



Establishing a methodological framework on digitalizing dietary assessment tool for contextual usage- A protocol of PakNutriStudy, Pakistan

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Assessing the dietary intake is quite technical component of determining the overall nutritional status of people. There are several dietary assessment tools available for gathering data on dietary intake. However, the food consumption being a complicated human behavior makes it difficult to state the validity of these tools. Recent advances in application of computer methods in health sector have led to focusing on technology in gathering diet related data. There can be some feasibility issues that may hamper the practicality of these technologies in contextual usage. Unavailability of local food data base and portion sizes make it difficult to use in specific areas. This study was designed to establish a protocol for an image based, digital dietary assessment tool and test its validity against the simplified version of same tool (24 hour recall [24HR]). This paper presents the prototype for PakNutriStudy, Pakistan. A digitalized version of 24HR was developed with incorporation of local features. The tool aims at reducing the biases and errors that arise during dietary data collection. We expect that the two versions would yield comparable results and that technological advancements can offer promising outcomes for better quality dietary assessment.

Keywords: Dietary intake assessment; nutritional assessment; digitalization; food record; feasibility; effectiveness; tool validation

INTRODUCTION

Nutrition, food and diet have been suggested to impact individual and group health through physical, biochemical, metabolic, genomic, as well as psychosocial mechanisms to name a few (Mahan & Raymond, 2016; Qasim et al. 2021). This link between nutritional exposures and health outcomes is quite useful for informing small- and large-scale policies in various domains of health sector and food industry as well as in the academia. Dietary data collection is one of the most important part of nutritional assessment but it presents several challenges in terms of authenticity and reliability of data collection through it. There are several tools and methods established for dietary assessment. Knowledge about the composition of tool, procedure of usage, challenges and considerations gives insight into the type of method to be adopted in a certain circumstance. These challenges may impact the validity and reliability of data collected using those tools and thus may have detrimental effects on the authenticity of the dietary exposure- health outcome pairs. A summary of some commonly used tools of dietary data collection along

with an account of major limitations and factors affecting their validity have been presented in Table 1

Measurement errors and biases in dietary data collection

Dietary data, though a unique and important set of information, can be regarded flawed at several points of its collection and processing (Delgado-Rodriguez & Llorca, 2004). A hierarchy of these errors can be established, indicating the farther we move in the data processing, more sources of errors get introduced into it, with the final buildup being immense and much deviated from the original values. The Figure 1 summarizes the undulating effects of errors in dietary data collection tools (systematic errors) or methods of data collection (random errors) that can lead to misinterpretations of overall research findings.

Table 1: Summary of direct dietary assessment tools- their purpose and factors affecting their validity

Name of tool	Purpose of tool	Factors affecting validity
Retrospective methods		
Food frequency questionnaire [ffq]	Semi quantitative estimation of frequency of consumption of foods specified in pre structured list	Number and order of items on food frequency list, time frame of recall period, mode of administration, data entry and computation
24 hour recall [24HR]	Recall and reporting of food and beverages taken during the previous day using standard probes and structured interview schedule; usually reported for more than one non-consecutive days	Number of 24 hour recalls collected from single person, effect of seasonality on diet, portion size estimation, overlooked food items, under/over reporting, recall bias, interviewer's techniques
Dietary history	Assessment of usual food intake along with taking into account variations over a long period of time	Used as validity reference for evaluating 24HR and ffq. Recall bias, applicable for limited population, trained personnels needed (interviewer bias)
Prospective methods		
Estimated food records	A self-reported single day or multiple day food record of meal items, amounts and other details as they are consumed.	Reporting error, numeracy and literacy skills, respondent burden, interference with eating routine, portion size estimation difficult
Weighed food record	Modification of estimated food record for a predefined measurement period with the addition of weights of foods and beverages	Considered gold standards against which other dietary assessment methods are tested; reporting error, numeracy and literacy skills, respondent burden, interference with eating routine
Duplicate meal method	Laboratory based chemical analysis of duplicate portions of foods and beverages consumed; used in institutional and metabolic studies	Serves as a reference method for other tools; reporting error, numeracy and literacy skills (if self-reported), respondent burden, interference with eating routine

Adapted from (Food and Agriculture Organization of the United Nations, 2018)

Reducing measurement errors in dietary intake data

The measurement errors introduced at several points in data collection and data handling threaten the validity of dietary intake data. There can be approaches to minimize the biases whether they are selection, information or confounding and on part of the participant, observer/interviewer, or the instrument. Tool standardization, selection of appropriate tools, blinding, or using statistical approaches to correct them at data analysis stage (Lovegrove et al. 2015).

