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A web-based dietary assessment method for exploring iron and zinc bioavailability

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1 Abstract

The absorption of iron and zinc is strongly influenced by food components that are consumed in the same meal. To date, algorithms developed to quantify 'bioavailable' iron and zinc intake have performed poorly, but have focused on total daily intake. In this project, a web-based version of the Meal-Based Intake Assessment Tool (the 'Web-MBIAT') has been developed. As proposed, the Web-MBIAT measures dietary intake by meal, can be used on either PC or Macintosh computer, and can be used with data from either the Australian food composition database NUTTAB 2010, or the New Zealand food composition database FOODFiles 2010. A food list has been developed to assess intakes of iron and zinc and their key absorption modifiers – vitamin C, haem iron (novel data), meat/fish/poultry (novel data), red meat (novel data), and phytate (novel data). Pre-testing has been carried out with 10 interviewers (nutritionists, dietitians, and postgraduate nutrition students) and 10 participants (premenopausal adult women), and adjustments made to the programme in response. The Web-MBIAT is now ready to undergo a validation study in preparation for its use in research studies developing and validating algorithms for estimating 'bioavailable' iron and zinc in meals with and without absorption modifiers such as red meat.

2 Executive summary

The most severe form of iron deficiency, iron deficiency anaemia, is associated with impaired work performance and an increased risk of adverse pregnancy outcomes in adults; and poorer cognition and developmental delay in children (Food and Nutrition Board, Institute of Medicine, 2001). Non-anaemic iron deficiency, which is more common than iron deficiency anaemia, may be associated with poorer endurance (Brownlie et al., 2004), and fatigue (Verdon et al., 2003). Severe zinc deficiency has been associated with a wide range of disturbances that vary with age and the severity of deficiency. Manifestations in infancy often include diarrhoea, dermatitis, and behavioural changes, whereas in children, anorexia, impaired taste acuity and linear growth, and recurrent infections are more common. During adolescence, delayed sexual maturation and abnormalities in skeletal growth and mineralization have been described, and among the elderly, chronic non-healing leg ulcers and recurrent infections occur (Brown et al., 2004).

Although the total intake of iron and zinc is important, the absorption of both minerals is profoundly affected by other food components that are consumed at the same time. For instance, red meat is not only an excellent source of both iron and zinc, it also enhances their absorption (Heath & Fairweather-Tait, 2002; Gibson & Heath, 2011). A number of algorithms have been developed that have attempted to quantify this effect in order to estimate 'bioavailable' iron and zinc intake (i.e., the proportion of the nutrient that is absorbed and becomes available for physiological processes). However, to date, algorithms have performed poorly as tools to estimate risk of iron deficiency (Beard et al., 2007) and zinc (Arsenault et al., 2010). We hypothesise that this is because they have been used with data on total daily intake of iron or zinc and their absorption modifiers. It is not, therefore, surprising that their performance is poor, because the modifiers have to interact chemically with iron and zinc as they pass through the gut together in order to have an effect on their absorption. Instead, what are needed are robust data on absorption modifiers *consumed at the same time* as the iron and zinc – and this requires a dietary assessment tool that is based on the meal, rather than on daily intake.

Our group has previously developed a dietary assessment tool that collects data on intake of iron and zinc and their absorption modifiers by meal - the Meal-Based Intake Assessment Tool (MBIAT). The MBIAT has a lower respondent burden, and requires fewer financial and logistical resources than the weighed diet record or a 24-hour recall repeated on multiple days. It also allows analysis of intake by meal which will enable us to investigate the ability of absorption algorithms applied to complex 'real world' meals to predict iron and zinc status in future studies. The MBIAT has shown good agreement with the results of 11- and 12-day weighed records in premenopausal adult New Zealand women (Heath et al., 2000), and in men aged 40 years and over in the United Kingdom (Heath et al., 2005).

