

DIETARY GUIDELINES

How much is '5-a-day'? A qualitative investigation into consumer understanding of fruit and vegetable intake guidelines

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Abstract

Background: Despite the known health benefits of fruit and vegetables (FV), population intakes remain low. One potential contributing factor may be a lack of understanding surrounding recommended intakes. The present study aimed to explore the understanding of FV intake guidelines among a sample of low FV consumers.

Methods: Six semi-structured focus groups were held with low FV consumers ($n = 28$, age range 19–55 years). Focus groups were recorded digitally, transcribed verbatim and analysed thematically using NVIVO (QSR International, Melbourne, Australia) to manage the coded data. Participants also completed a short questionnaire assessing knowledge on FV intake guidelines. Descriptive statistics were used to analyse responses.

Results: The discussions highlighted that, although participants were aware of FV intake guidelines, they lacked clarity with regard to the meaning of the '5-a-day' message, including what foods are included in the guideline, as well as what constitutes a portion of FV. There was also a sense of confusion surrounding the concept of achieving variety with regard to FV intake. The sample highlighted a lack of previous education on FV portion sizes and put forward suggestions for improving knowledge, including increased information on food packaging and through health campaigns. Questionnaire findings were generally congruent with the qualitative findings, showing high awareness of the '5-a-day' message but a lack of knowledge surrounding FV portion sizes.

Conclusions: Future public health campaigns should consider how best to address the gaps in knowledge identified in the present study, and incorporate evaluations that will allow the impact of future initiatives on knowledge, and ultimately behaviour, to be investigated.

Introduction

The World Health Organisation (WHO) set a minimum daily target of 400 g of fruit and vegetables (FV), which has subsequently been translated into the '5-a-day' public health message within the UK^(1,2). Despite these guidelines, current population intakes remain suboptimal⁽³⁾.

Knowledge is potentially an important predictor of FV intake^(4–7). Few studies have investigated consumer

understanding of the meaning of the '5-a-day' message, including which foods are included in the guidelines and what counts as a portion of FV. Greater awareness of the amounts and types of FV needed to achieve the recommended guidelines might promote better adherence and increased intake. For example, improved comprehension of what constitutes a portion of FV may enhance consumers' capability and motivation to achieve the recommendations⁽⁸⁾. It might also help individuals to

accurately assess their current FV intake and, consequently, plan dietary changes. Discordant findings between people's perception of their FV intake and their actual intake have been observed. For example, one study⁽⁹⁾ found that, amongst 426 elderly participants, 83% were aware of FV intake guidelines and 35% considered that they were eating sufficient FV. However, a closer examination (using a dietary recall of typical FV intake) of the latter group showed that some individuals were consuming as little as two portions of FV per day. One explanation for this discrepancy might be that the individuals considered they were eating sufficient FV for their health personally, and so did not need to meet the intake guidelines⁽¹⁰⁾. However, another possibility is that participants did not understand how to quantify a portion of FV.

The few studies that have been conducted to date on consumer understanding of FV intake guidelines have primarily investigated knowledge amongst American^(7,11–14), Australian^(8,15–17) and New Zealand consumers⁽¹⁸⁾. Only two studies^(19,20) have investigated knowledge within the UK, and these studies used samples of University students and socially-deprived individuals. Given that FV-based public health campaigns, intake recommendations and portion size (PS) guidance vary greatly between countries (see Supporting information, Table S1), the majority of evidence to date cannot necessarily be generalised to a UK context. Hence, the present study aimed to explore the awareness and understanding of FV intake guidelines, with a particular emphasis on sources of FV and FV PS, within a sample of low FV consumers.

Materials and methods

Study sample and recruitment

The current sample comprised participants taking part in a pilot randomised controlled feeding study, entitled the Biomarkers of Fruit and Vegetable (BIOFAV) study. Full details of the pilot trial have been reported elsewhere⁽²¹⁾. In brief, it was designed to investigate novel biomarkers of FV consumption amongst 32 healthy, low FV (≤ 2 portions) consumers. Participants were recruited through an intranet advertisement published within Queen's University Belfast, and through word-of-mouth. The study was approved by the School of Medicine, Dentistry and Biomedical Sciences research ethics committee of Queen's University Belfast, and participants provided their written informed consent.