There are several points in dietary assessment where innovative technologies find their application. A quicker input can be ensured by using technology for standardization of questions and probing. The processing of data utilizes technology by computerized coding and scoring of items. Food composition data bases can be directly linked to data collection terminals. The comparison

of intake with reference standards can also be automated (Wenhold, 2018).

Technological advances in dietary assessment tools

Recent advances in the field of communication technologies have led to the improved solutions to data management. Data management in research has recently evolved as a separate science. Various stages of research render themselves to require a management of quantitative as well as qualitative data. Data collection, entry/coding, analysis and interpretation – every stage requires careful planning and execution lest it would result in flawed linkages between variables, thus disrupting the overall outcome of the whole effort. The current era has seen several efforts on part of digitalizing and computerizing the data collection, entry/coding, analysis and interpretation of data so as to reduce the human errors. The innovative dietary data collection methods include: Personal Digital Assistant, Image assisted

method, Mobile based technologies, Web based technologies, Scan and sensor-based technologies. Such information and communication technologies aim to overcome the limitations of paper and pen method. The major advantages offered include: they are not reliant on

respondent's memory, automatic data processing, and real time personalized dietary feedback and advise (Food and Agriculture Organization of the United Nations, 2018). The incorporation of technology in various stages of dietary assessment are shown in the Figure 2.