The objectives of this project were to:
1. Develop and pretest a web-based version of the Meal-Based Intake Assessment Tool ('Web-MBIAT') that: measures dietary intake by meal, can be used on either PC or Macintosh computer, and can be used with a range of food composition databases.
2. Compile the following data for all foods in New Zealand FOODFiles 2010 (New Zealand Institute for Plant & Food Research, 2010), a comprehensive national food composition database:
    (a) haem iron (well-absorbed iron present only in animal tissue)
    (b) grams of meat/fish/poultry (a powerful enhancer of iron absorption)
    (c) grams of red meat (a powerful enhancer of iron absorption)
    (d) phytate (a powerful inhibitor of zinc and iron absorption).

In this project, we have developed a web-based version of the MBIAT – the 'Web-MBIAT'. The Web-MBIAT measures dietary intake by meal, can be used on PC or Macintosh computer, and can be used with data from the Australian food composition database NUTTAB 2010 as well as the New Zealand food composition database FOODFiles 2010. A food list has been compiled that includes 664 food items identified as contributing significant amounts of iron or zinc, or their key absorption modifiers - meat/fish/poultry, red meat, vitamin C, phytate, or tea and coffee. In addition, haem iron, meat/fish/poultry, red meat, and phytate values have been assigned to each of the foods listed in the Web-MBIAT.

Pre-testing was carried out with both interviewers (n=10), and participants (premenopausal adult women) (n=10). All interviewers made positive comments about the Web-MBIAT as a dietary assessment tool (Hussein, 2013); and the participants found it easy to complete, giving it a mean score of 8.2/10 when asked to score how easy it was to complete on a scale of 1 (hardest) to 10 (easiest) (Luey, 2013). A number of suggestions were made, and the following changes have been made in response: interviewers are given a full food list to work from so that they are familiar with the foods available and how they are described in the food list (to facilitate efficient searching), and a wider range of measure descriptors has been added to the foods in the food lists (to facilitate description of amounts consumed). In addition, we are considering adding questions on supplement intake.

The Web-MBIAT is now ready to undergo a validation study in preparation for its use in research studies developing and validating algorithms for estimating ‘bioavailable’ iron and zinc in meals. This will enable exploration of the impact of different food choices – for example adding or removing red meat from meals - on estimated iron and zinc absorption.

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4 Background

4.1 The importance of determining bioavailable iron intake

Iron is a key component of a number of proteins including haemoglobin, and enzymes involved in energy metabolism and neurotransmission. The most severe form of iron deficiency, iron deficiency anaemia (IDA), is associated with impaired work performance and an increased risk of adverse pregnancy outcomes in adults; and poorer cognition and developmental delay in children (Food and Nutrition Board, Institute of Medicine, 2001). Non-anaemic iron deficiency, which is more common than IDA, may be associated with poorer endurance (Brownlie et al., 2004), and fatigue (Verdon et al., 2003). The recent New Zealand Adult Nutrition Survey found that up to 16% of young adult New Zealand women have suboptimal iron status (University of Otago & New Zealand Ministry of Health, 2011). Although national data for Australia are not yet available, recent data from the USA also report a prevalence of approximately 16% (Cogswell et al., 2009).

Although iron intake is of course important, there is a surprising lack of association between total dietary iron intake and the risk of iron deficiency (Heath et al., 2001). This is because iron absorption is powerfully affected by the source of the iron (haem iron from meat and other flesh foods is considerably better absorbed than non-haem iron), and by the presence of other food components that enhance ('meat/fish/poultry' factor (using grams of animal tissue as a proxy), ascorbic acid) or inhibit (e.g., phytate, tea) iron absorption (Heath & Fairweather-Tait, 2002). It is therefore essential to determine the bioavailability of iron as well as its total intake in any study of the role of foods in iron nutrition.

