booth et al., 2020; Stachyshyn, 2017; Wham et al., 2017).

In Wham et al. (2017), New Zealanders aged 15-51 years participated in focus groups where they were asked about their perception of caffeinated foods and beverages. Some participants (proportion not reported) reported that caffeine had no effect on them, whereas others reported perceived negative side effects from consuming coffee and energy drinks, such as heart palpitations, tremors, migraines and/or diarrhoea. Some participants also viewed themselves as being "addicted" or "dependent" on caffeine, and reported experiencing headaches or tremors when ceasing consumption. Coffee, soft drinks, and energy drinks were seen as addictive, the latter two due to their high sugar content. Participants in this study reported ceasing caffeine use when negative effects occurred.

Two quantitative studies found that most participants reported perceived negative side effects from caffeine consumption. In a sample of the New Zealand general population, Booth et al. (2020) found that nearly 85%[9] reported at least one caffeine-related harm in the past 12 months. The most common harms were dehydration (48%), feeling dependent (47.2%), insomnia (47.1%), irritability (44.2%) and headaches (43.5%)[10]. It was not reported whether participants in this study ceased their caffeine intake when negative effects occurred.

Similarly, in a sample of New Zealand university students, Stachyshyn (2017) found that 84.7% reported at least one perceived adverse symptom post caffeine consumption. Common symptoms were "needing to pee a lot" (42.5%), "unable to sleep" (38%) "feeling excited" (37.4%), "a fast heart or uneven heartbeat" (32%) and "an upset stomach" (30%). Most consumers (64.2%) also reported that they were dependent on caffeine, particularly for coffee and energy drinks. Just under half (47.5%) of consumers also reported at least one withdrawal symptom shortly after stopping consumption of caffeine (such as tiredness or drowsiness, difficulty concentrating, mood changes and headaches). In contrast to Wham et al. (2017), coffee and energy drinks were still regularly consumed despite adverse symptoms (by 77.3% and 76.9% of symptomatic participants, respectively).

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[9] "Nearly 85%" is the wording provided by the authors in the paper. The exact figure is not provided.

[10] Other harms included: Desire for sugar (42.1%), fatigue (36.9%), upset stomach (34.6%), spending too much (33.6%), increased heart rate (30.3%), teeth stains (27.7%), reduced functioning (26.6%), muscle tremors (26.5%), skin problems (14.9%).

*Do consumers understand what is a safe level of caffeine consumption?*

No studies examined consumer awareness of the safe recommended level of caffeine (400 mg/day).

*Summary*

Consumers may not always be aware that a product contains caffeine. Specifically, one study found that consumers from the broader population were unaware that caffeinated RTDs contain caffeine. Consumer awareness of the caffeine content of other products was not directly examined, however, findings from one study indicate that consumers are at least aware that energy drinks contain caffeine.

Most people from the broader population report perceived negative side effects from consuming caffeinated food and beverage products. Additionally, some perceived themselves as being “addicted” or “dependent” on caffeine, particularly for coffee and energy drinks. In the New Zealand general population, negative side effects caused consumers to reduce their caffeine intake. Conversely, coffee and energy drinks were still regularly consumed by New Zealand university students despite adverse symptoms. However, it is unclear whether consumers viewed the negative side effects as a high risk to their health. Additionally, no studies examined whether consumers are aware of the safe recommended daily limit of caffeine (400 mg/day).

Furthermore, consumers of energy drinks are generally aware of the health risks associated with energy drink consumption, however, it is unclear whether they view these health risks as being applicable to them. There was a general view that the risks are associated with overconsumption, although it is unclear whether consumers know what constitutes a safe level of consumption.

# Research Question 5: Where do consumers get their information about caffeinated food products?

This section seeks to answer the following research question: Where do consumers get their information about the safety, recommended usage levels and/or performance benefits of caffeinated products, and how to use these products?

## Overarching Findings

Advertising and parents or other significant adults (e.g. coaches) were the key sources of information concerning energy drinks and/or caffeinated sugary drinks for children and adolescents. Parents could play a role in either discouraging or normalising the consumption of energy drinks or caffeinated sugary drinks, however their influence over adolescents' behaviour waned as they grew older. Mandatory advisory statements on energy drinks were not a key source of information.

Athletes sourced their information about supplements or sports foods from medical professionals (dietitians/nutritionists, doctors, pharmacists, sports scientists), coaches, family/friends, and the internet. One Australian study that investigated whether elite swimmers read the labels of supplements/sports foods found that they usually consult the label, although they were not asked about the importance of different labelling elements or the label's importance relative to other information sources.

No studies considered caffeine specific information sources during pregnancy and lactation. However, two New Zealand studies found that midwives were the most common, trusted, or influential source of dietary information during pregnancy and lactation. While midwives remained influential during lactation, the internet and family friends became relatively more important sources of information than they were during pregnancy. In addition, one of the studies found that overall 88% of participants reported using the New Zealand Food and Nutrition Guidelines for Healthy Pregnant and Breastfeeding Women.

No studies directly examined where consumers from the broader population receive their information about caffeinated food products. However, consistent with the findings for children and adolescents, one study found that advertising was a key factor driving consumption of caffeinated products in a sample of the New Zealand general population. This was particularly the case for energy drinks and RTDs. Advertising may therefore serve as an important information source for consumers from the broader population. However, it is important to note that other potential information sources were not directly examined, and therefore it is unclear whether advertising is a more prominent source of information than other sources within the broader population. Two additional studies also found that the majority of consumers could not accurately recall advisory statements on the label of energy drinks.