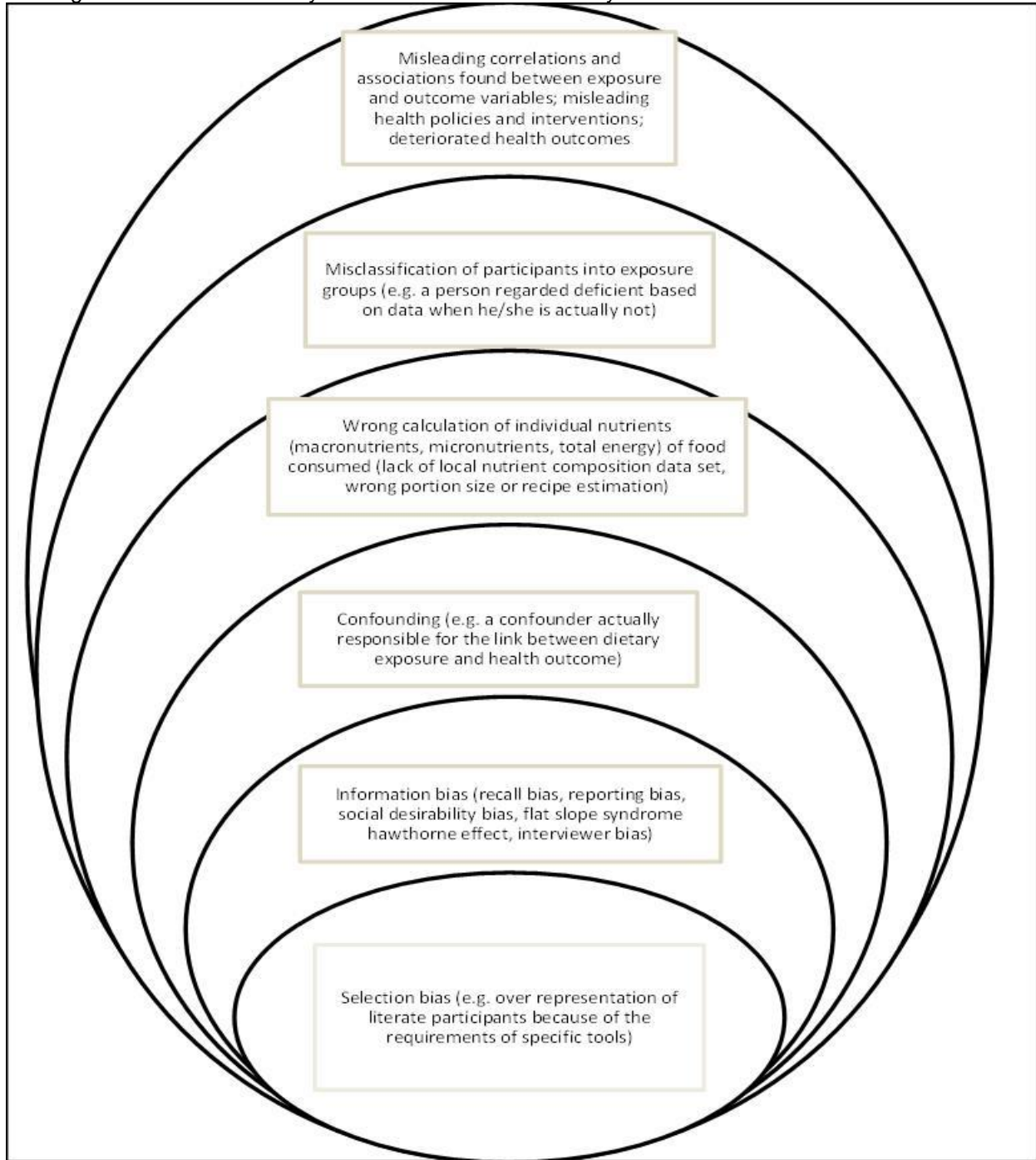


Figure 1: Rippling effects of errors and biases in dietary data collection on overall health outcomes