4.2 The importance of determining bioavailable zinc intake

Zinc has a critical role in a wide range of biochemical, immunological and clinical functions. Hence, in severe zinc deficiency a wide range of disturbances occur which vary with age and the severity of deficiency. Manifestations in infancy often include diarrhoea, dermatitis, and behavioural changes, whereas in children, anorexia, impaired taste acuity and linear growth, and recurrent infections are more common. During adolescence, delayed sexual maturation and abnormalities in skeletal growth and mineralization have been described, and among the elderly, chronic non-healing leg ulcers and recurrent infections occur (Brown et al., 2004). Data on the zinc status of population groups in Australasia are limited. In a recent review, only 31 studies were identified (Gibson & Heath, 2011), of which only one was based on a national survey - of New Zealand school children. Of the children, Pacific children had the highest prevalence of biochemical zinc deficiency, and this prevalence was at a level indicative of public health concern (Gibson et al., 2010). In most countries, the risk of inadequate intakes of zinc is likely to be comparable to that of iron because zinc and iron have a similar distribution in the food supply and are affected by many of the same dietary absorption modifiers. Indeed, low iron stores have been a risk factor for suboptimal zinc status in several studies (Yokoi et al., 1994; 2003; Donovan and Gibson, 1995; Gibson et al., 2001; Cole et al., 2010).

Inadequate intakes of dietary zinc over a prolonged time period are considered to be the most likely cause of zinc deficiency (Hotz 2007). They may arise from low levels of zinc in the diet *per se* or poor bioavailability. It is well recognized, however, that food composition values indicate the total amount of the constituent in the food rather than the amount actually absorbed. Hence, data on total zinc intakes, like iron, must be adjusted to take into account the bioavailability of zinc from the usual diet. Food components that have been shown to modify zinc absorption include cellular animal protein (e.g., from meat) which enhances zinc absorption, and phytate, a potent inhibitor of zinc absorption (Gibson & Heath, 2011).

4.3 Algorithms for estimating bioavailable iron and zinc

Because the absorption of both iron and zinc is strongly influenced by other food components, a number of algorithms have been developed that have attempted to quantify this effect in order to estimate ‘bioavailable’ iron and zinc intake (i.e., the proportion of the dietary nutrient that is absorbed and becomes available for physiological processes). The most commonly used algorithms that have attempted to estimate bioavailable iron have included a range of food components, including the enhancers: grams of cooked animal tissue (Monsen & Balintfy, 1982; Reddy et al., 2000; Hallberg and Hulthen, 2000; Tseng et al., 1997) or protein from animal tissue (Murphy et al., 1992), and ascorbic acid (Monsen & Balintfy, 1982; Murphy et al., 1992; Reddy et al., 2000; Hallberg and Hulthen, 2000; Tseng et al., 1997); and the inhibitors: phytate (Reddy et al., 2000; Hallberg and Hulthen, 2000; Tseng et al., 1997) and tea (Murphy et al., 1992; Tseng et al., 1997). Hallberg and Hulthen (2000) also included the inhibitors: polyphenols, calcium, soy protein, and eggs; and alcohol as an enhancer. Several algorithms have been developed to estimate the bioavailability of zinc. They are based on the presence of inhibitors, the most potent being phytate, together with the quantity of zinc in a meal - increasing amounts of zinc result in lower zinc absorption. The most widely used algorithm is that developed by the International Zinc Nutrition Consultative Group (IZiNCG) (Brown et al., 2004), in which in the final logit regression model, only zinc and the phytate-to-zinc molar ratio were shown to be significant predictors of the percentage of zinc absorption in adults (r^2=0.413), p<0.001).