A more detailed description of the findings is provided below, grouped by the type of subpopulation.

## Children

No studies specifically examined children’s information sources concerning caffeinated food products, however there was incidental data in two studies that are suggestive of children’s information sources in respect of energy drinks and caffeinated sugary drinks.

In Visram et al.’s (2017) qualitative focus group study with 37 students from low socio-economic areas in northern England (aged 10-11 years and 13-14 years), participants reported seeing a range of different media through which they were targeted with promotional messages about energy drink products. These included: the internet (in the form of pop-ups or banners at the side of webpages), television (including energy drink consumption or product placement during popular shows), computer games, bus-stop advertisements, supermarket promotions, and sponsorship of sports or other entertainment events.

As noted in Research Question 3, Visram et al. (2017) found that parents, carers, and other significant adults (like sports coaches) played a role in either facilitating or limiting children’s access to energy drinks, and normalising their consumption or not. For example, one boy (10-11 years) reported that “[Coach says] “Don’t drink [energy drinks] before football, just bring some water”. [. . .] The coach just cares for you and he wants to look out for you. And he doesn’t want your heart full of junk” (Boy, 10–11 years) .

In Sylvetsky et al.’s (2020) focus group study of 37 children aged 8-14 years (mean age 10.5 ± 1.9 years) from low-income minority populations in Washington, D.C. in the United States, the vast majority of participants reported that they obtained caffeinated sugary drinks from their parents and consumed them while at home. This suggests the role that parents may play in normalising the consumption of caffeinated sugary drinks and implying that they are an appropriate drink for children.

*Summary*

Children’s information sources included the media, parents/carers, and other significant adults. Parents could play a role in either discouraging or normalising the consumption of energy drinks or caffeinated sugary drinks. There was no mention of advisory statements on caffeinated beverages as a source of information.

## Adolescents

Two qualitative Australian studies examined adolescents' information sources for energy drinks. Costa et al. (2014) conducted focus groups with 40 adolescents aged 12-15 years from two high schools in regional Victoria, while Francis et al. (2017) conducted group interviews with 41 adolescents aged 12-25 years from a youth group or two independent high schools.

Costa et al. (2014) and Francis et al. (2017) both found that parents were often sources of information about the negative health effects of energy drinks, and played a role in discouraging use particularly among younger adolescents. However, parents could also normalise the use of energy drinks by encouraging or condoning their use for functional outcomes, such as alleviating fatigue for sports and recreation.

Participants in both studies also recalled energy drink advertising campaigns, including on the Internet, in convenience, department and gaming stores, and through promotion in video games and sports sponsorship. Few participants in Francis et al. (2017) were aware of the advisory statements on energy drink labels, and no mention of advisory statements was made by participants in Costa et al. (2014).

*Summary*

The literature found that parents play a role in providing information about energy drinks to adolescents, although this could either discourage or normalise energy drink consumption. Advertising was a key source of information about energy drinks for adolescents. Advisory statements, however, had little mention.

## Athletes and army/military personnel

Four studies examined where athletes get information about supplements or sports foods (Clancy, 2020, Study 1; Pumba, 2007; Shaw, 2012; Shaw, 2013). All studies used quantitative survey designs, where participants were provided with a list of information sources to select from, including an option to specify their own source that was not on the list. Although participants in these studies were not asked about caffeinated products in particular, these findings still provide some insight into influential information sources for this subpopulation in general. No studies examined this question in army/military personnel.

Overall, the most prevalent information sources were professional advice (dietitians /nutritionists, doctors, pharmacists, sports scientists), coaches, family/friends, and the internet. However, it is difficult to determine which of these top information sources were *most* prevalent, as studies gave participants a list of options to choose from, and this list varied across studies and therefore makes it difficult to compare relative rankings across studies.

Only one study directly examined whether athletes read the labels of supplements/sports foods (Shaw, 2013). In this study, elite swimmers were asked how often they read the labels of supplements/sports foods before taking them (on a scale from 1 [Always] to 5 [Never], where a rating of 3 indicated 'Sometimes'). The group median rating was 2, indicating that the frequency of label reading was between 'sometimes' and 'always.' Participants were not asked about the importance of specific types of information on the label (e.g., list of ingredients vs. claims, etc.), or asked how important labelling information was compared to other information sources.

## Pregnant/Lactating Women

No studies considered caffeine specific information sources during pregnancy and lactation. However, two New Zealand studies considered where pregnant and lactating women source general dietary advice, including on caffeine. Across both studies, midwives were the most common, trusted or influential source of dietary information during pregnancy.

In a 2020 study of 458 New Zealand women, Brown and colleagues identified the both sources of dietary information during pregnancy and lactation, and those that were most influential. 87% of participants received dietary advice from a lead maternity carer, and 40% of women attending antenatal classes received dietary advice from those classes. Pregnant women also used information sheets on food safety (54%) and general healthy eating (40%).

Midwives were the most influential source across pregnancy and lactation, for 37% and 30% of participants respectively. During pregnancy, midwives were followed by the New Zealand Food and Nutrition Guidelines for Healthy Pregnant and Breastfeeding Women (NZPBG) at 25%, and family and friends at 8%. However, the most influential information sources shifted during lactation, with alternative health practitioners (26%) and family and friends (12%) becoming relatively more influential.

The study also reported the use of different information sources during lactation. 77% of participants received information from their lead maternity carer (typically a midwife), 67% from the internet, 67% from family and friends and 45% from the NZPBG. The charity Plunkett (44%), other parents (44%), health professionals (33%), and books/magazines/newspapers (31%) were also sources for many women. Similar data on the use of dietary information sources was not provided for pregnant women.