Focus group discussions

Six focus groups (FGs) were conducted between August 2011 and May 2012, during the first week of the 4-week

BIOFAV study. The FGs ranged in size between four and six participants. They lasted 45–60 min and were recorded digitally.

The FGs were moderated by the first investigator (CR), with assistance from another researcher (CRD/AJMcG). Moderators received formal training in conducting FGs. To ensure consistency, a semi-structured topic guide was developed based on a prior literature search. The guide was piloted on a group of four research students (age range 20–30 years); sample questions are provided in the Supporting information (Table S2). The co-moderator ensured that all topic areas were covered within each session and volunteers were encouraged to fully express their views, provided that the conversation was relevant to the aims of the research. At the end of each session, participants were asked if they had any other issues they would like to raise.

Questionnaire

Prior to the FGs, demographic information was collected on the sample. A questionnaire about the '5-a-day' FV guidelines was also administered. The purpose of the questionnaire was to provide some context on the sample and also to aid with the interpretation of participant responses during the qualitative discussions.

The questionnaire covered four areas: (i) awareness of the '5-a-day' message; (ii) knowledge on foods that are classified as a fruit or vegetable according to the '5-a-day' message; (iii) PS of commonly consumed FV; and (iv) knowledge on portions provided by combinations of FV (to reflect normal dietary consumption patterns). Participants were firstly asked 'Are you aware of the '5-a-day' message about FV consumption?', to which they could answer 'yes', 'no' or 'not sure'. Secondly, participants were given a categorisation task requiring them to identify foods that counted as a fruit or vegetable according to the '5-a-day' message from a list of 39 commonly consumed foods. A third question showed a list of 27 FV with specific quantities (e.g. four spears of broccoli) and asked participants to record how many portions of fruit or vegetables each would contribute towards the '5-a-day' message (e.g. half portion). Finally, the questionnaire presented seven combinations of FV (e.g. one medium apple, one medium pear and two medium glasses of fruit juice) and asked participants to specify how many portions each set would equate to if eaten within the course of 1 day.

Statistical analysis

FGs were transcribed verbatim by CR. Another study team member listened to the audio recordings and checked this against the transcripts. Data were analysed

using Braun and Clarke's inductive thematic analysis framework⁽²²⁾. This involved six steps: (i) familiarisation with data; (ii) initial descriptive coding of data; (iii) search for themes; (iv) review of themes; (v) naming and defining of themes; and (vi) writing up of results. CR carried out this process, and the transcripts were then read by MCMcK and the codes were checked and compared. Few between-researcher discrepancies were found and consensus was reached through discussion. NVIVO, version 8 (QSR International, Melbourne, Australia) was used to facilitate data coding and management.

Questionnaire responses were analysed using PASW (SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to describe the demographic profile of participants. Categorical data are presented as frequencies and percentages, whereas continuous data are shown as the median and interquartile range (IQR) (as a result of the small sample size). For questionnaire analysis, correct responses were given a score of one, whereas incorrect and 'don't know' responses were given a score of zero, making a maximum possible score of 74. The percentage of correct responses was calculated for each participant for the questionnaire as a whole and for each of the four questionnaire domains. Descriptive statistics were used to report the frequency of correct and incorrect responses, and percentage knowledge scores for the sample are presented as the median and IQR. The small sample size did not permit statistical testing of responses by demographic variables.

Results

Twenty-eight participants took part in the FGs (sample characteristics are shown in Table 1). The main themes that emerged from the analysis of the transcripts were: (i)

knowledge; (ii) education; and (iii) suggestions for improving FV PS knowledge (for a full list of themes, subthemes and quotations, see the Supporting information, Table S3).