4.4 The need for meal-based dietary data

To date, algorithms have performed poorly as tools to estimate risk of iron deficiency (Beard et al., 2007) and zinc (Arsenault et al., 2010). However, they have been used with data on total daily intake of iron or zinc and their absorption modifiers. It is not, therefore, surprising that their performance is poor, because the modifiers have to interact chemically with iron and zinc as they pass through the gut together in order to have an effect on their absorption. Instead, what are needed are robust data on absorption modifiers *consumed at the same time* as the iron and zinc – and this requires a dietary assessment tool that is based on the meal, rather than on daily intake. While this can, in theory, be achieved using diet record or 24-hour recall data, these methods have a large respondent, logistical, and financial burden, particularly when multiple days of data are required in order to determine ‘usual’ intakes in large populations.

4.5 The Meal-Based Intake Assessment Tool

Our group has previously developed a dietary assessment tool that collects data on intake of iron and zinc and their absorption modifiers by meal - the Meal-Based Intake Assessment Tool (MBIAT). The interviewer-administered MBIAT collects usual intake over the past month directly onto a computer in a one-hour interview (see Methods below). The MBIAT has a lower respondent burden, and requires fewer financial and logistical resources than the weighed diet record or a 24-hour recall repeated on multiple days. It also allows analysis of intake by meal which will enable us to investigate the ability of absorption algorithms applied to complex 'real world' meals to predict iron and zinc status in future studies.

The MBIAT has shown good agreement with 11- and 12-day weighed records in premenopausal adult New Zealand women (Heath et al., 2000), and in men aged 40 years and over in the United Kingdom (Heath et al., 2005), with Spearman's correlation coefficients as follows:

Food component	Spearman's correlation coefficients comparing MBIAT and diet record data
Zinc	0.42 to 0.75
Iron	0.52 to 0.76
Haem iron	0.61 to 0.80
Animal tissue	0.52 to 0.73
Phytate	0.68 to 0.78
Ascorbic acid	0.39 to 0.63

Furthermore, classification to the same quartile for intakes of zinc was between 35-60%, and for iron, animal tissue and phytate was between 43-56%. A total of 73-94% MBIAT intakes were classified to within one quartile of the weighed diet record intake (zinc = 82-90%). Gross misclassification was only 0-4% (zinc = 0-2%). The original version of the MBIAT did tend to overestimate zinc intake (Wilcoxin matched-pairs signed rank test, $p<0.001$): by 11% based on the mean zinc intakes (10.1 vs. 8.5 mg/d), but the revised version used in the United Kingdom gave a mean intake that was not significantly different to the weighed diet record (11.42 vs. 11.72 mg/d). Repeatability of the MBIAT was assessed by administering the MBIAT on a second occasion to the same participants. Spearman rank correlation coefficients were 0.64-0.67 for zinc, with iron, animal tissue and phytate ranging from 0.65-0.86. These results emphasize that the computer-administered MBIAT is an appropriate tool for assessing zinc, iron, animal tissue, phytate and other food components of interest at the group level, and for ranking individuals according to their intake of the tested components.

4.6 The need for a Web-Based version of the MBIAT

The original MBIAT was developed for use on a Macintosh computer with a modified New Zealand food composition database (Heath et al., 2000). This was revised for use on a PC in a United Kingdom (UK) population (Heath et al., 2005). However, these versions were both limited to the platform on which they were developed, and neither software programme is now supported. The use of a web format (as developed in this project) ensures cross-platform compatibility, ease of distribution to other users, and enables future-proofing.

4.7 The need to compile meat, haem iron, and phytate food composition data

As described above, animal tissue (also referred to as 'meat/fish/poultry') and phytate are powerful modifiers of iron and zinc absorption, and haem iron is considerably better absorbed than non-haem iron. It is therefore essential to include these food components in any analysis of iron and zinc bioavailability. However, they are not included in national food composition databases. The addition of these food components to the Web-MBIAT (as has been achieved in this project) is essential in order to estimate iron and zinc bioavailability.