Of participants who avoided certain foods (such as alcohol, raw milk and milk products, and raw, smoked or pre-cooked fish and fish products) 88% of pregnant women and 48% of lactating women reported doing because they were following the NZPBG. Other influential sources of information for avoiding foods in pregnancy was advice from health professionals (68%), advice from the internet, magazines, books, or newspapers (36%), and advice from family and friends (27%).  Other influential sources of information for avoiding foods during lactation was advice from health professionals (28%).

In a 2010 study of 6,882 women from the ‘Growing Up in New Zealand’ cohort, Morton and colleagues considered the most common and most trusted sources of dietary information during pregnancy. As in Brown et al. (2020), midwives were both the most common (73.8%), and most trusted (83.6%) source of information, with GPs the second most common (34.7%) and most trusted (69.4%). Other health care providers, including obstetricians (7.6%), dietitians/nutritionists (3.6%) and antenatal classes (6.7%) were relatively less common sources. The GP finding was in contrast to Brown et al. (2020), which found that just 4% of pregnant and 3% of lactating women reported GPs as their most influential source of dietary advice. This difference may be due to the measures of importance used – common and trusted, vs influential. It may also reflect differences in the sample (Morton et al. (2010) used a larger, nationally representative sample compared to Brown et al. (2020)’s non-representative sample), or a genuine change between when the data was collected from both studies (Morton et al. 2009-2010, Brown et al. 2019).

In further contrast to Brown et al. (2020), Morton et al. (2010) found that books, magazines and newspapers were more commonly used than the internet to find dietary information during pregnancy with 29.3% using books and 17.7% using the internet as their most common source. This difference may reflect a change in internet usage patterns between when the data was collected for both studies.

Alternative health practitioners were also infrequently the most common information source, at just 1.5% of participants. This was comparable to 2% of pregnant women reporting alternative health practitioners as their most influential source during pregnancy in Brown et al. (2020). This supports Brown et al.'s finding that alternative health practitioners are influential for some women during lactation, but less so during pregnancy. They suggest that the greater reliance on these, and other 'unreliable' sources like the internet or family and friends during lactation, may be due to the NZPBG's greater emphasis on pregnancy over lactation.

## Broader Populations

No studies directly examined where consumers from the broader population get information about caffeinated food products.

However, as previously described under Research Question 3 ('Why do consumers use caffeinated food products?'), one study found that advertising was a key factor driving consumption of caffeinated products in a sample of the New Zealand general population (Wham et al., 2017). This was particularly the case for energy drinks and RTDs. Energy drinks were seen as being marketed towards teenagers, whereas RTDs were seen as being marketed towards young adults. Advertising may therefore serve as an important information source for consumers from the broader population. However, it is important to note that other potential information sources were not directly examined in this study, and therefore it is unclear whether advertising is a more prominent source of information than other sources within the broader population.

Also of relevance to this question, two Australian-based studies (Caruso, 2019; Zhu, 2021) examined consumers' awareness of advisory statements on energy drinks. In these studies, participants were asked: "Are you aware of any warnings currently on energy drink cans?" (response options were yes/no/don't know). Participants who answered yes were then asked to recall the detail of these statements, and if they were unsure to write 'don't know'. Content analysis was used to determine the presence of correct key word responses. Just under half of the participants correctly recalled (or partially correctly recalled[11]) daily limit information (48-51%). Even smaller percentages of the participants correctly recalled (or partially recalled) other information on the label, including 'not recommended for pregnant or lactating women' (39-42%), 'contains caffeine' (6-18%), 'Not recommended for children' (12%), 'Not recommended for individuals sensitive to caffeine' (10-11%), and 'consume responsibly' (0.5-2%)[12]. These studies indicate that the majority of consumers may not pay attention to advisory statements on the label of energy drinks, which suggest that they may not be prominent information sources.

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[11]In these studies, the authors combined the percentage of participants who correctly recalled all elements of an advisory statement, as well as those who correctly recalled at least one element of a typical advisory statement. Examples were not provided for what would constitute as a partially correct recall.

[12] Although the statement 'consume responsibly' was deemed to be a correct response in this study, manufacturers are not legally required to have this statement on the label of energy drinks under the Code.

# Research Question 6: Do consumers feel they have sufficient information about caffeinated food products?

This section seeks to examine whether consumers feel they have sufficient information to enable them to make an informed choice regarding their caffeine intake. If additional information was desired, it also sought to understand the preferred sources.

## Overarching Findings

Limited information was available on the perceived sufficiency of caffeine information. Children, adolescents and consumers in the broader population wanted the advisory statements on energy drink labels to draw more attention to them and to provide more specific advice. For children and adolescents, this included more interpretive measures of caffeine content, plain language to describe potential negative health effects, and a recommended age limit. Consumers from the broader population more vaguely reported a desire for more clearly defined safety labelling on energy drinks. It is important to note that these findings were in the context of participants being prompted to suggest additional information on energy drink labels, and the studies did not examine the effect of these potential labelling changes on consumers' consumption behaviours. Labelling effectiveness was beyond the scope of the current literature review. Adolescents also reported an interest in education campaigns for energy drinks, with trusted GPs identified as a preferred source.

No studies examined caffeine information sufficiency for athletes, military personnel and pregnant and lactating women. However, one additional study identified that midwives, who are a key source for dietary information for pregnant and lactating women, often lack knowledge and confidence in providing nutritional advice.

