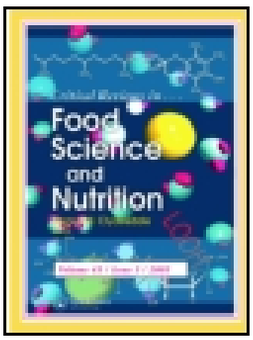

Critical Reviews in Food Science and Nutrition

ISSN: 1040-8398 (Print) 1549-7852 (Online) Journal homepage: http://www.tandfonline.com/loi/bfsn20

How dietary intake has been assessed in African countries? A systematic review

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To cite this article: Catarina Vila-Real , Ana Pimenta-Martins, Ana Maria Gomes, Elisabete Pinto & Ndegwa Henry Maina (2016): How dietary intake has been assessed in African countries? A systematic review, Critical Reviews in Food Science and Nutrition, DOI: 10.1080/10408398.2016.1236778

To link to this article: http://dx.doi.org/10.1080/10408398.2016.1236778

Accepted author version posted online: 20 Dec 2016.
Published online: 20 Dec 2016.

CRITICAL REVIEWS IN FOOD SCIENCE AND NUTRITION
https://doi.org/10.1080/10408398.2016.1236778

How dietary intake has been assessed in African countries? A systematic review

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ABSTRACT

Background: Dietary patterns are often considered as one of the main causes of non-communicable diseases worldwide. It is of utmost importance to study dietary habits in developing countries since this work is scarce.

Objective: To summarize the most recent research conducted in this field in African countries, namely the most used methodologies and tools.

Methods: A systematic review was conducted on MEDLINE®/PubMed, aiming to identify scientific publications focused on studies of dietary intake of different African populations, in a ten-year period. Papers not written in English/Portuguese/Spanish, studies developed among African people but not developed in African countries, studies aiming to assess a particular nutrient/specific food/food toxin and studies that assessed dietary intake among children were excluded.

Findings: Out of 99 included studies, the 24-hour recall and the food-frequency questionnaire were the most used dietary intake assessment tools, used to assess diet at an individual level. It was also observed that often country-unspecific food composition databases are used, and the methodologies employed are poorly validated and standardized.

Conclusions: There is an emergent need to improve the existing food databases by updating food data and to develop suitable country-specific databases for those that do not have their own food composition table.

KEYWORDS
Dietary intake assessment tools; 24-hour recall; Food-frequency questionnaire; food composition databases; African countries

Introduction

Over the last years, we have witnessed a shift in demographics in developing countries, namely in what concerns the lifetime expectancy and the organization of the societies, since there has been a growth in urbanization. This reality has led to changes in people's lifestyles, resulting in a transition from traditional to modern realities, subsequently leading to an epidemiological transition. Developing countries, especially in Africa have shown an increase in the prevalence of Non-Communicable Diseases (NCDs), while Communicable Diseases are still a major challenge, despite the success of vaccination programs (Boutayeb, 2006; World Health Organization - Reginal Office for Africa, 2006; Haregu et al., 2014; Islam et al., 2014). According to the World Health Organization (WHO) Global Status Report (2011), NCDs are responsible for almost 80% of deaths in low and middle-income countries. Although the major cause of deaths in African countries are communicable, maternal, perinatal, and nutritional diseases, NCDs are emerging in an exponential rate, being foreseen a switch of trends a switch of trends in 2030 (World Health Organization, 2011).

Dietary patterns are often considered as one of the main causes of NCDs, so it is of utmost importance to describe the expectable nutritional transition, in order to quantify the impact of diet in this group of diseases. However, in developing countries this work is scarce or insufficiently documented, probably due to logistic and financial constraints. According to Pisa et al. (2014), another reason that justifies the scarcity of this work is the lack of reliable dietary assessment methodologies, which upholds the emergent need for the development, validation and standardization of tools for measuring and monitoring food intake in different countries (Pisa et al., 2014). In this regard some work has been done, namely by the Dietary Exposure (DEX) assessment group (Pisa et al., 2014), which addresses its research to studies on diet and cancer and other NCDs. Its main goal is to develop and to validate dietary methods to assess dietary exposures.

The assessment of dietary intake is imperative to know population's food habits, including the inadequacy prevalence of different nutrients, as well as the study of the relationships between dietary patterns and disease. Dietary assessment may be done at national, household and individual level, when approaching food supply and production, food purchases or food consumption, respectively (Thompson and Byers, 1994; Gibson, 2005). At the individual level, several methodologies may be used, and these may be divided into two major groups: retrospective and prospective methods. Retrospective methods comprise the twenty-four hour Recall (24hR), the Food-Frequency Questionnaire (FFQ), and the Dietary History (DH), while prospective methods include Food/Weighed Records (WR) (Thompson and Byers, 1994; Gibson, 2005). Ideally these

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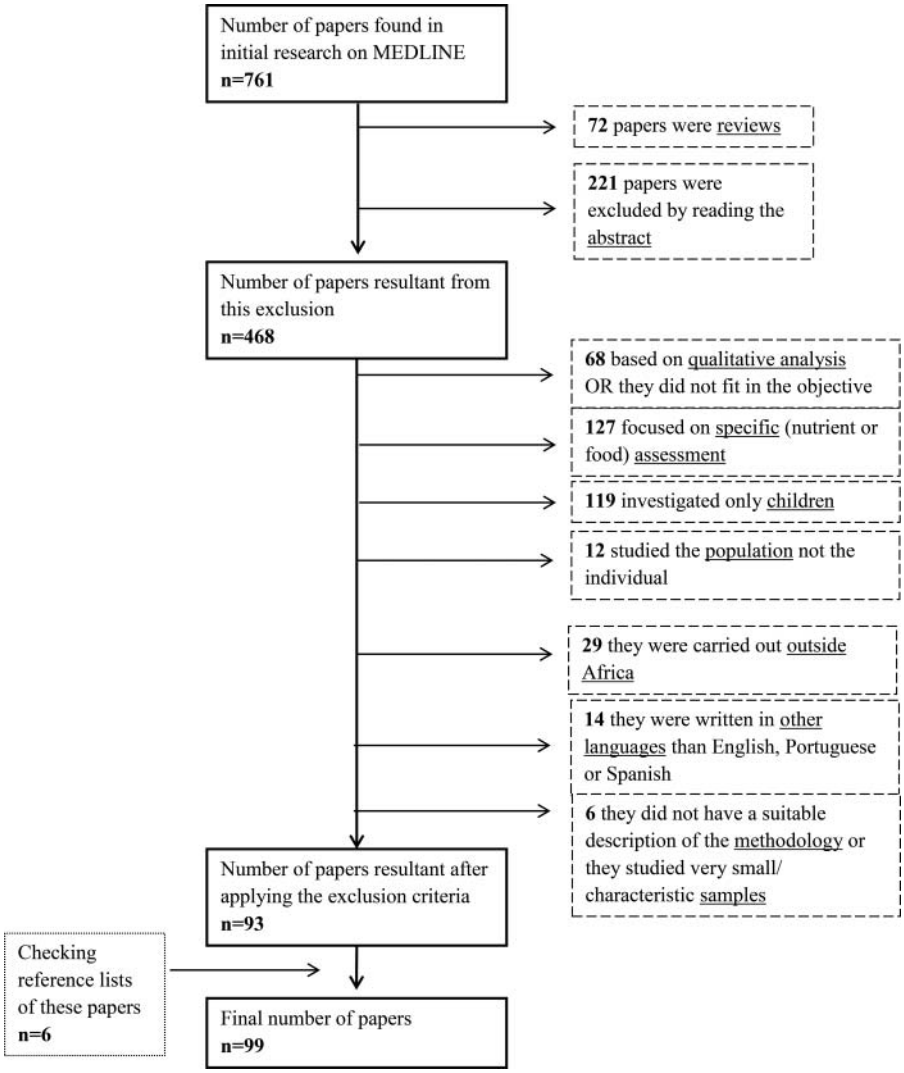

Figure 1. Flowchart of the paper's selection procedure.

tools need to be reproducible and valid in order to assure the consistency and accuracy of measurements (Willet, 1998). The choice of an appropriate method will depend on the aims of the study, the population approached as well as the research team's experience.

This systematic review intends to summarize the most recent research conducted in this field in African countries, specifically in what concerns the most used methodologies and tools.