Knowledge

Although the majority of participants claimed to be aware of the '5-a-day' campaign, a lack of knowledge was evident regarding the specifics of the message (Quote 1 in Table 2). For example, most participants were confused as to which foods counted as a fruit or vegetable according to the '5-a-day' message. Additionally, when prompted by the moderator, some expressed their surprise at foods such as tomato-based sauces, which they would not have previously classified as a fruit or vegetable (Quote 2 in Table 2). Some participants also said they were unaware that potatoes were not classified as a vegetable according to the guidelines. Most ambiguity existed with regard to composite foods (e.g. spaghetti bolognese and stew), with many participants stating they did not normally count these foods towards their FV intake (Quote 3 in Table 2). One participant also indicated that they were uncertain about what conditions a food needed to satisfy to be classified as a fruit or vegetable (Quote 4 in Table 2).

Most participants also expressed a lack of awareness surrounding PS for FV, and this was the prevailing topic of conversation during the FG discussions about the '5-a-day' message. Respondents mentioned varieties they considered particularly difficult, including lettuce, and the heterogeneity in PS for different FV was highlighted as a factor that made it more difficult to identify a portion of FV (Quote 5 in Table 2). When additional FV guideline rules were discussed (e.g. that fruit juices can only count

Table 1 Demographic profile of participants ($n = 28$)

Characteristics	Overall	Focus Group 1	Focus Group 2	Focus Group 3	Focus Group 4	Focus Group 5	Focus Group 6
Participants (n)	28	4	6	4	4	4	6
Women (n)	15	1	0	4	4	4	2
Men (n)	13	3	6	0	0	0	4
Age (years)*	21 (20–31)	23.5 (19.3–30)	20 (19.8–20.3)	20 (20–20)	31.5 (30.3–33.5)	29 (22.8–48.8)	32 (19–49.8)
Range (years)	19–55	19–31	19–21	20	30–34	21–55	19–55
Occupation (n)							
Employed	10	1	0	0	2	2	5
Unemployed	1	0	1	0	0	0	0
Student	17	3	5	4	2	2	1
Education (years)*	15 (14.3–17.0)	16.5 (15.3–19.3)	15.0 (14.8–15.5)	16.0 (15.3–16.0)	19.5 (15.3–21.5)	18.0 (14.8–21.3)	14.0 (12.8–15.0)
BMI (kg m^{-2})*	22.9 (21.5–25.3)	21.7 (18.7–24.0)	21.5 (21.0–22.5)	24.0 (22.3–31.9)	24.2 (20.9–25.3)	23.0 (22.5–24.9)	27.3 (21.0–31.2)

BMI, body mass index; IQR, interquartile range.

*Median (IQR).

Table 2 Example quotations from focus group discussions

Quotation number	Quotation
Knowledge	
1	It's the big '5-a-day' rather than saying what '5-a-day' (FG2, M, 19 years)
2	I'm very surprised, I wasn't counting tinned tomatoes as a portion (FG5, F, 55 years)
3	Also the sauces, I didn't realise like in bolognaise with a tomato base would have been a portion you know, or even on pizza, I didn't think that would be a portion (FG4, F, 31 years)
4	So this one of five a day, what makes a fruit and vegetable qualify for it, must be a measure of vitamins and mineral levels? (FG1, M, 19 years)
5	And fruit and that have a huge range of what's [a portion], some of the stuff is nothing, some stuff is huge amounts (FG2, M, 19 years)
6	If you eat two oranges does that count as two portions, but if you drink two portions of orange juice it doesn't count? ... why does that make sense again? (FG2, M, 21 years)
7	It's fine for stuff like bananas and all you know is a portion, but whenever you get down to ... stuff that's in sandwiches and in your meals at dinner time ... I think that's a lot harder to work out then (FG3, F, 20 years)
8	Up until a few days ago, I actually thought that it was five portions of veg and five portions of fruit a day (FG2, M, 20 years)
9	Most of my friends wouldn't realise it's five different ones do you know (FG4, F, 30 years)
10	I didn't realise how much fruit and veg I probably ate, because you put so much into dinners and that, and you don't realise but (FG2, M, 20 years)
11	So maybe, you're right, things like the cans of tomatoes and stuff that I would use in cooking, I maybe didn't realise I was getting portions, but on the other hand, I think the fruits I thought I was eating was less (FG5, F, 30 years)
Education	
12	I would read it on the packets, like because I get pre-packed foods (FG3, F, 20 years)
13	I think the last time someone talked to me about that was probably at primary school ... when they talked about eating your fruit and veg (FG5, F, 30 years)
14	Probably grams are the easiest, when you buy it and checking the packaging, you know how much is in there (FG1, M, 20 years)
15	But what's the difference, say it was 75 g or 83 g you know, it's not really that big a difference between them, so being exact isn't really ... (FG2, M, 20 years)
16	I think tablespoons would be a lot easier, cause it takes out the weighing (FG2, M, 20 years)
17	I think it depends on the size of your hands [laughs]. My boyfriend's hands are twice the size of mine, does that mean he needs bigger portions? I'm not too sure, does that mean there is less portions in his meal than there is in mine? Confusing yeah (FG4, F, 32 years)
18	I think it's easier to base it on emm size, like maybe an apple ... it's more difficult with like berries or something, but even if you think you can hold an apple in your hand, and like fit as many blueberries into your hand as you can (FG3, F, 20 years)
19	I would never think of trying to up my consumption to five a day, just cause I wouldn't really know what five, like how much of everything I would need to make five up. But if you knew exactly what I was getting ... I would probably do it (FG1, M, 20 years)
20	It would definitely help me to know what a portion is, it would be general knowledge to me then (FG6, M, 33 years)
21	If I cook, I wouldn't measure one portion, two portions, I won't do that (FG1, M, 31 years)
22	Emm but I don't think I would improve apart from that really, just because it's the fact that for me it's all preparation (FG4, F, 32 years)
Suggestions for improving portion size knowledge	
23	Or even someone standing there to talk to you, to you know, to ... (FG5, F, 55 years)
24	I would hate that (FG5, F, 21 years)