A more detailed description of the findings is provided below, grouped by each subpopulation.

## Children

One European study was found that examined children's perception of information sufficiency concerning energy drinks.

In Visram et al.'s (2017) qualitative focus group study with 37 students from low socio-economic areas in northern England (aged 10-11 years and 13-14 years), participants suggested that information about caffeine content could be presented on energy drinks in ways that are easier for children and young people to understand by including some form of interpretation rather than a mg amount.

Other suggestions included using plain English on packaging to describe potential health effects (e.g. instead of using unfamiliar terms like insomnia), and featuring a "Think before you drink" sign, or making the text about potential health risks more visible. Many participants suggested that there should be a clear age restriction visible on energy drinks. One female participant aged 10-11 years was reported as saying, "[The packaging] doesn't exactly say, 'Don't give it to someone under age 16'."

## Adolescents

Two Australian studies considered information sufficiency around energy drinks for adolescents.

Costa et al. (2016) found that participants were unaware of the current recommendations that energy drinks are not appropriate for children, and that there is a need for clearer information and education about the potential harm of energy drinks for children and adolescents.

As noted in Research Questions 4 and 5, Francis et al. (2017) found that few participants were aware of the advisory statements written on energy drink cans. Participants were also confused by the serving size on labels and how they related to caffeine content. Because labels on both 250 mL and 500 mL cans stated that they contained 1 serving per package, many participants concluded that the amount of caffeine in 500 mL cans was equivalent to those in 250 mL cans. For example, one 22 year old male participant said, “All of those cans over there are one serve. That one’s just more concentrated. They’re just bigger to make you think you’re getting more.”

When asked to consider strategies for decreasing consumption of energy drinks by young people, participants in Francis et al. (2017) suggested a range of labelling options. These included:

- Changing the font size and colour of advisory statements to increase their visibility;
- Stating a specific age under which energy drink consumption is not recommended (either 16 or 20 years, depending on respondent);
- Using interpretive labelling for ingredients, including caffeine;

The other major avenue of information suggested by adolescents was education campaigns, including:

- school visits and education sessions with interactive activities and experiments
- news stories and television announcements about the negative health effects;
- informing trusted sources of information such as parents and general practitioners.

Francis et al. (2017) found that trusted general practitioners were a preferred source for delivering health messages to adolescents and young adults

## Athletes and army/military personnel

No studies directly examined athletes or army/military personnel’s perceptions of information sufficiency concerning caffeinated food products.

## Pregnant/Lactating Women

No studies examined whether pregnant or lactating women feel that they have sufficient information to enable them to make an informed choice regarding their caffeine intake.

Brown et al. (2020) provided some commentary on their New Zealand finding that midwives are a key source of dietary information during pregnancy and lactation (see Research Question 5). Citing previous studies, they highlight that midwives often lack knowledge around nutrition, and do not feel confident giving nutritional advice. This was particularly true for vegetarian women and those with a health condition. However, this commentary did not relate specifically to recommended caffeine intake, which may be more straightforward than other dietary advice.

### Broader Populations

Only one study examined consumer perceptions of information sufficiency concerning caffeinated food products (Bunting et al., 2013).

Bunting et al. (2013) conducted focus groups with New Zealanders who consume energy drinks at least twice per month, aged 16-35 years. Participants in the older age groups (aged 22-35 years) expressed a desire for more clearly defined safety labelling on energy drink products. They were concerned about the potential dangers of children consuming energy drinks, and highlighted the vulnerability of children to advertising for energy drinks.

# Limitations

The purpose of this literature review was to examine the existing evidence regarding consumer behaviour, understanding, risk perceptions, and information sources regarding caffeinated foods. The primary relevant demographic for this evidence review is Australian and New Zealand consumers. However, for some subpopulations (children and pregnant/lactating women) it was necessary to draw on the international literature to supplement a small number of available studies. Furthermore, most available Australian- and New Zealand-based studies did not use nationally representative samples. The findings may therefore not be generalisable to all Australians and/or New Zealanders, particularly those from ethnic minorities.  There was a lack of studies that specifically examined First Nations Australian, Māori, or Pasifika communities.

Secondly, studies commonly examined different types of caffeinated food products and/or different timeframes of use. For example, some studies only examined consumption of energy drinks or caffeinated beverages, while others considered caffeine intake across various types of foods and beverages. Studies that examined athletes and army/military personnel in particular tended to only examine consumption of caffeinated supplements or products that may be regulated as a formulated supplementary sports food under the Code (such as sports gels). This limits some prevalence and intake information, as caffeine may not have been measured across the entire diet, or in a way that can be compared across studies. Conclusions are therefore made cautiously where appropriate.

Thirdly, it is acknowledged that caffeine intake and motivations for consuming caffeine were generally measured through self-report, which is limited by recall bias and social desirability bias. However, this is an inherent limitation of any questionnaire, and therefore some level of these biases is unavoidable.

The methodological approach of this review is also not without limitations. Firstly, relevant literature was found from searching six databases. While we selected databases based on their appropriateness for the search topic (and availability to FSANZ), it is possible that additional relevant literature was missed from other databases. However, this possibility was mitigated by searching for further literature via other sources (i.e., searching the reference lists and citing studies of all obtained studies, searching files from FSANZ's earlier work relevant to sports foods).

Secondly, it is acknowledged that only one officer screened and extracted data for each study, and that database searching was limited to studies from 2010 onwards. However, this was necessary in order to provide a timely evidence synthesis, and these are commonly used approaches when conducting rapid systematic reviews (Tricco et al., 2015).