Methods

The literature search was conducted on MEDLINE®/PubMed in order to identify scientific papers focused on studies about dietary intake of different populations, among African countries. This research considers several African countries, from North, East, West, Central and South Africa. In order to narrow down and systematize the search in more recent literature, only original papers published between January 2005 and December 2014 were considered and specific key MeSH terms were used: *dietary intake*; *Africa*.

Several papers were identified but not all were considered for the systematic review. The inclusion criteria established were related to: the objective of the study: only studies intending to assess dietary intake; the methodology: only studies with a suitably described methodology; and the language: only papers written in English, Portuguese and Spanish. The exclusion criteria were: studies carried out among African people but not in African countries (for example, African immigrants in other countries); assessment of a particular nutrient or a specific food or food toxin; non-quantitative assessment of the diet; dietary assessment among children; and studies performed at household level. Studies that were focused on micronutrient assessment but further evaluated the contribution of macronutrients were also considered. Figure 1 shows a flowchart representing the paper's selection procedure.

A total of 761 studies were identified in the initial search by using the combination of the key terms mentioned above. Out of these, 221 were excluded by reading the abstract while 72 were reviews that were not included in the present study. After applying exclusion criteria, 68 papers were excluded because they did not involve a quantitative analysis or they did not comply to the established objective, 127 studies were related to a single nutrient or food, 119 investigated only children, 12

Table 1. Selected studies (n = 54) which assessed dietary intake of different African populations using 24-hour recall [from 2005 to 2014].

Author	Country	Study Design	Study Population	Number of recalls	Determination of Portion Sizes	Tools for Dietary Analysis
2014						
(Zeba et al. 2014)	Burkina Faso	Cross-sectional study	110 Adults (25–6 years-old)	2 non-consecutive	Local kitchen utensils	Malian FCT[1]; C-SIDE[2] (Iowa State University, 1996)
(Kim et al. 2014)	Tanzania	Cross-sectional study	80 Pregnant and/or Lactating Women (>18 years-old)	2 non-consecutive	Standardized food models	Tanzanian FCT Harvard University School of Public Health
(May et al. 2014)	South Africa	Case Control Study	128 Women (Mean age of 35 years-old)	Single	Photographs of local alcoholic beverage	Nutrition Data System for Research (Nutrition Coordinating Center's University of Minnesota n.d.)
(Changamire et al. 2014)	Tanzania	Cohort Study	8428 Pregnant and/or Lactating Women (>18 years-old)	3	N.A.[3]	Tanzanian FCT Harvard University School of Public Health
(Oldewage-Theron et al. 2014)	South Africa	Cross-sectional study	722 Women (19–90 years-old)	≥3	Food models, household utensils	FoodFinder® (Grant et al. 1992)
2013						
(Powell et al. 2013)	Tanzania	Cross-sectional study	274 Women	2 non-consecutive	Local serving sizes aids	Programme CANDAT(Godin, 2007); Tanzanian FCT, FAO FTC, USDA Database (US Department of Agriculture, Agricultural Research Service, 1996) and scientific literature[4].
(Koethe et al. 2013)	Zambia	Prospective Cohort study	142 Adults	4 non-consecutive	Artificial food models and serving utensils	FCT published by the Zambian National Food and Nutrition Commission; Nutrition Data System for Research (Nutrition Coordinating Center's University of Minnesota n.d.)
(Kolahdooz et al. 2013)	South Africa	Cross-sectional study	137 Adults (>19 years-old)	2 non-consecutive	3D food models; local household utensils	Nutribase (CyberSoft, 1986)
2012						
(Walton et al. 2012)	Kenya	Cross-sectional study	111 Women	Single	Placing dried beans into the individual bowl to represent the serving	World Food Dietary Assessment System (Bunch & Murphy, 1997) and the Kenyan food composition database (Sehmi, 1993); USDA database[5] (US Department of Agriculture, Agricultural Research Service, 1996)
(Termote et al. 2012)	Democratic Republic of Congo	Cross-sectional study	492 Women	2 non-consecutive	1) a booklet with photographs of different calibrated portion sizes; 2) an extensive price-weight-conversion list covering all foods or ingredients reported during the 24 h recalls; and 3) direct measurements of estimated leftovers	Lucille food analysis software (UGent Research Group Food Chemistry and Human Nutrition & Medicine n. d.)
(Steyn et al. 2012)	Kenya	Cross-sectional study	1008 Women (15–60 years-old)	Single	Dietary assessment kit comprising life-size drawings and generic food models.	FoodFinder® (Grant et al. 1992)
(Pereko et al. 2012)	Ghana	Cross-sectional study	252 Adults (20–50)	3 non-consecutive	N.A.	ESHA Food Processor® (Davison & Mandible, 1994) and the Ghanaian FCT
(López et al. 2012)	Morocco	Cross-sectional study	327 Adolescents (15–20 years-old)	3 non-consecutive	N.A.	DIAL 1.0 (Ortega et al. 2008); FCT for use in Africa, from FAO.
(Mupere et al. 2012)	Uganda	Cross-sectional study	131 Adults (>18 years-old)	Single	Local food photographs, portion-size images, volumetric vessels	East African FCT and African FCT; USDA database (US Department of Agriculture, Agricultural Research Service, 1996); NutriSurvey Program (Erhardt & Gross, 2007)
(Papathakis & Pearson, 2012)	South Africa	Cohort Study	142 Pregnant and/or Lactating Women	4 non-consecutive	Volume of cups, bowls and plates	FoodFinder® (Grant et al. 1992)
(Nyuar et al. 2012)	Sudan	N.A.	113 Women (18–42 years-old)	Single	Household measures	Foodbase Nutritional Program[6]
(Boumaiza et al. 2012)	Tunisia	Cross-sectional study	329 Adults (Mean age of 44,9 years-old)	3 non-consecutive	Household measures	Dietetik® and Nutrilog®(SAS, 2007)

(*Continued on next page*)

Table 1. (*Continued*)

Author	Country	Study Design	Study Population	Number of recalls	Determination of Portion Sizes	Tools for Dietary Analysis
2011						
(Steyn et al. 2011)	Kenya	Cross-sectional study	1050 Women (15–60 years-old)	Single	Photographs, life-size drawings food models.	FoodFinder® (Grant et al. 1992)
(Naude et al. 2011)	South Africa	Cross-sectional study	162 Adolescents (12–16 years-old)	3 non-consecutive	Household measures; Pictures from the Dietary Asessment and Educacioal Kit[7]; MRC Food Quantities Manual.	FoodFinder® (Grant et al. 1992)
(Gibson et al. 2011)	Malawi	Cross-sectional study	80 Pregnant Women (14–45 years-old)	3 non-consecutive	N.A.	Malawian FCT
(Hansen et al. 2011)	Kenya	Cross-sectional study	1163 Adults (18–68 years-old)	2	Real food items/Paper models, utensils from the local market	GIES[8]
(Addo et al. 2011)	Ghana	Cross-sectional study	70 Pregnant and/or Lactating Women (18–42 years-old)	3 non-consecutive	Household measures, weigh portion made at home or bought	ESHA Food Processor® (Davison & Mandible, 1994) and published food composition information
(Irvine et al. 2011)	Tanzania	Case Control Study	171 Adults (Mean age of 38 years-old)	Single	Real food items; Kitchen utensils; Serving dishes.	ESHA Food Processor® (Davison & Mandible, 1994)
(Luke et al. 2011)	Ghana, South Africa, Seychelles, Jamaica and United States	Longitudinal observational study	2500 Adults (25–45 years-old)	2	Photographs; usual portions of local foods	Nutrition Data System for Research (Nutrition Coordinating Center's University of Minnesota n.d.)
(Alemayehu et al. 2011)	Ethiopia	Cross-sectional study	68 Women (15–49 years-old)	Single	Weigh of the estimated portion consumed (using a spoon); households measures and actual food samples purchased in markets.	Ethiopian FCT and USDA database (US Department of Agriculture, Agricultural Research Service, 1996)
(Rankin et al. 2011)	South Africa	Cross-sectional study	131 Adolescents	7 non-consecutive	Validated food portion photograph book (Venter et al. 2000)	FoodFinder® (Grant et al. 1992)
2010						
(Scarcella et al. 2011)	Mozambique	Cohort Study	106 Adults	Single	Food models and images of portion sizes	FAO FCT for Africa and Mozambique[9]
(Becquey & Martin-Prevel, 2010)	Burkina Faso	Cross-sectional study	182 Women (19–49 years-old)	3	Household measures	C-SIDE Software (Iowa State University, 1996); Malian FCT, INFOODS[10] database (Senegal), USDA Database (US Department of Agriculture, Agricultural Research Service, 1996)
(Oldewage-Theron et al. 2010)	South Africa	Cross-sectional study	235 Elderly (≥60 years-old)	2 non-consecutive: 2nd 59% of the sample	Food Models	FoodFinder® III (Grant et al. 1992)
(Nago et al. 2010)	Benin	Cross-sectional study	656 Adolescents (≥13 years-old)	2 non-consecutive	Household utensils.	Malian FCT; FCT for use in Africa; East African FCT.
(Dapi et al. 2010)	Cameroon	Cross-sectional study	227 Adolescents (12–16 years-old)	3 non-consecutive	Household measures, real food portions and information about the amount of money spent on some foods. Colour picture booklet	Becel Institution Nutrition Software
(Heimburger et al. 2010)	Zambia	Cohort Study	874 Adults	4 non-consecutive	N.A.	Nutrition Data System for Research (Nutrition Coordinating Center's University of Minnesota n.d.)
2009						
(Lamri-Senhadji et al. 2009)	Algeria	Cross-sectional study	46 Adults (Mean age: 24 years-old)	5 weeks of measurements	Small, medium or large (graduated measure, soup and coffee spoons, dinner and soup plates, etc).	La composition des aliments Tableaux des valeurs nutritives*
(Sodjinou et al. 2009)	Benin	Cross-sectional study	200 Adults (25–60 years-old)	3	Local cups, bowls, spoons, plates and glasses	WorldFood Dietary Assessment System(Bunch & Murphy, 1997); FCT of neighboring countries; C-SIDE Software (Iowa State University, 1996)
(Huybregts et al. 2009)	Burkina Faso	Cross-sectional study	394 Pregnant and/or Lactating Women (15–45 years-old)	Single	Validated booklet with food photographs	Malian FCT; ESHA Food Processor® (Davison & Mandible, 1994)
(Alaofè et al. 2009)	Benin	Quasi experimental	68 Adolescents (12–17 years-old)	48hR (single) 24hR (3)	Food models, portion-size models, containers and photographs of foods	Nutrifiq® software, DANA-INFRE FCT used in Benin[11]