5 Project objectives

1. Development and pretesting of a web-based version of the Meal-Based Intake Assessment Tool (Web-MBIAT) that: measures dietary intake by meal, can be used on either PC or Macintosh computer, and can be used with a range of food composition databases.
2. Compilation of the following data for all foods in the New Zealand FOODFiles 2010 (New Zealand Institute for Plant & Food Research, 2010), a comprehensive national food composition database:
   (a) haem iron (well-absorbed iron present only in animal tissue)
   (b) grams of mea/fish/poultry (a powerful enhancer of iron absorption)
   (c) grams of red meat (a powerful enhancer of iron absorption)
   (d) phytate (a powerful inhibitor of zinc and iron absorption).

6 Methods

The project had four phases:

1. Programming a web-based version of the existing Meal-Based Intake Assessment Tool (MBIAT) (Heath et al., 2005).

2. Generating a food list capturing foods from the New Zealand food composition database FOODFiles 2010 (New Zealand Institute for Plant & Food Research, 2010) that met the following inclusion criteria:
   (a) *Iron* (≥2mg iron/100g, or generic food items that contributed ≥4% of total iron intake for New Zealand females aged 19-50 years (University of Otago & Ministry of Health, 2011))
   (b) *Zinc* ((≥0.5mg zinc/100g, or generic food items that contributed ≥3% of total zinc intake for New Zealand females aged 19-50 years (University of Otago & Ministry of Health, 2011))
   (c) *Meat/fish/poultry* (generic composite cuts of meat, fish, poultry; mixed dishes with ≥30g MFP/100g)
   (d) *Vitamin C* (≥7mg vitamin C/100g, or ≥10mg vitamin C/100g for non-alcoholic drinks, or generic food items that contributed ≥10% of total vitamin C intake for New Zealand females aged 19-50 years (University of Otago & Ministry of Health, 2011))
   (e) *Phytate* (≥50mg phytate/100g food, generic food items from food groups contributing ≥6% to average daily phytate intake in UK study by Amirabdollahian & Ash (2010))

(f) *Tea and coffee* ('as consumed' food items).

Exclusion criteria were:

(a) *Similar food item already included in food list* (e.g., 'biscuit chocolate base, digestive/wheat' was excluded because 'biscuit plain, digestive' was already on the food list
(b) *Non-generic foods where a generic food item was available* (e.g., red delicious apples were not included because 'apple, assorted variety' was in the food list)
(c) *Foods that are not commonly eaten by the target population* (e.g., 'Tongan soup')
(d) *Foods in a form not commonly consumed* (e.g., flour)
(e) *Portion-size extremely small* (e.g., herbs and spices)
(f) *Mixed dishes unless a standard recipe is usually followed* (e.g., McDonald's 'Big Mac').

3. Food composition data were generated for the following food components that do not appear in national food composition databases:
(a) *Haem iron* (calculated as: mean percentage of total iron that was haem iron for meat cut (sourced from the literature[1]) * total iron content for meat cut from FOODfiles 2010; conversion factors (based on data for which there were both raw and cooked values) were used when only a raw value was available; where the literature did not include the particular meat cut, a substitute was chosen on the basis of similar animal, similar total iron content, similar energy, protein and fat content) (Barris, 2012)
(b) *Meat/fish/poultry* (MFP) (the grams of MFP in 100g of the food item (calculated from recipes in the case of mixed dishes)) (Barris, 2012)
(c) *Red meat* (grams of MFP for beef, veal, lamb, mutton) (Barris, 2012)
(d) *Phytate* (phytate content was sourced from the literature[2]; recipes were developed where necessary; adjustments were made for differences in moisture content between foods in the literature and FOODfiles foods, for the higher extraction rate of New Zealand white flour, and for the effects of yeast fermentation where relevant) (Hartley, 2013).

4. Pre-testing was carried out with two groups of people:
(a) Interviewers (n=10) – to determine the usability of the Web-MBIAT programme from the perspective of the interviewer, ten dietitians, nutritionists, and postgraduate Human Nutrition students were asked to conduct a dietary assessment interview using the Web-MBIAT. A

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[1] Haem iron data were sourced from the following papers: Carpenter et al. (1995), Clark et al. (1997), Garcia et al. (1996), Hallberg et al. (2000), Kalpalathika et al. (1991), Kongkachuichai et al. (2002), Leonhardt et al. (1997), Lombardi-Boccia et al. (2002), Purchas et al. (2010), Rangan et al. (1997), Turhan et al. (2004).