# Conclusions

This review examined literature from 2010-2022 on consumer behaviour, understanding, risk perceptions, and information sources regarding caffeinated food and beverage products. It includes a specific focus on the subpopulations of children, adolescents, athletes, and pregnant and/or lactating women as well as the broader population. No studies were found that examined caffeine-sensitive individuals.

The review is based on 65 studies, predominantly from Australia and New Zealand, except for children and pregnant/lactating women where it was necessary to draw on the international literature to supplement a small number of available studies.

Most of the Australian and New Zealand studies did not use nationally representative samples. The findings may therefore not be generalisable to all Australians and/or New Zealanders, particularly those from ethnic minorities. There was a lack of studies that specifically examined First Nations Australian, Māori, or Pasifika communities.

Studies also commonly examined different types of caffeinated food products and/or different timeframes of use. This limits some prevalence and intake information, as caffeine may not have been measured across the entire diet, or in a way that can be compared across studies. Acknowledging these limitations, there are a number of conclusions that can be made. These are grouped by research question below:

**Research Question 1: Who consumes caffeinated food products?**

The majority of children, adolescents, pregnant women, and the general population consume caffeinated food and beverage products, across all different age groups. At least some athletes and military personnel use caffeinated sports supplements such as gels, gums, and capsules, however the prevalence varied widely across studies (from 10.8% to 49% for athletes; 1.4% to 73% for military personnel).

Prevalence of use for different caffeinated food and beverage products was only available for adolescents, university students, pregnant women and the general population. In adolescents and university students, the top three caffeinated products were chocolate, coffee, and tea.  In the general population, they were soft drink, coffee, and energy drinks – however, chocolate was not examined in this study. International literature highlights that pregnant women commonly consume coffee and tea, but this was influenced by cultural factors. For example, soda was the most common drink in the United States, while coffee was more prominent in Italy. Note, however, that prevalence does not necessarily mean that these products contributed the most to overall caffeine intake.

Older children and adolescents were more likely to consume caffeinated products or beverages than younger children and adolescents. In the general population, age was associated with prevalence of consumption for energy drinks in particular, with younger people (those aged 18-49) more likely to consume energy drinks than older people (those aged 50+ years).

Sex was associated with the likelihood of consumption of some products.  Caffeinated soft drinks were more likely to be consumed among male adolescents than female adolescents, and energy drinks were also more likely to be consumed by males among children, adolescents, army personnel, and the general population. In adolescents and university students, females were more likely than males to consume tea, coffee and chocolate.

Employed adolescents and university students (either part-time or full-time) were more likely to consume energy drinks and (for university students only) caffeine tablets than those who were unemployed. Perhaps related, one study found that energy drink consumption was associated with adolescents who had more discretionary money (at least $40/week) compared to those who had less (less than $10/week). There were, however, mixed findings about the influence of socioeconomic status on likelihood of caffeine consumption.

First time mothers were less likely to consume caffeine than those experiencing their second or subsequent pregnancy.

**Research Question 2: How do consumers use caffeinated food products, and are they consuming them within the recommended daily limit?**

The majority of the general population and each examined subpopulation appear to be consuming caffeine within the relevant recommended daily limits (i.e., 400 mg/day for adults and athletes; 3 mg/kg bw/day for children, 5.75 mg/kg bw/day for adolescents, and 200 mg/day for pregnant/lactating women). There is no evidence that adolescents are exceeding the recommended daily limit of caffeine on a regular basis. There is evidence, however, that a subset of pregnant women (typically less than 15%), and the general population (14-33%) exceed the limits on a regular basis. One study (among university students) found that coffee consumers were significantly more likely to exceed the safe limit of caffeine than those who do not consume coffee.

There is little evidence that children are regularly exceeding the recommended daily limit of caffeine. One international study found that a very small proportion of children (less than 0.6%) exceed the recommended daily limit by consuming cola and energy drinks. One South Australian study found that at least some 8-12 year olds exceed the recommended daily limit, however the exact proportion was not reported. There was no available evidence on caffeine consumption in children based on New Zealand studies.

For children and adolescents, the top contributors tended to be soft drinks, tea, chocolate, and/or coffee. One study found that a subset of adolescents (less than 3.4%) report exceeding the daily safe limit of caffeine solely by consuming energy drinks. However, as this finding only reflects days in which energy drinks were consumed, it is unclear whether adolescents are exceeding the recommended limits on a regular basis. Coffee and tea were the top contributors for pregnant women. In the broader population, coffee was consistently the highest contributor to caffeine intake. The proportions contributed by other products varied between studies but included energy drinks, caffeinated 'ready to drink' alcoholic beverages, and tea. Two studies found that a subset of individuals from the broader population (proportion not quantifiable) are either reaching or exceeding the daily safe limit of caffeine by solely consuming energy drinks.

Sports foods were not a major contributor to daily caffeine intake in children, adolescents or a sample of university students. However, no studies directly examined the contribution of sports foods products to total caffeine intake in athletes, pregnant women or the general population. There was some evidence relevant to sports foods consumption among athletes and the general population. However, this evidence was limited by a lack of direct examination of the contribution that sports foods make to daily caffeine intake, and category definition issues in which the "caffeine/sports supplements" measured included but also extended beyond the definition of 'formulated supplementary sports foods' within the Code.

One study found that a subset of individuals from the general population (proportion not quantifiable) may be exceeding the daily safe limit of caffeine solely by consuming caffeine tablets, medications, and/or sports supplements. It is not possible to determine which of these products was the major contributor to exceeding the daily recommended limit of caffeine as they were combined into one category.