(Wiesmann et al. 2009)	Mozambique	Cross-sectional study	409 Women (15–49 years-old)	Single and 2 non-consecutive	Direct weighing, volume containers, photographs.	Specific FCT based on USDA Database (US Department of Agriculture, Agricultural Research Service, 1996)
(Kennedy et al. 2009)	Mali	Cross-sectional study	102 Women (15–49 years-old)	2 non consecutive	Household measures	VBS Food Calculation System (KOMEET, VBS MANAGER, ORION and FOOD GROUPS)[12]
(Becquey et al. 2009)	Burkina Faso	Cross-sectional study	182 Women (17–49 years-old)	3 non consecutive	Weighing of a replica, measure of the volume, use of calibrated household measures, portion sizes or price	Malian FCT; Worldfood FCT for Senegal; USDA Database (US Department of Agriculture, Agricultural Research Service, 1996).
2008						
(Sodjinou et al. 2008)	Benin	Cross-sectional study	200 Adults (25–60 years-old)	3 non consecutive	Local cups, bowls, spoons, plates and glasses	WorldFood Dietary Assessment System (Bunch & Murphy, 1997). FCT of neighboring countries; C-SIDE Software (Iowa State University, 1996).
(Ijarotimi & Keshinro, 2008)	Nigeria	Cross-sectional study	452 Adults (≥20 years-old)	Single	Household measures	Food analysis: AOAC[13] method
(Oldewage-Theron et al. 2008)	South Africa	Cross-sectional descriptive study	170 Elderly (≥60 years-old)	2	N.A.	FoodFinder® III (Grant et al. 1992)
(Maruapula & Chapman-Novakofski, 2008)	Botswana	Cross-sectional study	99 Elderly (60–95 years-old)	Single	N.A.	Nutritionist Five[14]
(Gewa et al. 2008)	Kenya	Cross-sectional study	44 Women	Single	Food models, measuring cylinders, local household measures	WorldFood Dietary Assessment System (Bunch & Murphy, 1997)
(Tesfaye et al. 2008)	Ethiopia	Cross-sectional study	619 Adults (18–64 years-old)	Single	Household measures, described as S, M, L., pictures of foods and utensils	FCT for Ethiopia
(Oldewage-Theron et al. 2008)	South Africa	Cross-sectional study	138 Elderly (60–93 years-old)	2 non-consecutive	Food Models	FoodFinder® (Grant et al. 1992)
(Oldewage-Theron et al. 2008)	South Africa	Cross-sectional study	101 Elderly (60–110 years-old)	2 non-consecutive	Food Models	FoodFinder® (Grant et al. 1992)
2007						
(Kamau-Mbuthia & Elmadfa, 2007)	Kenya	Cross-sectional study	716 Pregnant and/or Lactating Women (Reproductive age)	Single	Household measures (cups, tea and tablespoons and bowls) and also preparation methods for the different foods.	NutriSurvey Program (Erhardt & Gross, 2007)
(Wiig & Smith, 2007)	Ghana	Cross-sectional study	50 Adults (18–65 years-old)	Single	Food models; Portion Size images	ESHA Food Processor® (Davison & Mandible, 1994) and published food composition information
(Mounir et al. 2007)	Egypt	Cross-sectional study	1606 Adolescents (Menarcheal age)	Single	N.A.	Egyptian FCT, National Nutritional Institute
(O'Keefe et al. 2007)	South Africa	Cross-sectional study	52 Adults (50–60 years-old)	3-consecutive	N.A.	South African Food Composition Database of the MRC
2006						
(Steyn & Nel, 2006)	Kenya	Cross-sectional study	1008 Women (15–60 years-old)	Single	Household utensils, life-size drawings and food models.	Kenyan FCT and FoodFinder® (Grant et al. 1992).
2005						
(Mostert et al. 2005)	South Africa	Cohort Study	46 Pregnant and/or Lactating Women (<40 years-old)	2	N.A.	South African Food Composition Database of the MRC
(Charlton et al. 2005)	South Africa	Cross-sectional study	285 Elderly (>60 years-old)	Single	Standard household measuring utensils, rulers and validated food photographs	FoodFinder® III (Grant et al. 1992)

[1]FCT: Food Composition Table
[2]C-SIDE: Software for Intake Distribution Estimation
[3]N.A.: Information not available
[4]Lukmanji et al. 2008; Wu Leung 1968
[5]US Department of Agriculture-Agriculture Research Service (2007) USDA National Nutrient Database for Standard Reference 6version 4, Institute of Brain Chemistry and Human Nutrition, London Metropolitan University
[7]Steyn and Senekal, 2002
[8]GIES: General Intake Estimation System Program, GIES; National Food Institute, Søborg, Denmark
[9]Repartição de Nutrição (1991) Tabela de Composiçao de Alimentos Maputo:MISAU
[10]INFOODS: International Network of Food Data Systems
[11]DANA-INFRE: Direction de l'alimentation et de la nutrition–Institut national pour la formation et la recherche en education
[12]Bas Nutrition Software, Arnhem, The Netherlands, www.bware.nl.
[13]AOAC: Association of Official Agricultural Chemists
[14]Nutritionist Five, Version 2.3; First DataBank, San Bruno, CA 2000.

were not performed at an individual level, 29 were carried out outside Africa, 14 were written in other languages than English, Portuguese or Spanish, six did not have a suitable description of the methodology or were carried out in very small and characteristic samples. By checking the reference lists of each of these papers, another six papers, which complied with the inclusion criteria, were identified. Thus, the final number of papers was 99. Tables 1–4 summarize the main methodological issues of the included studies, allowing a comprehensive comparison between them. Papers were divided in the four tables according to the method used for dietary assessment: 24hR (Table 1) FFQ (Table 2), both 24hR, and FFQ (Table 3) and WR (Table 4). In each table, in addition to information about the country where the study was conducted and the year of publication, information about methodological issues, such as the study design, studied sample, dietary assessment methods and particularities are presented. Besides these aspects, the sampling methodology and main limitations of the studies were summarized in order to understand the most difficult challenges that researchers found in the field. Furthermore, the application of innovative technologies on dietary assessment in African countries was explored.

Results

The research retrieved 99 papers (102 studies) carried out among different African populations, namely adults (men and/or women), adolescents and elderly people.