[2] Phytate data were sourced from the following papers: Abebe et al. (2007), Bunch & Murphy (1997), Chan et al. (2007), Egli et al. (2002), Ferguson et al. (1988), Ferguson et al. (1993), Harland & Oberleas (1987), Holland et al. (1988), Holland et al. (1991), Holland et al. (1992a), Holland et al. (1992b), Lott et al. (2000), Perlas & Gibson (2005), Reddy et al. (1989), Umeta et al. (2005).

standardised interview schedule on the usability of the Web-MBIAT was used. The participants' responses were audio-recorded and transcribed. Predetermined categories were used to analyse the data according to 'interface', 'instructions and questions', 'logic and navigation', and 'food list' (Hussein, 2013)

(b) Pre-menopausal adult women (n=10) – to determine the usability of the Web-MBIAT from the perspective of a study participant, ten women aged 18-50 years were asked to attend a dietary assessment interview in which dietary information was collected using the Web-MBIAT. A semi-standardised interview schedule on the usability of the Web-MBIAT was used. The participants' responses were audio-recorded and transcribed. Predetermined categories were used to analyse the data according to 'likeability', 'comprehensibility', 'ease of use', and 'method of administration' (Luey, 2013).

7 Results

7.1 The Web-MBIAT has been developed

A web-based version of the Meal-Based Intake Assessment Tool has been developed – the 'Web-MBIAT'. As proposed, the Web-MBIAT measures dietary intake by meal, can be used on PC or Macintosh computer, and can be used with data from the Australian food composition database NUTTAB 2010 as well as the New Zealand food composition database FOODFiles 2010.

The Web-MBIAT has the following components:

- Username and password protected *log-in*
- *Welcome page* offering access to the user's projects
- *Administrator's page* listing people with access and their level of access
- List of *records already entered* within a chosen project – with edit option
- Option to *create a new record*, assigning an ID number and interview date
- Screen asking *global meal frequency* (e.g., how often participant has breakfast in a usual week)
- Screen for collecting a *description of each meal* reported (a general description, then specific foods and amounts) with a search function, and 'favourites' for commonly eaten foods. Participants report their intake, and the interviewer then summarises it by choosing from the wide variety or iron- and zinc-relevant foods that are listed in the main food list (see below).
- Dialogue box that requests *individual meal frequency* after each meal is recorded
- Screen that lists '*forgotten foods'* that the researcher is particularly interested in (e.g., a list of foods rich in iron and its absorption modifiers) that is presented once all described meals have been entered, and allows the interviewer to return and enter further meals if

the food list reminds the participant of foods that have been eaten but not yet recorded

- *Results* screen that gives average intake of the food components of interest by meal occasion. Results are presented using both 'unadjusted' frequency for each meal (i.e., frequency reported in the dialogue box after each meal is described); and adjusted frequency for each meal (i.e., frequency reported in the dialogue box adjusted using the global meal frequency).

7.2 An iron- and zinc-relevant food list has been compiled

A total of 664 food items were identified as contributing significant amounts of iron or zinc, or their key absorption modifiers - meat/fish/poultry, vitamin C, phytate, or tea and coffee. These comprise the main Web-MBIAT food list. In addition, a shorter 'forgotten foods' list of 47 foods with the highest concentrations of iron, zinc, vitamin C or phytate has been developed to remind participants to report important foods that they may have forgotten during the main interview.

7.3 Novel food composition data have been determined

Haem iron, meat/fish/poultry, red meat, and phytate values have been assigned to the foods in the Web-MBIAT food lists.