The available evidence also suggests that some consumers among athletes, military personnel, and the general population may consume multiple sports foods products, although it is unclear if the products in question contained caffeine. Five quantitative studies reported that athletes/military personnel consume multiple sports foods products, although it is unclear whether these are consumed within the same day (i.e. stacking behaviour). In addition, one qualitative study found that consumers from the general population use multiple types of sports food products within the same day. Although it is unclear whether these studies examined consumption of caffeinated sports foods in particular, they still provide insight into how consumers use sports foods more broadly. This is of relevance should caffeinated sports foods become more prominent in the market.

There were similar sociodemographic factors for those consumers who were more likely to consume caffeine, and who had a higher consumption of caffeine. Age was associated with the level of caffeine consumption in both children and adolescents, with older children and adolescents being more likely to consume greater amounts of caffeine than younger children and adolescents. Increased age was also associated with increased caffeine consumption among university students.

There were mixed findings about the influence of sex on overall caffeine intake, however sex *was* significantly associated with the proportion of caffeine intake associated with particular caffeinated food products. In line with the findings in Research Question 1 regarding the prevalence of consumption of caffeinated food products, adolescent females had higher caffeine intakes from tea, and males had higher intakes from soft drinks and energy drinks.

There is evidence that socioeconomic status may influence overall caffeine intake among children, with higher socioeconomic status correlated with lower total caffeine consumption.

Among pregnant women, the sociodemographic factors associated with caffeine intake were generally mixed. Some studies found that those who had higher caffeine intake were significantly more likely to have had a previous pregnancy, to be older, and to also smoke tobacco or consume alcohol. Whereas other studies found that these factors were not significantly associated with caffeine intake. The reasons for these inconsistent findings is unclear, and thus confidence in these findings is low.

**Research Question 3: Why do consumers consume caffeine?**

Research on motivations for consuming caffeinated food products differed across subpopulations and product types. The majority of the research on children and adolescents focused on motivations for consuming caffeinated soft drinks and/or energy drinks, whereas studies that examined consumers from the broader population tended to examine motivations for consuming a wider variety of caffeinated food and beverages. Across these studies, however, recurring motivations were: taste, a desire for increased energy, and social considerations. No studies examined why athletes or pregnant/lactating women consume caffeinated food products.

Some studies also looked at the reasons why participants did *not* consume certain caffeinated food products. There is some evidence that children and adolescents were deterred from energy drink consumption when aware of the risks associated with their sugar and/or caffeine content. There is also some evidence that pregnant women reduced their caffeine intake due to concerns about safety risks, particularly in regard to coffee. For more information on consumers' understanding of safety risks, see the following section.

**Research Question 4: What is consumers' understanding of caffeinated food products and their risks?**

Few studies specifically examined consumer awareness of the caffeine content of caffeinated products. However, there is some evidence that consumers may not always be aware that caffeine has been added to certain beverages. Specifically, two studies suggested that younger adolescents may not be aware that energy drinks contain caffeine. One additional study found that consumers from the broader population may be unaware that caffeinated ready-to-drink alcoholic beverages contain caffeine. Consumer awareness of the caffeine content of other products was not directly examined, however findings from one study indicate that older consumers from the general population are aware that energy drinks contain caffeine.

No studies examined consumer awareness of the recommended daily limit for caffeine.

Six studies found that children, adolescents and consumers from the broader population were aware of 'health risks' associated with energy drink consumption. However, there was some evidence that children and adolescents may not understand the specific nature of these health risks or whether they were related to the caffeine content. In addition, two studies (one with children and one with adolescents) found that most of their participants were not aware that there were any health risks associated with energy drink consumption. No studies examined consumer awareness of the risks associated with caffeinated food products beyond energy drinks for these subpopulations.

There is evidence that at least some pregnant and/or lactating women are aware that caffeine consumption poses a risk during pregnancy. However, it is unclear whether pregnant women are specifically aware of the safe recommended caffeine limit of 200 mg/day.

Most consumers from the broader population reported perceived negative side effects from consuming caffeinated food and beverage products. However, this did not always cause consumers to reduce their caffeine intake. In one study, coffee and energy drinks were still regularly consumed by New Zealand university students despite experiencing adverse symptoms. This finding, coupled with the finding in Research Question 2 that some individuals regularly exceed the recommended daily limit of caffeine, suggest that some consumers are unable to self-regulate their caffeine intake.

**Research Question 5: Where do consumers get their information about caffeinated food products?**

No studies directly examined where consumers receive their information about caffeinated food products. However, advertising was a recurring theme in discussions of energy drinks among children, adolescents, and the broader population. Parents/carers or other significant adults also played an important role in discouraging or normalising energy drink consumption among children and adolescents, although one study found that general practitioners were the preferred avenue for health messages among adolescents.

Advisory statements on energy drinks were not a reported source of information among any of the studies. In addition, two studies found that the majority of consumers among the broader population could not accurately recall advisory statements on the label of energy drinks.

Athletes sourced information about supplements or sports foods from medical professionals, coaches, family/friends, and the internet. One Australian study of elite swimmers found that they usually read the label of supplements/sports foods.

Among pregnant women, midwifes were the most important sources of dietary information during pregnancy. While midwives remained influential during lactation, the internet and family friends became relatively more important than they were during pregnancy.