The included papers describe studies from twenty-two different countries, located in different African regions: Algeria (n = 1), Egypt (n = 1), Morocco (n = 2), Sudan (n = 1) and Tunisia (n = 5) (Northern Africa), Ethiopia (n = 6), Kenya (n = 10), Malawi (n = 1), Mozambique (n = 3), Uganda (n = 3), Tanzania (n = 7), Zambia (n = 2) and Zimbabwe (n = 1) (Eastern Africa), Benin (n = 4), Burkina Faso (n = 4), Ghana (n = 4), Mali (n = 1) and Nigeria (n = 2) (Western Africa), Botswana (n = 2), and South Africa (n = 38), (Southern Africa), Cameroon (n = 3) and Democratic Republic of the Congo (n = 1) (Central Africa), each region representing 10% (n = 10), 32% (n = 33), 15% (n = 15), and 39% (n = 40), and 4% (n = 4) of the total sample, respectively. The huge representation of Southern Africa is caused by the high number of studies developed in South Africa, representing 37% (n = 38) of the included papers. This division of African regions is based on United Nation (UN) Statistics Division.

Dietary assessment methods

Almost all of these studies are cross-sectional studies, which capture the dietary practices in a specific population, at a particular point in time (Thompson and Byers, 1994; Gibson, 2005).

Overall, the two most used dietary assessment tools were the 24hR and the FFQ, which were applied separately or together. Among the studies, most of them (n = 54) only used 24hR and in some cases the authors chose a single day of recall (n = 20) (Charlton et al., 2005; Steyn and Nel, 2006; Kamau-Mbuthia and Elmadfa, 2007; Mounir et al., 2007; Wiig and Smith, 2007; Gewa et al., 2008; Ijarotimi and Keshinro, 2008; Maruapula and Chapman-Novakofski, 2008; Tesfaye et al., 2008; Huybregts et al., 2009; Wiesmann et al., 2009; Alemayehu et al., 2011; Irvine et al., 2011; Scarcella et al., 2011; Steyn et al., 2011; Mupere et al., 2012; Nyuar et al., 2012; Steyn et al., 2012; Walton et al., 2012; May et al., 2014), whilst others utilized multiple recalls (n = 34) (Mostert et al., 2005; O'Keefe et al., 2007; Oldewage-Theron et al., 2008; Oldewage-Theron et al., 2008; Oldewage-Theron et al., 2008; Sodjinou et al., 2008; Alaofè et al., 2009; Becquey et al., 2009; Kennedy et al., 2009; Lamri-Senhadji et al., 2009; Sodjinou et al., 2009; Becquey and Martin-Prevel, 2010; Dapi et al., 2010; Heimburger et al., 2010; Nago et al., 2010; Oldewage-Theron et al., 2010; Addo et al., 2011; Gibson et al., 2011; Hansen et al., 2011; Luke et al., 2011; Naude et al., 2011; Rankin et al., 2011; Boumaiza et al., 2012; López et al., 2012; Papathakis and Pearson, 2012; Pereko et al., 2012; Termote et al., 2012; Koethe et al., 2013; Kolahdooz et al., 2013; Powell et al., 2013; Changamire et al., 2014; Kim et al., 2014; Oldewage-Theron et al., 2014; Zeba et al., 2014), covering a range of two to eight recalls. One study did not mention the use of a 24hR, however the described procedure allows us to conclude that this was the methodology followed (Tesfaye et al., 2008). Some studies (Maruapula and Chapman-Novakofski, 2008; Sodjinou et al., 2008; Alaofè et al., 2009; Becquey et al., 2009; Sodjinou et al., 2009; Wiesmann et al., 2009; Becquey and Martin-Prevel, 2010; Alemayehu et al., 2011; Luke et al., 2011; Termote et al., 2012; Powell et al., 2013; Kim et al., 2014; Zeba et al., 2014) followed a validated method for collecting interviewer-administered 24hR, the so called United States Department of Agriculture (USDA) Automated Multiple-Pass Method (AMPM), which is a computerized method that can be applied in person or by telephone. Five other studies (Oldewage-Theron et al., 2008; Oldewage-Theron et al., 2008; Namugumya and Muyanja, 2011; Walton et al., 2012; Oldewage-Theron et al., 2014) mentioned other validated methods, one based on four steps developed by Gibson and Ferguson (1999) and Gibson (2005), and another one which is a 24hR questionnaire developed and validated by Oldewage-Theron et al. (2005). All the dietary information collected from these studies using the 24hR reference tool is summarized in Table 1.

In some papers (n = 30), authors selected only the FFQ for the dietary assessment (Kesa and Oldewage-Theron, 2005; Merchant et al., 2005; Belgnaoui and Belahsen, 2006; Hattingh et al., 2006; Jackson et al., 2007; MacKeown et al., 2007; Oguntibeju et al., 2007; Vorster et al., 2007; Hogenkamp et al., 2008; Tessier et al., 2008; Goedecke et al., 2009; Zingoni et al., 2009; Joffe et al., 2010; Anderson et al., 2011; Aounallah-Skhiri et al., 2011; Delport et al., 2011; Joffe et al., 2011; Kruger et al., 2011; Wentzel-Viljoen et al., 2011; Jackson et al., 2012; Joffe et al., 2012; Kruger et al., 2012; Pisa et al., 2012; Pretorius et al., 2012; Jordan et al., 2013; Lukmanji et al., 2013; Sheehy et al., 2013; Baroudi et al., 2014; Botha et al., 2014; Wrottesley et al., 2014), using either quantitative FFQ (n = 23) (Kesa and Oldewage-Theron, 2005; Belgnaoui and Belahsen, 2006; Hattingh et al., 2006; Jackson et al., 2007; Oguntibeju et al., 2007; Vorster et al., 2007; Hogenkamp et al., 2008; Tessier et al., 2008; Goedecke et al., 2009; Zingoni et al., 2009; Joffe et al., 2010; Anderson et al., 2011; Joffe et al., 2011; Kruger et al., 2011; Wentzel-Viljoen et al., 2011; Jackson et al., 2012; Joffe et al., 2012; Kruger et al., 2012; Pisa et al., 2012; Pretorius et al., 2012; Sheehy et al.,

Table 2. Selected studies (n = 30) which assessed dietary intake of different African populations using food frequency questionnaires [from 2005 to 2014].

Authors	Country	Study Design	Study Population	Dietary Assessment Method (Source)	Number of food items	Reference time frame	Validation/ Reproducibility	Determination of Portion Sizes	Tools for Dietary Data Analysis
2014									
(Wrottesley et al. 2014)	South Africa	Cross-sectional study	247 Women (23–39 years-old)	QFFQ	214	Preceding 7 days	N.A.[1]	Household measures,2D life-size drawings of foods and utensils, 3D food models	FoodFinder® III (Grant et al. 1992)
(Baroudi et al. 2014)	Tunisia	Case Control Study	348 Adults (20–89 years-old)	sFFQ (Decarli et al. 1996; Franceschi et al. 1993)	77	Preceding year	Tested for reproducibility and validated against 7-day WR	N.A.	Binult logiciel[2]
(Botha et al. 2014)	South Africa	Cross-sectional Study	1068 Adults (Mean age: 56.4 years-old)	QFFQ (MacIntyre et al. 2001b; MacIntyre et al. 2001a)	145	N.A.	Tested for reproducibility and validated against 7-day WR and biomarkers	N.A.	FoodFinder® (Grant et al. 1992)
2013									
(Sheehy et al. 2013)	South Africa	Cross-sectional study	81 Adults (19–79 years-old)	QFFQ	71	N.A.	Not tested for reproducibility or validated	Household units/3D models; weighed portions	Nutribase (CyberSoft, 1986)
(Lukmanji et al. 2013)	Tanzania	Longitudinal clinical trial	1078 Pregnant and/or Lactating Women	SQFFQ	85	Preceding 3 months	Not tested for reproducibility or validated	Standard utensils and Food Models	Tanzanian FCT[3]
(Jordan et al. 2013)	Tanzania	Case Control Study and a validation study	345 Women (26–85 years-old)	SQFFQ	65	N.A.	Validated against 2 non-consecutive 24hR	Household measures and solid foods in pieces or slices (in the validation study)	NutriSurvey Program (Erhardt & Gross, 2007)
2012									
(Jackson et al. 2012)	Botswana	Validation study	79 Adults (18–75 years-old)	QFFQ	122	Preceding year	Validated against 4 non-consecutive 24hR	Food models; household utensils; measuring cups and measuring tape.	FoodFinder® (Grant et al. 1992)
(Pretorius et al. 2012)	South Africa	Nutritional Survey	50 Adults (Mean age: 47± 18 years-old)	QFFQ (MacIntyre et al. 2001b; MacIntyre et al. 2001a)	139	Usual intake (daily, weekly and monthly basis)	Tested for reproducibility and validated against 7-day WR and biomarkers	Standardized Portions pictures and utensils (cups, teaspoons)	FoodFinder® (Grant et al. 1992)
(Kruger et al. 2012)	South Africa	Cross-sectional study	1325 Adults (25–64 years-old)	QFFQ (MacIntyre et al. 2001b; MacIntyre et al. 2001a)	145	N.A.	Tested for reproducibility and validated against 7-day WR and biomarkers	Food portion photograph book[4]; Household measures	South African Food Composition Database _MRC[5]
(Pisa et al. 2012)	South Africa	Cross-sectional study	2010 Adults (≥ 35 years-old)	QFFQ (MacIntyre et al. 2001b; MacIntyre et al. 2001a)	145	N.A.	Tested for reproducibility and validated against 7-day WR and biomarkers	Food models and food photographs	FoodFinder® (Grant et al. 1992)
(Joffe et al. 2012)	South Africa	Cross-sectional study	256 Adults (18–45 years-old)	QFFQ (Steyn & Senekal, 2005; de Villiers et al. 2006)	129	N.A.	Relative-validated	Food Photographs	FoodFinder® (Grant et al. 1992)
2011									
(Wentzel-Viljoen et al. 2011)	South Africa	Cross-sectional study	175 Adults (35–70 years-old)	QFFQ (MacIntyre et al. 2001b; MacIntyre et al. 2001a)	145	Preceding month	Tested for reproducibility and validated against 7-day WR and biomarkers	Food models, food pictures, real food, food dishes, utensils	South African Food Composition Database _MRC, USDA database (US Department of Agriculture, Agricultural Research Service, 1996)