Table 2. (Continued)

Quotation number	Quotation
25	I think like leaflets through doors or, if all packets said on them how much of your five a day that is, you'd be more willing (FG3, F, 20 years)
26	If you had a board like that said you were getting a chicken sandwich with whatever vegetables, how many portions it is a day (FG4, F, 31 years)
27	I think when you're faced with like your meal plan*, and like what you eat in the day, you feel very aware of how you could drop in a couple of portions easily (FG5, F, 21 years)
28	I really just think if you let people know that they can put this veg or this fruit in something easily, they're just going to end up doing it (FG2, M, 19 years)

F, female; M, male; FG, focus group.

*Participants were asked to adhere to set meal plans as part of the Biomarkers of Fruit and Vegetable (BIOFAV) study.

as a maximum of one portion per day), some participants questioned the reasoning behind this rule (Quote 6 in Table 2). Generally, it was suggested by participants that PS for fruit were easier to establish than vegetables, with some mentioning fruit as 'more discrete' (FG1, male, 19 years) and the fact that you could 'use the whole thing' (FG2, male, 20 years). Most participants claimed that composite food dishes including FV (e.g. sandwiches, stew and soup) were particularly difficult to quantify in terms of the number of portions that were provided in one serving (Quote 7 in Table 2).

Variety was a key concept discussed in multiple FGs. First, some participants claimed that they had misinterpreted the '5-a-day' message as meaning five portions of fruit, plus five portions of vegetables a day (Quote 8 in Table 2). Many participants also alluded to the fact that they were not previously aware that FV intake should ideally be comprised of a variety of FV, and some thought that eating five of the same type of fruit or vegetable would be sufficient to meet recommendations (Quote 9 in Table 2).

Finally, in relation to their lack of knowledge of FV PS, some participants expressed that they had difficulty estimating their current intake of FV (Quotes 10 and 11 in Table 2).

Education

Overall, findings from the FGs suggested that participants had received little or no information on what constituted a portion of FV according to intake guidelines. However, some sources of education mentioned included front-of-pack labelling, as well as school and magazine articles (Quotes 12 and 13 in Table 2). There were mixed opinions with regard to the preferred unit of measurement for FV PS. Some said grammes were superior because

this is a universal measurement and is used on packaging (Quote 14 in Table 2). Others expressed concern that they were not familiar with grammes as a form of measurement, it would be a hassle to weigh FV before eating, and there was no need to be so precise (Quote 15 in Table 2). Tablespoons and handfuls were both generally perceived as more useful measures for FV PS (Quote 16 in Table 2). However, some participants considered that handfuls could be confusing because individual hand sizes differ (Quote 17 in Table 2). In two FGs, participants stated that they preferred to guess FV PS based on the size of well-known FV such as an apple (Quote 18 in Table 2).