**Research Question 6: Do consumers feel they have sufficient information about caffeinated food products?**

Children, adolescents and consumers in the broader population wanted the advisory statements on energy drink labels to draw more attention to them and to provide more specific advice. For children and adolescents, this included more interpretive measures of caffeine content, plain language to describe potential negative health effects, and a recommended age limit. Consumers from the broader population more vaguely reported a desire for more clearly defined safety labelling on energy drinks. It is important to note that these findings were in the context of participants being prompted to suggest additional information on energy drink labels, and the studies did not examine the effect of these potential labelling changes on consumers' consumption behaviours. Labelling effectiveness was beyond the scope of the current literature review. Adolescents also reported an interest in education campaigns for energy drinks, with trusted GPs identified as a preferred source.

No studies examined whether athletes, military personnel, and pregnant/lactating women felt that they had sufficient information.  However, one study identified that midwives, who are a key source for dietary information for pregnant/lactating women, often lack knowledge and confidence in providing nutritional advice.

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# Appendix 1: Literature Review Methods

All decisions regarding inclusion/exclusion criteria were made prior to the literature search commencing, except where otherwise stated.

## Inclusion criteria

The review included studies that examined, both in the general population and in certain subpopulations (children, adolescents, athletes, pregnant/lactating women, and caffeine sensitive individuals):

- Prevalence and level of caffeine use;
- How consumers use caffeine (i.e., whether they are using them at the recommended levels, use of multiple caffeine products, which products are contributing to overall caffeine intake);
- Consumers’ reasons or motivations for consuming caffeine;
- Consumers’ perceived risks/side effects of caffeine products;
- Consumers’ knowledge of the safe level and risks of caffeine consumption;
- Consumers’ information sources (current and preferred) regarding the safety/recommended usage of caffeine; and/or
- Whether consumers feel the information available to them regarding caffeine is sufficient.

No restrictions were placed with respect to study type (e.g. experiments, surveys, focus groups, interviews, observational studies).

## Exclusion criteria

Searches were limited to papers available in English. Studies that collected data prior to 2000 were excluded to ensure that the data were reflective of more recent consumption trends in the population. The review also excluded studies that primarily examined:

- Safety/toxicology of caffeine;
- Caffeine’s physiological effects, including the effects of caffeine on foetal development and birth outcomes, or on sports performance (ergogenic effects);
- Associations between caffeinated beverage consumption and alcohol consumption, drug use, smoking, or vaping;
- Associations between caffeine consumption and other physiological, neurological or health effects, (e.g. obesity [including in offspring], energy consumption, mental health, sleep quality, etc.);
- Associations between psychological traits (e.g. sensation-seeking or risk-taking personality) and caffeine consumption;

- The amount of sugar, energy, and/or caffeine in products;

- The marketing of, or a survey of the market regarding, caffeine products;

- Effectiveness of labelling or education in helping consumers make informed choices regarding their caffeine intake.

Studies examining the effectiveness of labelling or education were excluded because the primary aim of the literature review was to examine whether caffeine in sports foods and the general food supply poses a significant risk to consumers.

Studies that examined an out-of-scope topic, and only reported prevalence of caffeine consumption as a minor finding (and no other relevant findings) were excluded. This was to keep the number of included studies manageable. Studies that examined an out-of-scope topic, but reported more than one relevant finding, were included.

## Online database searches

Six online databases were searched via EBSCO Discovery (available through the FSANZ library):

- Science Direct
- Food Science Source
- FSTA - Food Science and Technology Abstracts
- MEDLINE with Full Text
- SocINDEX with Full Text
- EconLit with Full Text

Online database searches were undertaken using simple Boolean search term combinations. Searches were undertaken in January 2022 as outlined below. Studies were limited to peer-reviewed journal articles. Studies were also limited to those published in the years 2010-2022 in order to keep the number of hits manageable and to ensure the data were reflective of more recent consumption trends in the population.

*Search string 1[13]:*

(caffeinate* OR caffeine*) AND (consumer* OR child* OR adolescen* OR teenage* OR youth OR pregnan* OR lactat* OR breastfeed* OR “caffeine sensitiv*” OR athlete*) AND AB (understand* OR know* OR aware* OR comprehen* OR value* OR motivat* OR belie* OR attitude* OR concern* OR behav* OR consum* OR purchas* OR deci* OR choice* OR intent* OR judg* OR perce* OR seek*) NOT (HPLC OR electro* OR toxic* OR neuro* OR TBARS OR nutrigenetic OR derm* OR chemic* OR receptor* OR "blood pressure" OR acid OR placebo OR pharmac* OR contamina* OR psychopharmac* OR rat OR cancer OR nicotine OR catechins OR metaboli* OR adeni* OR gene OR alkaloid* OR bitter* OR spectro* OR adiposi* OR OR aqueous OR urin* OR neuronal OR antimicrob* OR psychomotor OR extinction OR "sensory analysis" OR "sensory characteristics" OR fertil* OR composition OR cosmetic OR extraction OR ecstasy OR animal OR anaesthesia OR aggressi* OR violen* OR retardation OR genetic OR "dose-response" OR "sleep hygiene" OR hospitali* OR "maternal nutrition*" OR airway OR OR fetal OR foetal OR "recurrent

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13 ‘TI’ indicates that the terms must be in the title of the study. ‘AB’ indicates that the terms must be in the abstract of the study.

miscarriage" OR preconception OR hypertension OR anemia OR chronotype OR gambling OR “car seat” OR hormon*)

## Other sources/grey literature

To ensure the literature review incorporated a suitably broad range of references, further literature was sought by hand-searching:

- references obtained in the process of conducting FSANZ’s literature review on sports foods (both included and excluded studies);
- the reference lists of all included studies.
- studies that have citied any of the included studies (using Google Scholar).