(*Continued on next page*)

Table 2. (*Continued*)

Authors	Country	Study Design	Study Population	Dietary Assessment Method (Source)	Number of food items	Reference time frame	Validation/ Reproducibility	Determination of Portion Sizes	Tools for Dietary Data Analysis
(Anderson et al. 2011)	Cameroon	Cross-sectional study	1790 Adults (24–74 years-old)	QFFQ (Sharma et al. 1996)	76	Preceding year	N.A.	Wooden food models and cutlery	Several FCT[6] and Microdiet Software (Fletcher, 1994)
(Joffe et al. 2011)	South Africa	Case Control Study	148 Women (18–45 years-old)	QFFQ (Steyn & Senekal, 2005; de Villiers et al. 2006)	129	N.A.	Relative-validated	Food photographs	FoodFinder® III (Grant et al. 1992)
(Aounallah-Skhiri et al. 2011)	Tunisia	Cross-sectional study	1019 Adolescents (15–19 years-old)	SQFFQ (El Ati et al. 2004)	134	Preceding month	Tested for reproducibility and validated	Visual tools	Tunisian Food Composition Database; ESHA Food Processor® (Davison & Mandible, 1994)
(Kruger et al. 2011)	South Africa	Cross-sectional descriptive study	330 Adults (> 30 years-old)	QFFQ (MacIntyre et al. 2001b; MacIntyre et al. 2001a)	145	N.A.	Tested for reproducibility and validated against 7-day WR and biomarkers	Validated food portion photograph book[7], common utensils and containers	South African Food Composition Database _MRC USDA database (US Department of Agriculture, Agricultural Research Service, 1996)
(Delport et al. 2011)	South Africa	Cross-sectional study	318 Men (18–40 years-old)	SQFFQ (MacIntyre et al. 2001a)	15 food groups	N.A.	Tested for reproducibility and validated against four 24hR	N.A.	FoodFinder® (Grant et al. 1992)
2010									
(Joffe et al. 2010)	South Africa	Case Control Study	233 Women (18–45 years-old)	QFFQ (Steyn & Senekal, 2005; de Villiers et al. 2006)	129	N.A.	Relative-validated	Food Photographs	FoodFinder® III (Grant et al. 1992)
2009									
(Zingoni et al. 2009)	South Africa	Cohort Study	83 Adolescents	QFFQ (Steyn & Senekal, 2005; de Villiers et al. 2006)	N.A.	Usual intake (daily, weekly and monthly basis)	Not validated or tested for reproducibility	Food Photo Manual; FoOd flour models; Household utensils	FoodFinder® (Grant et al. 1992)
(Goedecke et al. 2009)	South Africa	Cross-sectional study	57 Adults (18–45 years-old)	QFFQ (Steyn & Senekal, 2005; de Villiers et al. 2006)	129	N.A.	Relative-validated	Food Photographs	FoodFinder® (Grant et al. 1992)
2008									
(Tessier et al. 2008)	Tunisia	Cross-sectional study	724 Adults	QFFQ (El Ati et al. 2004)	146	N.A.	Tested for reproducibility and validated	N.A.	ESHA Food Processor® (Davison & Mandible, 1994)
(Hogenkamp et al. 2008)	South Africa	Cross-sectional study	1605 Adults (15–65 years-old)	QFFQ (95)	145	N.A.	Relative-validated	Validated photographs [8]; Household measures; Food models.	FoodFinder® (Grant et al. 1992)
2007									
(Oguntibeju et al. 2007)	South Africa	Cross-sectional study	35 Adults (18–65 years-old)	QFFQ (MacIntyre et al. 2001b; MacIntyre et al. 2001a)	145	Preceding 6 months	Tested for reproducibility and validated against 7-day WR and biomarkers	Food models; Household measures; MRC Food Quantities Manual	FoodFinder® (Grant et al. 1992)

(MacKeown et al. 2007)	South Africa	Cohort Study	143 Adolescents (10 and 13 years-old)	SQFFQ (Richter et al. 2007)	145	N.A.	Tested for Reproducibility and validated	NRPNI[9]; Food quantities manual; Household measures	South African Food Composition Database _MRC[10]; SAS software
(Vorster et al. 2007)	South Africa	Cross-sectional study	1854 Adults (≥15 years-old)	QFFQ (MacIntyre et al. 2001b; MacIntyre et al. 2001a)	145	N.A.	Tested for reproducibility and validated against 7-day WR and biomarkers	N.A.	FoodFinder® (Grant et al. 1992)
(Jackson et al. 2007)	Cameroon	Cross-sectional study	547 Adults (25–74 years-old)	QFFQ (Sharma et al. 1996)	37	Preceding year	N.A.	N.A.	N.A.
2006									
(Belgnaoui & Belahsen, 2006)	Morocco	Cross-sectional study	172 Pregnant and/or Lactating Women (16–44 years-old)	QFFQ	N.A.	Usual intake (daily, weekly and monthly basis)	N.A.	N.A.	Bilnut Software[11]
(Hattingh et al. 2006)	South Africa	Cross-sectional study	488 Women (25–44 years-old)	QFFQ	N.A.	N.A.	Validated	Food Quantities Manual	FoodFinder® (Grant et al. 1992)
2005									
(Kesa & Oldewage-Theron, 2005)	South Africa	Cross-sectional study	431 Pregnant and/or Lactating Women (16–35 years-old)	QFFQ	N.A.	Habitual consumption	Validated	Food Models	Dietary Manager Program®
(Merchant et al. 2005)	Zimbabwe	Cross-sectional study	100 Adults (34–93)	SQFFQ	30	Previous year	Validated against 24hR	Standard portion sizes	ESHA Food Processor® (Davison & Mandible, 1994)