7.4 Pre-testing has been conducted

Although the pretesting focused on identifying improvements that could be made to the Web-MBIAT, all interviewers had positive comments to make about the Web-MBIAT as a dietary assessment tool (Hussein, 2013); and, overall, the participants found it easy to complete, giving it a mean score of 8.2/10 when asked to score how easy it was to complete on a scale of 1 (hardest) to 10 (easiest) (Luey, 2013).

The interviewers suggested the following improvements:
(a) Modify the food search function so that it is not case-sensitive
(b) Modify the food search function so that it does not require expected spelling (e.g., it recognises 'yogurt' as well as 'yoghurt')
(c) Make it easier for the interviewer to recall the 'overall meal frequency' so that they can make sure that the individual meal frequencies add up to the overall frequency
(d) Collect data on supplement intake
(e) Provide more prompts to guide the interviewer.

The participants suggested the following improvements:
(a) More measure descriptors for some foods
(b) Make the food list more complete
(c) Advise the participant to record what they eat for a period of time before the interview so that they do not need to remember what they have eaten.

8 Discussion/Conclusion

A web-based version of the Meal-Based Intake Assessment Tool (the 'Web-MBIAT') has been developed. As proposed, it measures dietary intake by meal, can be used on either PC or Macintosh computer, and can be used with data from either the Australian food composition database NUTTAB 2010, or the New Zealand food composition database FOODFiles 2010. A food list has been developed to assess intake of iron and zinc and their key absorption modifiers – vitamin C, haem iron (novel data), meat/fish/poultry (novel data), red meat (novel data), and phytate (novel data).

Pre-testing identified a number of possible changes that could be made to the Web-MBIAT. These are listed below with a response to each suggestion:

(a) Modify the food search function so that it is not case-sensitive → Interviewers are now given a copy of the full food list so that they can become familiar with it before the interview (a more complex search function is not appropriate because the Web-MBIAT is downloaded onto the client's computer at the start of the interview and then reloaded at the end of the interview – to ensure that its speed is not dependent on the speed of the client's internet connection – this limits the size and complexity of the programme.)

(b) Modify the food search function so that it does not require expected spelling (e.g., it recognises 'yogurt' as well as 'yoghurt') → As above.

(c) Make it easier for the interviewer to recall the 'overall meal frequency' so that they can make sure that the individual meal frequencies add up to the overall frequency → This is not appropriate as it would add considerably to participant burden (and the cognitive requirement), and is not necessary - validation of earlier versions of the MBIAT suggest that researchers can achieve good to very good levels of validity by using the overall meal frequency to mathematically adjust individual meal frequencies (Heath et al., 2000; Heath et al., 2005).

(d) Collect data on supplement intake → This is not part of the current contract, but is under consideration.

(e) Provide more prompts to guide the interviewer → These prompts would be study specific so would need to be developed by the researcher for their specific study.

(f) More measure descriptors for some foods → These have been added.

(g) Make the food list more complete → The food list is dependent on the nutrient of interest – in this case iron and zinc and their absorption modifiers. Each additional food that is reported takes time to record because an appropriate food needs to be chosen, and an appropriate portion size determined. For this reason it is important to only include foods that are likely to impact on intake of the nutrient(s) of interest.

(h) Advise the participant to record what they eat for a period of time before the interview so that they do not need to remember what they have eaten → This would not be appropriate as it would negate the benefits of using a 30-60 minute interview to capture usual intake – in terms of both participant burden, and interviewer burden (particularly for training and data entry). Validation studies of the MBIAT suggest that participants are able to recall their usual eating patterns well, at least as they relate to iron and zinc intake, without needing to record their intake beforehand (Heath et al., 2000; Heath et al., 2005).

The Web-MBIAT is now ready to undergo a validation study in preparation for its use in research studies developing and validating algorithms for estimating 'bioavailable' iron and zinc in meals with and without absorption modifiers such as red meat.

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