On the whole, participants agreed that having more information on what constitutes a portion of FV would impact positively on their current FV consumption (Quotes 19 and 20 in Table 2). With increased information, some said they would feel 'more informed' and 'more aware', and that the guidelines would seem 'more achievable'. However, others said they did not think about FV PS, instead preferring to eat depending on their appetite. Some participants also suggested that increased FV PS information would not overcome other barriers towards FV consumption, including routine and preparation (Quotes 21 and 22 in Table 2).

Suggestions for improving portion size knowledge

Suggestions for improved future communication of FV PS included increased information on packaging and displays in the FV produce section of supermarkets. Some participants said they would like personal assistance when shopping for FV (i.e. somebody to inform you of how much you need to make up a portion of FV) (Quote 23 in Table 2), although this idea was refuted by younger participants (Quote 24 in Table 2).

Other proposals included increased FV PS information in eateries that could be used when ordering food, governmental campaigns and more promotional material, including leaflets or posters (Quotes 25 and 26 in Table 2). Assistance with meal planning and FV PS information in recipe books were also suggested as possible motivators for increasing FV intake (Quotes 27 and 28 in Table 2).

Questionnaire results

A summary of the scores from each domain of the FV guidelines questionnaire is provided in the Supporting information (Table S4). All participants were aware of the '5-a-day' FV guidelines and the majority were able to correctly identify foods that counted as a fruit or vegetable (median knowledge score 91%). Only 39.3% and 42.9% of participants correctly stated that jacket potatoes and potatoes, respectively, were not included in the FV count (see Supporting information, Table S5).

The median knowledge score for identifying the portions provided by different amounts of individual types of FV was 37% (see Supporting information, Table S6). For most foods (59%), less than half of the sample correctly answered the portions provided by the stated quantities of FV. More than 50% of participants correctly identified the portions provided by 10 foods only. These were mostly in the form of one 'piece' of fruit or vegetable (e.g. one apple, one banana).

Apart from one combination of FV (one apple, one banana, one glass of fruit juice), the majority of participants ($\geq 50\%$) incorrectly assessed the number of portions provided by different selections of FV (see Supporting information, Table S7). The median knowledge score for this task was 21.4%.

Discussion

Despite awareness of the UK government's '5-a-day' recommendation for FV, the present study demonstrated a lack of knowledge with regard to the specifics of the message. Some misunderstandings of '5-a-day' exist, notably the belief that it recommends five fruit *and* five vegetables per day, and not appreciating the importance of variety. There were also knowledge gaps regarding what is included in the FV recommendation, and a lack of knowledge about what constitutes a portion of FV, or how to actually achieve the recommended intake target.

Identification of fruit and vegetables within the context of the '5-a-day' guidelines

The FG discussions highlighted a lack of clarity with regard to which foods count as a fruit or vegetable

according to the '5-a-day' message. Specifically, individuals demonstrated a deficit of knowledge about whether certain composite foods counted towards FV guidelines. This is in line with the findings reported from another study⁽¹⁴⁾ suggesting that FV consumed in composite dishes were the most difficult to classify for American consumers. The exclusion of composite foods when assessing FV intake can have important implications in terms of the conclusions that are reached regarding current consumption. For example, a study⁽²³⁾ showed that excluding composite foods from FV estimates can misclassify participants as low/nonconsumers of FV. Indeed, a possible explanation for the increase in FV consumption observed in UK adults in the National Diet and Nutrition Survey between 2002⁽²⁴⁾ and 2012⁽⁴⁾ (2.8 portions FV day⁻¹ versus 4.1 portions FV day⁻¹, respectively) is that the most recent survey used disaggregated data for a wider range of composite dishes. Composite foods account for as much as 20–30% of vegetable intake and 10% of fruit intake, thus illustrating the need for consumers to be better informed of the value of FV-rich meals in relation to achieving FV guidelines⁽²⁵⁾. Additionally, the public should be made aware of how to easily incorporate portions into commonly consumed meals. Such information could have a positive impact in terms of making the '5-a-day' target seem more achievable; a point that was strongly advocated in the FGs within the present study.