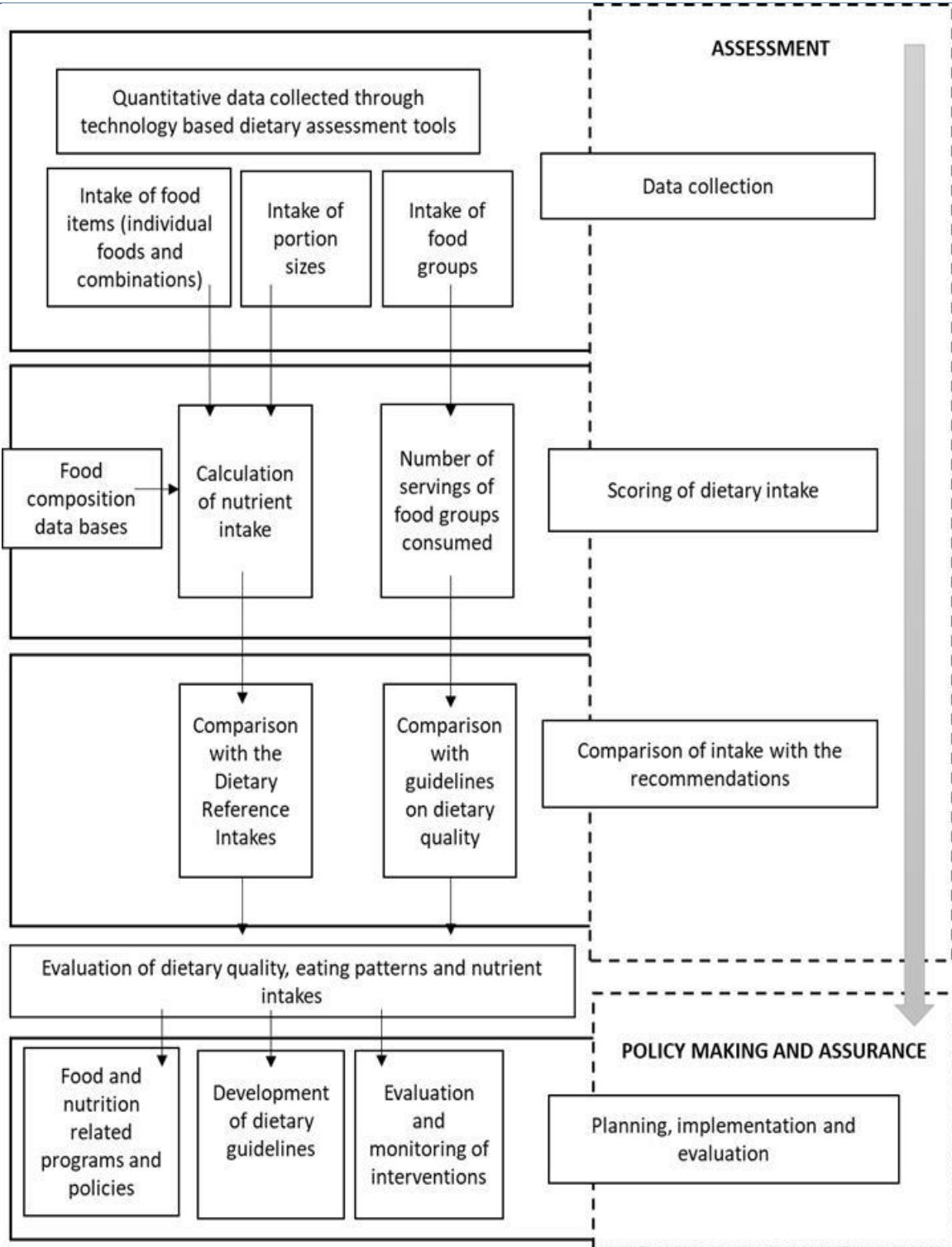


Figure 2: Linking technology to dietary assessment at various stages of data collection (Wenhold, 2018)

Appropriate technology can effectively take over selected tasks in some phases of dietary data collection. However, dietary intake being a complex human behavior,

the dietary assessment methods integrated with it need to be periodically evaluated for validity and reliability.

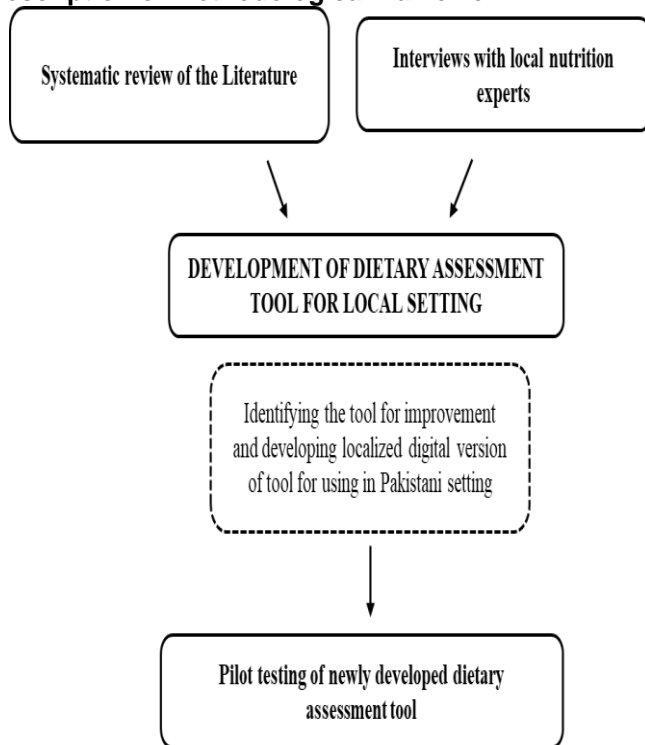
Description of methodological framework

Figure 3: Overall methodological framework of the project

Selection of dietary assessment tool

This phase of the current project was based upon the results of i) secondary data gathered through systematic review and ii) by primary data collected through semi structured interviews from nutrition experts. The complete methodology of these phases has been described elsewhere. The results of systematic review (total 33 articles published since 2010) showed 24 HR was used as a gold standard for testing the validity of other tools in several researches (n=10) (Polfuss M et al, Lindroos et al, Ambrosini et al.2018, Zang et al.2019, Rangan et al.2018, Albar et al.2016, Solbak et al.2016, Blanchard et al.2016, Bucher et a.2017l, Rangan et al.2018). The results of expert interviews showed that 24HR was the most commonly used tool by clinical dietitians as well as by nutrition researchers in Pakistan. Retrospective dietary assessment methods were more commonly used in the local settings and out of those 24HR was the most frequently used tool.