## Research review process

The literature review utilised a staged approach depending on the availability of Australian/New Zealand literature to answer each research question for each subpopulation.

The search process initially identified 1,096 potentially relevant documents; 574 after EBSCO removed duplicates. References were exported to EPPI-Reviewer 4, a web-based software program for managing and analysing data for literature reviews. Duplicates were then removed using EPPI-Reviewer 4 duplicate management tools; references allocated a similarity score of at least 0.95 by the software were automatically excluded. Each remaining potential duplicate identified by the software was manually screened and excluded by one officer

Following removal of duplicates, out of scope papers were removed based on title and/or abstract. Finally, documents identified as out of scope on the basis of full-text review were excluded. At this point, it became clear that there was insufficient information available to answer the research questions based on Australian-/New Zealand-based studies alone for children and pregnant/lactating women. International literature was therefore also included for children and pregnant/lactating women, but excluded for the other population groups. No studies were identified in the international literature for caffeine sensitive individuals.

This overall process resulted in 65 full text documents being included. The screening process was split among three officers (i.e., one officer screened studies that were completed prior to 2017, a second officer screened studies that were completed from 2017 onwards, and a third officer screened the international literature).

Figure A1 shows the number of documents retrieved at various stages of the review process. The information depicted in Figure A1 is based on the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA; Moher et al., 2010).

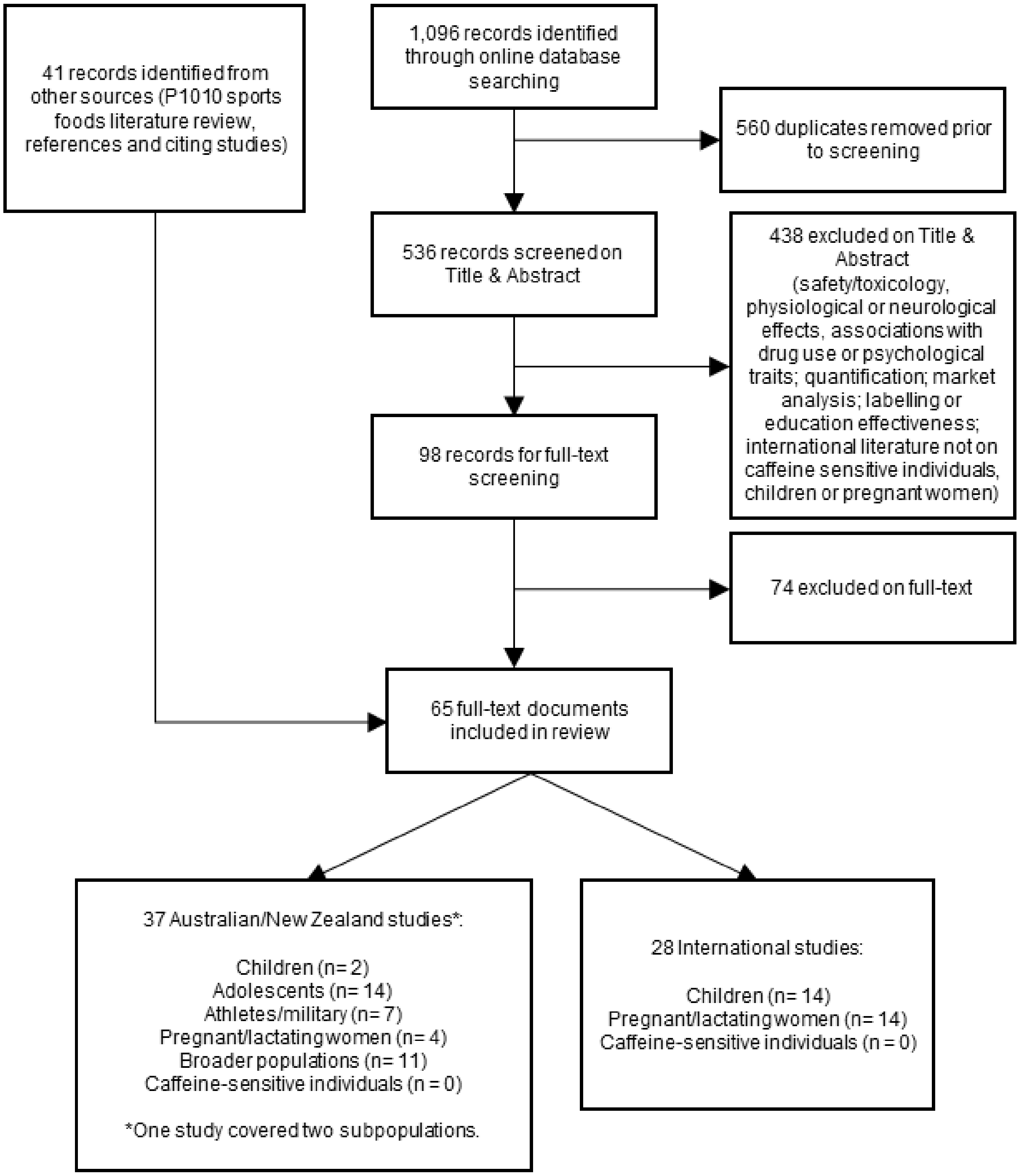


*Figure* **A1***: Number of documents retrieved at various stages of the review process.*

## Data extraction

The data extracted from each study included: Country and sampling approach, summary of data collection methods, research question(s) addressed relevant to the literature review, key findings, strengths and limitations. Data extraction was split among three officers.