[1]N.A.: Information not available
[2]Binult logiciel,2.01 version
[3]FCT: Food Composition Table
[4]Venter CS, MacIntyre UE, Vorster HH. The development and testing of a food portion photograph book for use in an African population. J Hum Nutr Dietet. 2000; 13:205–18.
[5]Wolmarans & Danster, 2008.
[6]Tan S, Wenlock R & Buss D (1985) Immigrant Foods: Second Supplement to McCance and Widdowson's The Composition of foods. London: HMSO.; Ngosom J & Abono A (1989) Les resources alimentaires du Cameroun: Répartition Ecologique, classification et valeur nutritive (The Food Resources of Cameroon: Ecological Distribution, Classification and Nutritional Value). Yaoundé: Institut de Recherche Médicinale et d'études de plantes médicinales. Holland B, Welch A, Unwin I, et al. (1991) McCance and Widdowson's The Composition of Foods. London: The Royal Society of Chemistry.
[7]Venter CS, MacIntyre UE, Vorster HH. The development and testing of a food portion photograph book for use in an African population. J Hum Nutr Dietet. 2000; 13:205–18.
[8]Venter CS, MacIntyre UE, Vorster HH. The development and testing of a food portion photograph book for use in an African population. J Hum Nutr Dietet. 2000; 13:205–18.
[9]National Research Programme for Nutritional Intervention
[10]Langenhoven, ML, Kruger, M, Gouws, E, Faber, M. MRC Food Composition Tables. 3rd edition. Parow Valley: Medical Research Council; 1991.; Kruger M, Sayed N, Langenhoven ML, Holing F. Composition of South African foods: vegetables and fruit. Supplement to the MRC Food Composition Tables 1991. Parow Valley: Medical Research Council; 1998; Sayed N, Frans Y, Schönfeldt HC. Composition of South African foods: milk and milk products, eggs, meat and meat products. Supplement to the MRC Food Composition Tables 1991. Parow Valley: Medical Research Council; 1999.
[11]Bilnut: SCDA Nutrisoft, Cerelles, France

Table 3. Selected studies (n = 11) which assessed dietary intake of different African populations using food frequency questionnaires and 24-hour recall [from 2005 to 2014].

Author	Country	Study Design	Study Population	Number of food items in the FFQ	Reference time frame of the FFQ	Number of recalls	Determination of Portion Sizes	Tools for Dietary Data Analysis
2014								
(Korkalo et al. 2014)	Mozambique	Cross-sectional study	551 Adolescents (14–19 years-old)	37	Preceding 7 days	4 non-consecutive (1 100%; 2 76%; 3 67%; 4 59%)	Food Photographs (Validated Food photographs in portion size estimation), Common utensils	Mozambique FCT[1] for NutriSurvey Program (Erhardt & Gross, 2007); Collection and Analysis of foods.
2012								
(Mbochi et al. 2012)	Kenya	Cross-sectional study	365 Women (25–54 years-old)	26	Preceding 7 days	Single	FFQ: no used of portion sizes; 24hR:Local household utensils; Real foods; SA Food Photo Manual	NutriSurvey Program (Erhardt & Gross, 2007)
(Amare et al. 2012)	Ethiopia	Cross-sectional study	356 Adults (>18 years-old)	8 food categories	Preceding 7 days	1 (100%) 3 (10%)	Household measures	Ethiopian FCT; FCT for use in Africa
(Mala et al. 2012)	Kenya	Cross-sectional study	107 Pregnant and/or Lactating Women (15–49 years-old)	N.A.	Usual intake	Single	Calibrated list of UNICEF; Household measures.	NutriSurvey Program (Erhardt & Gross, 2007)
2011								
(Oldewage-Theron & Kruger, 2011)	South Africa	N.A.	375 Women	>40	Preceding 7 days	Single	Food models	FoodFinder® (Grant et al. 1992)
(Namugumya & Muyanja, 2011)	Uganda	Cross-sectional	225 Adults (21–50 years-old)	55	Preceding week	Single	Food cost; Household utensils.	NutriSurvey Program (Erhardt & Gross, 2007); USDA database (US Department of Agriculture, Agricultural Research Service, 1996); FAO FCT for African foods.
2010								
(Baroudi et al. 2010)	Tunisia	Cross- sectional study	94 Adults (32–64 years-old)	168	Preceding month	Single	FFQ: household measures; 24hR: 3D food models; measurement aids; food specific units.	Bilnut Software[2]
2006								
(Oldewage-Theron et al. 2006)	South Africa	Cross- sectional study	357 Women	N.A.	N.A.	1	Food Models	Dietary Manager Program®
2005								
(Waudo et al. 2005)	Kenya, Tanzania e Uganda	Cross- sectional study	612 Women	N.A.	Previous 7-day	1	Water and measuring cylinders	Food Meter UK 07
(Faber & Kruger, 2005)	South Africa	Cross-sectional study	187 Women (25–55 years-old)	60	Preceding month	Single	24hR: Food models, household utensils, 3D sponge models dry oats utensils, and 3D sponge models	South African Food Composition Database of the MRC[3].
(Oldewage-theron et al. 2005)	South Africa	Cross sectional study	409 Women	N.A.	N.A.	1	Food Models	N.A.

[1]FCT: Food Composition Table
[2]Bilnut: SCDA Nutrisoft, Cerelles, France
[3]Medical Research Council

Table 4. Selected studies (n = 4) which assessed dietary intake of different African populations using weight records [from 2005 to 2014].

Author	Country	Study Design	Study Population	Number of days	Other collected information	Tools for Dietary Data Analysis
2013						
(Haileslassie et al. 2013)	Ethiopia	Cross-sectional study	60 Pregnant and/or Lactating Women (15–49 years-old)	1 day	Description of the foods and their cooking methods	ESHA Food Processor® (Davison & Mandible 1994); Ethiopian FCT[1]
2012						
(Olayiwola et al. 2012)	Nigeria	Cross-sectional study	240 Elderly (>60 years-old)	3 consecutive days	Description of the what was eaten on the day before	FAO FCT; Total Dietary Assessment Software (NUTRIDATA)(Pirone & et al. 1993)
2008						
(Gibson et al. 2008)	Ethiopia	Cross-sectional study	99 Women (Mean age: 27,8 years-old)	1 day	N.A.	Ethiopian FCT
(Abebe et al. 2008)	Ethiopia	Cross-sectional study	99 Women (Mean age: 27,8 years-old)	2 non-consecutive days	Detailed weighed recipe data for all the composite dishes	Development of a database based on the Ethiopian FCT

[1]FCT: Food Composition Table

2013; Botha et al., 2014; Wrottesley et al., 2014) or semi-quantitative FFQ (n = 7) (Merchant et al., 2005; MacKeown et al., 2007; Aounallah-Skhiri et al., 2011; Delport et al., 2011; Jordan et al., 2013; Lukmanji et al., 2013; Baroudi et al., 2014). Several studies (Oguntibeju et al., 2007; Vorster et al., 2007; Hogenkamp et al., 2008; Goedecke et al., 2009; Zingoni et al., 2009; Joffe et al., 2010; Joffe et al., 2011; Kruger et al., 2011; Wentzel-Viljoen et al., 2011; Joffe et al., 2012; Kruger et al., 2012; Pisa et al., 2012; Pretorius et al., 2012; Botha et al., 2014; Wrottesley et al., 2014) developed in South Africa used a quantitative FFQ specific for the South African population, retrieved from two sources, namely the Transition Health and Urbanization in South Africa (THUSA) questionnaire, design by MacIntyre et al. (2001a, 2001b) and the Dietary Assessment and Education Kit (DAEK) questionnaire, developed by Steyn and Senekal and launched by the Medical Research Council (MRC) (Steyn and Senekal, 2005; de Villiers et al., 2006). Within the employment of quantitative food frequency questionnaires (FFQs), Jackson et al. (2007) and Anderson et al. (2011), used the questionnaire of Sharma et al. (1996), which was developed specifically for Cameroonian people, but no information about its validation was reported Kesa and Oldewage-Theron (2005) and Hattingh et al. (2006) also mentioned that they used a previously validated questionnaire, but no reference was made to any paper where the validation study was published. Belgnaoui and Belahsen (2006) did not specify if the used FFQ was validated or not. Within semi-quantitative FFQs, a study carried out in Tunisia (Baroudi et al., 2014) used a validated FFQ developed in Italy, which was designed for a population with similar characteristics; both populations had cancer (Franceschi et al., 1993; Decarli et al., 1996). The study of MacKeown et al. (2007) used a FFQ based on the one used in the Birth-To-Twenty study (Richter et al., 2007). Two other Tunisian studies (Tessier et al., 2008; Aounallah-Skhiri et al., 2011) used an already validated questionnaire (El Ati et al., 2004) with few modifications according to the studied population. There were other cases in which the authors developed their own quantitative questionnaires for implementation (Merchant et al., 2005; Jackson et al., 2012; Jordan et al., 2013; Lukmanji et al., 2013; Sheehy et al., 2013). For example, Sheehy et al. (2013) developed a specific FFQ for use among rural South Africans and Jackson et al. (2012) developed, validated and tested for reproducibility a FFQ for use among adults in Botswana. Jordan et al. (2013) and Merchant et al. (2005) developed semi-quantitative FFQs to assess dietary intake in Tanzanian women and in Zimbabwean population, respectively. Lukmanji et al. (2013), authors of a Tanzanian study, also developed their own semi-quantitative FFQ but gave no information about a validation study. It is possible to observe that there are few recent validated dietary assessment instruments for African populations. As mentioned, some of the studies described so far utilized questionnaires published before 2005 have been used for dietary assessment (Sharma et al., 1996; El Ati et al., 2004), in the reviewed studies. In other cases, questionnaires were obtained from the Demographic and Health Surveys in the correspondent country. Table 2 summarizes characteristics of all the studies which used an FFQ to measure the dietary intake.