Although the sample scored well in the questionnaire when asked to identify foods that are classified as a fruit or vegetable, as voiced in the FGs, there was some uncertainty in relation to potatoes, chickpeas and lentils. The international variation in the classification of potatoes, with some countries, such as the USA, including potatoes as a vegetable, and others, such as the UK, excluding potatoes from their FV guidelines (in accordance with recommendations set by the WHO/Food and Agriculture Organization), may be confusing for individuals as indicated by the data gathered in the present study. Regardless of the reason, this is an important finding because it emphasises that some consumers may count potatoes towards their daily intake of FV, and thus they may be over-estimating their consumption. Future education resources should endeavour to clarify this for the general public.

Understanding of fruit and vegetables portion sizes within the context of the '5-a-day' guidelines

Another key finding from the FGs was that the majority of participants had trouble conceptualising a portion of different types of FV, which is a key skill required in understanding the '5-a-day' message. This finding is

consistent with previous studies conducted in the area (8,12,14,15,18–20). Participants generally found it more challenging to decipher the portions provided by FV that were not in the form of one whole food/piece, with some stating that this was the main reason why vegetables were often more difficult to determine in terms of portions compared to fruit. The questionnaire responses reinforced this finding, and also revealed that, when faced with a list of FV, most respondents were unable to tell how many portions the combination would provide. When translated into a normal day-to-day dietary context, this suggests that these consumers are unlikely to be able to accurately assess their own daily intake of FV, and this was acknowledged within the FGs. Hence, it is possible that individuals in the sample are making dietary choices regarding FV consumption based on ill-informed perceptions about their current intake. Regarding another key finding, some participants considered that the '5-a-day' guidelines required the consumption of five portions of fruit in addition to five portions of vegetables per day. This notion has been observed elsewhere (26), and could potentially be demotivating, thus suggesting a need for the refinement of '5-a-day' to facilitate better consumer understanding. There may be some merit, for example, in providing separate intake recommendations for FV, as is the case in Australia ('Go for 2&5' campaign).

From a nutrition research perspective, the lack of PS knowledge presented within the present study emphasises the complexities of measuring FV intake using self-report measures. Some measures of dietary intake, including FFQs, require respondents to report their frequency of consumption of FV based on an 'average portion'. As highlighted in the present study, people are not necessarily aware of what a standard portion of FV equates to and hence the validity of such data might be compromised. In terms of implications for the assessment of FV intake in the future, researchers should provide assistance to respondents when quantifying FV intake (e.g. through the use of a food PS atlas).

One of the key messages advocated by the '5-a-day' campaign is the importance of consuming a variety of FV; however, the present study demonstrates that this message is not well understood. For example, during the FGs, a number of individuals indicated that they believed eating five of the same FV would suffice in terms of achieving the '5-a-day' guidelines. Similarly, Carter *et al.* (16) also found that a sample of Australian participants were unclear as to whether FV intake guidelines stipulated that five different FV needed to be consumed each day. Again, these are important findings in terms of the probability that people are misjudging the adequacy of their FV intake. Participants in the present study also conveyed the notion that eating five of the same FV was

unappealing and an unrealistic target in relation to their satiety. Hence, education on consuming a variety of FV, particularly within meals, could make the guidelines more achievable.

There are a number of proposed explanations regarding why consumers lack an understanding of FV intake guidelines including PS. The first, and perhaps most obvious reason, could simply be a result of a lack of education. Within the present study, for example, the majority of participants claimed to have been exposed to limited information about FV PS, except occasionally from packaged FV sources. A second potential reason, as raised by participants, is the confusion generated by the substantial variation in the amounts of FV needed to achieve one portion.