Based upon the findings of both these phases, 24HR was selected to be improved in this research. The selection of 24HR was made because

- I. It was fairly common tool used in articles as determined in systematic review
- II. It was the most common gold standard for testing other tools
- III. Nutrition experts (clinical as well as researchers) used 24HR most commonly in local settings

Identifying best method to improve the tool

The results of systematic review showed that the usage of advanced technologies is beneficial for better portion size estimation and selecting right type of food items (Polfuss, M., et al.2018). 24HR is memory dependent. Interviewer administered 24HR may introduce observer bias during probing while computer generated probes help to reduce the systematic error. Image assistance in web based 24HR can help in better estimation of portion sizes (Albar, S.A., et al. 2016; Ashman, A.M., et al. 2016). Uploading the images of foods consumed in the software may yield benefits of correct portion size and recipe estimation. However, according to the findings of systematic review, image capturing was found to be burdensome for participants as it involved placement of a fiducial marker and responsibly taking a clear picture of items consumed (Fallaise, et al. 2014). Therefore, image assistance in semi structured 2HR that helps the participants select the image that closely resembles their intake was more suitable for practical usage.

Development of web based 24HR**Selection of software for localization**

Extensive literature search was done and several of the articles were read in which the authors used innovative 24HR methods for dietary intake data collection. As innovative technologies were found promising to improve dietary intake tools in literature and systematic review, this technique was selected for applying to tool of data collection for local use. The results of systematic review showed that there are several soft wares available which can aid in data collection in local settings as well. The graphics and user interface of these soft wares was quite appealing. They had well developed databases and large networking already incorporated into their systems. This made them feasible and acceptable for practical settings. Therefore, using the basic software already developed in previous researches and modifying the data base for local usage was considered a feasible approach for current research.

Software (EPIC- soft) was found interesting as the researchers who used this software for 24HR had very similar research aims as the current research. Therefore, corresponding authors who used this software in their published works (Ocke, M. C., et al. 2011; Huybrechts, Inge, et al. 2011; Slimani et al.2011 & Crispim, Sandra P., et al. 2011) were contacted via email. The study objectives were described briefly in the email text and the corresponding authors were asked about the way they developed this system to use in their research. One of the corresponding authors replied to the email and explained that EPIC-soft web-based system has not been developed further and cannot be used now. However, they suggested names of two other soft wares (myfood24 and Intake 24) which serve the similar purpose. The websites of these

soft wares were explored. It was found that there were several food items which were not consumed in local settings and were thus irrelevant to be included in the database for local use. Also, the software allowed individual 24HR as free trial but not for research purpose. For research purpose and testing of the tool, all responses of the respondents should be available to the researcher. Therefore, to explore about usability for research and local incorporation and improvement of database, the teams of these softwares were contacted via email.

Corresponding author of an article who used Intake24 was contacted via email to guide about usability of this software system in research setting from their experience Bradley, J., et al. 2016. Fortunately, the email enquiry was forwarded by the corresponding author to support team of Intake24 and they then guided about the procedure of using the software for external researchers.

Setting up study protocol with Intake24 software

A representative from the team of Intake24 corresponded extensively over the email and helped in every way to help localization and eventually pilot testing of the tool. They first provided the link to demo version of the tool with linked South Asian food database and asked to use it and provide feedback. The demo system allowed using the 24HR either as interviewer led or self-reported system. For the current study, the latter was selected. Reason being that the web based and traditional way of 24HR had to be compared. The traditional version of tool could not be made interviewer led as it was not possible to collect one on one data of participants during the situation of semi lockdown due to COVID-19 outbreak. So, in order to maintain uniformity in both the traditional and web-based versions of 24HR, self-completed form of Intake24 was selected. Also, interviewer led questionnaires may introduce a whole new set of biases in tools especially the interviewer bias Dao, M.C., 2019. Therefore, the scope of this research was delimited to test the effectiveness of the tool itself (24HR) in pure participant's self-reported settings.

Recruitment of research assistants

Seven research assistants were recruited for data collection and correspondence with the research participants. All assistants were final year students of undergraduate degree program in nutrition sciences studying at a private sector university located in Lahore, Pakistan. They had completed their theory courses on research methods, biostatistics and public health nutrition. They had a CGPA of ≥ 3.50 in their undergraduate program. They were enrolled in research project course required for their degree completion at the time of recruitment. Therefore, they had strong background in the field of nutrition as well as had basic knowledge about research.

The research assistants were asked to volunteer in the research project. They gave consent of maintaining

data confidentially and obliging the ethical principles of research during their work. An account of study aims and objectives was shared with the assistants. They were guided and followed up on a weekly basis about the project.