Several studies used a combination of both methods (n = 11), (Faber and Kruger, 2005; Oldewage-theron et al., 2005; Waudo et al., 2005; Oldewage-Theron et al., 2006; Baroudi et al., 2010; Namugumya and Muyanja, 2011; Oldewage-Theron and Kruger, 2011; Amare et al., 2012; Mala et al., 2012; Mbochi et al., 2012; Korkalo et al., 2014), as synthesized in Table 3. Namugumya and Muyanja (2011), applied 24hR aiming to study meal patterns and to assess meal quality, whereas with the application of a FFQ they intended to gather information on food selection patterns and portion sizes. Oldewage-theron et al. (2005) used the FFQ to study both quantitative and qualitative food consumption patterns and dietary intake of the respondents and they validated this FFQ using 24-hour recalls as a gold standard. This questionnaire was later used in 2006 by Oldewage-Theron et al. (2006). Korkalo et al. (2014), developed their own questionnaire and Mala et al. (2012) used a pre-existent FFQ (without mentioning its source) to gather information about frequency of food consumption while the 24hR was used to quantify the dietary intake. Faber and Kruger (2005), Amare et al. (2012), Mbochi et al. (2012) used a qualitative FFQ and 24hR to determine nutritional intake, while Oldewage-Theron and Kruger (2011) used a quantitative FFQ to assess dietary intake and food consumption patterns and a 24hR to confirm food variety and

dietary intake. The questionnaire used by Amare et al. (2012) was based on the Hellen Keller International FFQ, previously used in Ethiopia. Baroudi et al. (2010) assessed dietary intake using a quantitative FFQ and performed 24hR in order to obtain more qualitative information, related to food brand names and food preparation methods. Waudo et al. (2005) used 24hR to assess what mothers had eaten in the preceding 24 h and then applied an FFQ in order to obtain information about the types of foods commonly consumed.

Besides these two retrospective methods, weighed records were also utilized, but in a much smaller number; only four studies. Haileslassie et al. (2013) and Gibson et al. (2008) used only a single day as a measuring unit while Olayiwola et al. (2012) and Abebe et al. (2008) applied food records for three and two nonconsecutive days, respectively. More detailed information about these studies is compiled in Table 4.

Methods for the analysis of food intake data

A large range of software tools for the analysis of dietary data were mentioned in these studies. According to Table 5 it can be observed that there is a preferential selection of food databases of the countries within the same African region. For instance, in Western Africa the *Software for Intake Distribution Estimation* (C-SIDE) developed by Iowa State University is commonly used, while in Eastern Africa, NutriSurvey is the mainly chosen software. In the Northern African countries, Bilnut Software was used for the majority and in the South, FoodFinder® (Grant et al., 1992) was clearly the most utilized software. Several countries had to update these tools with their own typical foods or recipes of composite dishes, when these were not available.

In Western African countries the most used nutritional programs were ESHA Food Processor® (Food Processor Diet Analysis and Fitness Software) (Wiig and Smith, 2007; Huybregts et al., 2009; Addo et al., 2011; Pereko et al., 2012) and C-SIDE (Sodjinou et al., 2008; Sodjinou et al., 2009; Becquey and Martin-Prevel, 2010; Zeba et al., 2014). Several authors used other softwares, such as *NutriData*, developed in California (Olayiwola et al., 2012), *Nutrition Data System for Research* (NDSR), developed by University of Minnesota (Luke et al., 2011) and *Nutrifiq*, based on the Canadian Nutrient File (Alaofè et al., 2009). A very comprehensive software system, named VBS Food Calculation System, was chosen for the Women's Dietary Diversity Project (in Burkina Faso and Mali) (Becquey et al., 2009; Kennedy et al., 2009). VBS Food Calculation System is a set of three softwares, which include KOMEET (for food intake analysis), VBS MANAGER (nutrient composition information), ORION and FOOD GROUPS (both for nutrient intake by food group analysis).

In East Africa, almost all the studies performed therein used the *NutriSurvey Program*, which has seventeen different food databases (food composition tables from Tanzania, Kenya, Senegal, Mali and Germany among others) (Kamau-Mbuthia and Elmadfa, 2007; Namugumya and Muyanja, 2011; Mala et al., 2012; Mbochi et al., 2012; Mupere et al., 2012; Jordan et al., 2013; Korkalo et al., 2014). *ESHA Food Processor*® (Merchant et al., 2005; Irvine et al., 2011; Haileslassie et al., 2013), *FoodFinder*® (Steyn and Nel, 2006; Steyn et al., 2011; Steyn et al., 2012), which includes the latest version of the South African Food Composition Database, NDSR (Heimburger et al., 2010; Koethe et al., 2013), and WorldFood Dietary Assessment System (Gewa et al., 2008; Walton et al., 2012) were also used. Softwares such as Programme CANDAT (Powell et al., 2013), Food Meter UK 07 (Waudo et al., 2005) and *General Intake Estimation System*, developed by The National Food Institute, in Denmark (Hansen et al., 2011) (linked with Composition of Foods Commonly Eaten in East Africa, the UK Nutrient Databank and National Food Composition Tables and The Planning of Satisfactory Diets in Kenya), were also chosen for nutrient analysis.

Northern African countries based their nutrient analysis on *Bilnut Software* (Belgnaoui and Belahsen, 2006; Baroudi et al., 2010; Baroudi et al., 2014). However, other softwares such as *ESHA Food Processor*® (Aounallah-Skhiri et al., 2011), DIAL Programme (López et al., 2012), developed by several authors from Alce Ingenieria, *Tableaux des valeurs nutritives* (Lamri-Senhadji et al., 2009), built by Souci et al. (2000), Dietetik®, designed for Tunisian foods, Nutrilog®, a software with eleven different databases (Boumaiza et al., 2012) and *FoodBase Nutritional Program* (Nyuar et al., 2012) were also used in some studies.

Investigations carried out in South African countries mainly used *FoodFinder*® software(Charlton et al., 2005; Faber and Kruger, 2005; Mostert et al., 2005; Hattingh et al., 2006; O'Keefe et al., 2007; Oguntibeju et al., 2007; Vorster et al., 2007; Oldewage-Theron et al., 2008; Oldewage-Theron et al., 2008; Oldewage-Theron et al., 2008; Zingoni et al., 2009; Joffe et al., 2010; Oldewage-Theron et al., 2010; Joffe et al., 2011; Kruger et al., 2011; Naude et al., 2011; Oldewage-Theron and Kruger, 2011; Rankin et al., 2011; Wentzel-Viljoen et al., 2011; Jackson et al., 2012; Kruger et al., 2012; Papathakis and Pearson, 2012; Pretorius et al., 2012; Oldewage-Theron et al., 2014; Wrottesley et al., 2014).

Other software databases such as NDSR (May et al., 2014), *NutriBase* (Kolahdooz et al., 2013; Sheehy et al., 2013), developed by CyberSoft (both based on USDA National Nutrient Database for Standard Reference*), Dietary Manager* Program® (Kesa and Oldewage-Theron, 2005; Oldewage-Theron et al., 2006) managed by Oskar Scharf of Dietetic Services/Rand Software and Nutritionist Five (Maruapula and Chapman-Novakofski, 2008) were also used.

In Central Africa, the used software tools in Cameroon were *Microdiet* (Anderson et al., 2011) and *Becel Institute Nutrition Software* (Dapi et al., 2010) and Lucille food analysis software (Termote et al., 2012) in Democratic Republic of Congo.

Some studies did not mention the use of specific software, only referring the use of food composition databases, as source of information for the nutrient analysis, whose analysis was performed with a tool, such as Microsoft® Office Excel or IBM SPSS software for example, to compute dietary data.