In terms of the future and regarding how knowledge on achieving a portion of FV could be increased, the results from the FGs suggested that a collaborative effort is required from the food industry (e.g. packaging), retailers (e.g. supermarket displays and eateries) and health promotion bodies (e.g. campaigns and promotional material) to address key misconceptions or deficits in knowledge. With regard to PS information on packaged FV, it is worth noting that no regulations exist within the UK in relation to making claims on the portions provided by FV products. Manufacturers are not obliged to display such details, and thus there is great inconsistency with regard to the level of information currently provided. Furthermore, there is variability in the methods used to communicate PS information to consumers (e.g. various logos have been employed).

What is ambiguous from the present study was how PS information would best be communicated in terms of grammes/household measures. Future studies should seek to clarify this issue. Furthermore, public health campaigns should investigate not only whether increasing PS information can reduce confusion and increase understanding (knowledge), but also whether it has the potential to facilitate long-term increases in FV consumption (behaviour) and overcome other barriers towards FV intake such as those mentioned in the present study (appetite, routine, preparation).

Strengths and limitations

The present study provides some of the first evidence about consumer understanding of FV guidelines within the UK, including the novel topic area of FV PS. However, the findings should be interpreted in light of some limitations. Firstly, the sample comprises a small number of mostly well-educated young adults, with a normal body mass index; thus, the findings may not be generalisable to other groups in the population. However, this

sample of low FV consumers represented an ideal opportunity to investigate understanding of intake guidelines. Secondly, although the FGs were held as close as possible to the start of the 4-week intervention, participants may have sought information on FV from the research team during prior feeding sessions, which could have influenced their attitudes. Similarly, although the quantitative questionnaire was distributed at the beginning of the study, it is possible that participants may have acquired some information on FV during the screening visits. However, this was unavoidable because the questionnaire could not have been distributed before individuals were deemed eligible, and consented into the study. Furthermore, the question assessing knowledge of the '5-a-day' message may have facilitated guessing, which could have potentially inflated the accuracy score. Finally, the questionnaire was neither validated, nor formally piloted prior to use. Although one existing validated questionnaire contains questions on FV PS knowledge⁽²⁰⁾, it assessed knowledge on a limited number of foods and did not examine the understanding of sources of FV, which was a key aspect of the present study. In comparison with most previous studies assessing knowledge of FV intake guidelines, including FV sources and FV PS, the questionnaire used in the present study measured knowledge based on a greater number of items, making it one of the most comprehensive measures to date.

In conclusion, the present study showed some misunderstanding surrounding the UK '5-a-day' message, including what foods are included within the guidelines. It also emphasised a lack of knowledge with regard to FV PS. Future public health campaigns should attempt to address these misconceptions and gaps in knowledge, and incorporate evaluations that will allow the impact of future initiatives on knowledge, and ultimately behaviour, to be investigated.

Transparency declaration

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported, that no important aspects of the study have been omitted and that any discrepancies from the study as planned (and registered with) have been explained. The reporting of this work is compliant with STROBE guidelines.

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Conflict of interests, source of funding and authorship

The authors declare that they have no conflicts of interest.

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CR contributed towards the design of the PS questionnaire, conducted qualitative data collection, carried out all analyses and drafted the manuscript. JW designed the study and was principal investigator on the grant application. ISY, MCMcK and KMA were co-investigators on the grant application, and MCMcK assisted with the analysis and interpretation of the qualitative data. KMA developed the first draft of the PS questionnaire and provided advice on its analysis. CRD, LLH and AJMcG were responsible for participant recruitment and completion of the study protocol. CRD and AJMcG also assisted with the FG discussions. All authors critically reviewed and approved the manuscript.

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Supporting information

Additional Supporting Information may be found online in the supporting information tab for this article:

Table S1. Example of the variation in fruit and vegetable recommendations, public campaigns and portion size information between countries.

Table S2. Sample questions from the topic guide.

Table S3. Knowledge of fruit and vegetable intake guidelines: findings from thematic analysis.

Table S4. Overall and domain scores for fruit and vegetable knowledge questionnaire ($n = 28$).

Table S5. Percentage defining foods as a fruit or vegetable plus overall percentage of correct scores per food item.

Table S6. Percentage correctly identifying portions provided by different amounts of individual fruit and vegetables.

Table S7. Percentage of correct answers when identifying portions provided by combinations of fruits and vegetables.