Making local changes in the Intake24 software

During pilot testing of the Intake24 system, it was found that the system needs some localization for use in local content. System update in the data base of Intake 24 was suggested after discussion with the research team (principal researcher, supervisors and research assistants). The following changes were finalized:

A South Asian data base of food items was available in the system containing about 2500 items. It was decided that this data base should be used for current study i.e. the participants should see a list of only local food products to choose from while filling the 24HR.

Although a South Asian data base was available but it contained many of Indian food items. After discussion with team members a list of beverage items was formulated which are specifically consumed in Pakistan and were not present in the data base.

The recipes and ingredients of all the beverages identified were written.

Serving sizes and food composition per serving of these new beverages were calculated. The food composition data was calculated by addition of data of each ingredient through USDA food composition tables (USDA, 2021)

It was found that there was discrepancy in serving sizes in data base and actual serving size. So an adjustment in their serving sizes was made.

The names of food items were noted down in different variants as used locally. The generic names, translated names (Urdu (national language of Pakistan)) and local names of beverages were written.

This information was conveyed to the web expert of Intake24 system who was working with the research team. All the changes were incorporated into their web system. The aim of localization of system while using an already established web system was achieved.

The PakNutriStudy- Pilot testing

After all the required changes, the study protocol was registered with Intake24 system as PakNutristudy. It was ready to be used on 8th July, 2021. The basic characteristics of this study protocol were that it used local beverage list for probing. It also provided ingredient list and serving size and food composition provided for calculating the nutritional component. It was self-reported (self-completed) form with computer generated probes. The output file was available to the key researchers. It was downloadable as excel file.

A pilot testing was conducted to find out the validity of data collected through an online web based 24 hour recall method and traditional self-reported 24-hour recall. The objective was to determine the agreement between

data collected on both tools. The two methods of dietary data intake will be compared by collecting data on dietary intake through both methods from all participants aged 18-25 years. The sample size for pilot testing was calculated by using the current population of Pakistan reported by the Pakistan Bureau of Statistics (2021). Population proportion was taken as 8.97% reflecting the target age distribution of Pakistani population. At 95% confidence interval and 5% margin of error, a sample of 125 participants was calculated using an online sample size calculator (<https://www.calculator.net/sample-size-calculator.html?type=1&cl=95&ci=5&pp=8.97&ps=129175948&x=0&y=0>)

The participants were in close contact with the research team through text messages and phone calls and were guided whenever they found anything difficult while filling either form. The follow up by the research team also ensured that the participants fill both the questionnaires on the same day.

Expected outcomes

The following biases are expected to be ruled out with the web-based version of the 24HR

Reporting bias

The data sets for food items and portion sizes will be paired meal wise for the reported 24HR using both versions and compared for uniformity. Therefore, any differences between both versions will be analyzed.

Faulty portion size estimation

The image-based probing will be included in Intake 24. It will help the participants to select the estimated portion size that they consume. A visual representation of adjustable serving sizes will help to reduce the chances of reporting or recall bias for portion sizes. Left over for each food item will also be probed by the system which helped in better estimation of portion sizes.

Recall bias

Recalling the previous day's meals becomes easier when time and venue is recalled. Intake24 system probes the meals in chronological order of the day i.e. Breakfast, morning snack, lunch, evening snack, dinner, and post dinner snack. Also, the time of day will be asked for each meal to help in recalling the foods consumed. In addition, the system had questions related to the ingredients and left overs which helped to recall about any missed entry. At the end of each participant attempt, Intake 24 will present the data collected for whole day for review. This too will help the participant to recall and make any changes before submitting the recall.

1. Faulty estimation of dietary composition (specific recipe and ingredients)

CONCLUSION

Through Pak Nutri study, we would be able to test the

usability and effectiveness of web based vs. simplified version of same dietary assessment tool i.e. 24HR. The use of local data base and localization of food items, ingredients, recipes and serving sizes will help in correct data entry by participants. This is specifically useful in non-interviewer led (self-reported) 24 HR because the items listed to choose from must be abundant and easily understandable. The alternate local names, generic names and translated names of some food items were added in the data base to aid in better dietary composition reporting.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

AT and AH conceived the idea of this research. AT contacted the software teams for helping in digital data collection and recruited data collectors. AT wrote the first draft of article. SI and ZH critically reviewed for final submission. All authors read and approved the final manuscript

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