Generally in African countries, there is a lack of country-specific Food Composition Tables (FCTs), and the ones that have their own FCT, do not have it updated. For this reason some countries use FCTs from neighboring countries or use global databases. Examples of cited databases are: USDA Nutrient Database for Standard Reference and others developed by Food and Agriculture Organization (FAO), such as

Table 5. Nutritional Tools used in dietary data analysis in the selected studies carried out between 2005–2014, organized per African Regions (Western, Eastern, Central, Northern and Southern Africa).

WESTERN AFRICA	Benin	Burkina Faso	Ghana	Mali	Nigeria
Nutritional tools used in Dietary Data Analysis	Nutrifiq (Alaofè et al. 2009) C-SIDE[1] (Sodjinou et al. 2009; Sodjinou et al. 2008) FCT[2] for use in Africa (Nago et al. 2010)	USDA[3] Database (Becquey & Martin-Prevel 2010) ESHA Food Processor® (Huybregts et al. 2009) C-SIDE (Zeba et al. 2014; Becquey & Martin-Prevel, 2010) VBS Food Calculation System (Becquey et al. 2009)	ESHA Food Processor® (Addo et al. 2011; Wiig & Smith, 2007; Pereko et al. 2012) Nutrition Data System for Research (Luke et al. 2011)	VBS Food Calculation System (Kennedy et al. 2009)	Nutridata (Olayiwola et al. 2012) Food analysis methods (Ijarotimi & Keshinro, 2008)

EASTERN AFRICA	Ethiopia	Kenya	Tanzania	Uganda	Zambia	Zimbabwe	Mozambique
Nutritional tools used in Dietary Data Analysis	USDA Database (Alemayehu et al. 2011) ESHA Food Processor® (Haileslassie et al. 2013) FCT for use in Africa; Ethiopian FCT (Tesfaye et al. 2008; Gibson et al. 2008; Abebe et al. 2008; Amare et al. 2012)	WorldFood Dietary Assessment System (Gewa et al. 2008; Walton et al. 2012) NutriSurvey Program (Mbochi et al. 2012; Mala et al. 2012; Kamau-Mbuthia & Elmadfa, 2007) GIES[4] (Hansen et al. 2011) FoodFinder® (Steyn & Nel, 2006; Steyn et al. 2011; Steyn et al. 2012) Food Meter UK 07 (Waudo et al. 2005)	NutriSurvey Program (Jordan et al. 2013) ESHA Food Processor® (Irvine et al. 2011) Programme CANDAT (Powell et al. 2013) Tanzanian FCT (Kim et al. 2014; Changamire et al. 2014; Lukmanji et al. 2013) Food Meter UK 07(Waudo et al. 2005)	USDA database, NutriSurvey Program (Mupere et al. 2012; Namugumya & Muyanja, 2011) Food Meter UK 07 (Waudo et al. 2005)	Nutrition Data System for Research software (Koethe et al. 2013; Heimburger et al. 2010)	USDA Database; ESHA Food Processor® (Merchant et al. 2005)	NutriSurvey Program (Korkalo et al. 2014) FCT for Africa and FCT for Mozambique (Scarcella et al. 2011)

NORTHERN AFRICA	Algeria	Egypt	Morocco	Sudan	Tunisia
Nutritional tools used in Dietary Data Analysis	*Tableaux des valeurs nutritives* (Lamri-Senhadji et al. 2009)	Egyptian FCT_Nutrition Institute (Mounir et al. 2007)	Bilnut Software (Nutrisoft) (Baroudi et al. 2010) DIAL Programme [5] (López et al. 2012)	Foodbase Nutritional Program (Nyuar et al. 2012)	Dietetik® and Nutrilog® (Boumaiza et al. 2012) Bilnut Software (Logiciel and Nutrisoft) (Baroudi et al. 2014; Belgnaoui & Belahsen, 2006) ESHA Food Processor® (Aounallah-Skhiri et al. 2011; Tessier et al. 2008)

SOUTHERN AFRICA	Botswana	South Africa	CENTRAL AFRICA	Cameroon	D. R. Congo
Nutritional tools used in Dietary Data Analysis	Nutritionist Five (Maruapula & Chapman-Novakofski, 2008) FoodFinder® (Jackson et al. 2012)	FoodFinder® (Wrottesley et al. 2014; Oldewage-Theron et al. 2014; Papathakis & Pearson 2012; Pretorius et al. 2012; Joffe et al. 2011; Oldewage-Theron et al. 2010; Zingoni et al. 2009; W. H. Oldewage-Theron et al. 2008; Oguntibeju et al. 2007; Charlton et al. 2005; Rankin et al. 2011; Oldewage-Theron & Kruger, 2011; Joffe et al. 2010; Faber & Kruger, 2005; Wentzel-Viljoen et al. 2011; Kruger et al. 2011; Mostert et al. 2005; O'Keefe et al. 2007; Naude et al. 2011; Kruger et al. 2012; Jackson et al. 2012; Hattingh et al. 2006; Vorster et al. 2007; WH Oldewage-Theron et al. 2008; Wh Oldewage-Theron et al. 2008) Nutribase (Kolahdooz et al. 2013; Sheehy et al. 2013) Dietary Manager Program® (Kesa & Oldewage-Theron, 2005; Oldewage-Theron et al. 2006) Nutrition Data System for Research (May et al. 2014; Luke et al. 2011) South African Food Composition Database of the MRC (Mostert et al. 2005; Kruger et al. 2011; Kruger et al. 2012; Wentzel-Viljoen et al. 2011; MacKeown et al. 2007; Faber & Kruger, 2005)	**Nutritional tools used in Dietary Data Analysis**	Microdiet (Anderson et al. 2011) Becel Software (Dapi et al. 2010)	Lucille food analysis software (Termote et al. 2012)

[1]C-SIDE: Software for Intake Distribution Estimation
[2]FCT: Food Composition Table
[3]USDA: United States Department of Agriculture
[4]GIES: GIES: General Intake Estimation System Program, GIES; National Food Institute, Søborg, Denmark
[5]DIAL: Programa para evaluación de dietas y gestión de datos de alimentación.

Food Composition Table for Use in Africa, West African Food Composition Table and Composition of Selected Foods from West Africa. USDA Database was the most cited database, in countries such as Burkina Faso, Cameroon, Ethiopia, Uganda, Zimbabwe, Cameroon or Botswana. All of these databases could be accessed on the International Network of Food Data Systems (INFOODS) directory.

Sampling methodology

Sampling can be done using different methodologies, depending on the aim of the investigation, on the sample size, among other factors.

According to the range of studied papers, random and non-random sampling methods were used, random sampling being the most common. Some authors did not describe how the recruitment of subjects was done. Within random sampling the main methods used were stratified sampling, multi-stage sampling and simple random sampling. Non-random convenience sampling was also used.

In studies using a multistage sampling approach, probability proportionate to size method was frequently used in the first selection stage, i.e., in the selection of areas (rural/urban), districts, villages, communities or even quarters. Consequently households were simply randomly selected (Oldewage-theron et al., 2005; Ijarotimi and Keshinro, 2008; Sodjinou et al., 2009; Nago et al., 2010; Amare et al., 2012; Olayiwola et al., 2012) or the walk method was used (Alemayehu et al., 2011; Korkalo et al., 2014), for the identification of the subject that fulfilled the inclusion criteria, within each household. Besides these walk methods, the usage of township maps to more easily select residential areas was also utilized as one of the initial methodologies of the sampling procedure (Hattingh et al., 2006; Oldewage-Theron and Kruger, 2011; Kolahdooz et al., 2013; Oldewage-Theron et al., 2014). Few studies (Becquey et al., 2009; Nago et al., 2010; Powell et al., 2013) mentioned the possibility to access residential information in the studied city, which were provided by state agencies, such as the village government, Ministry of Education or the Higher Institute of Population Science. Since it was possible to differentiate segments in populations, in several cases creation of clusters (Waudo et al., 2005; Tessier et al., 2008; Kennedy et al., 2009; Aounallah-Skhiri et al., 2011; Jackson et al., 2012) or stratification of the sample (Kesa and Oldewage-Theron, 2005; Steyn and Nel, 2006; Jackson et al., 2007; Mounir et al., 2007; Vorster et al., 2007; Hogenkamp et al., 2008; Maruapula and Chapman-Novakofski, 2008; Dapi et al., 2010; Anderson et al., 2011; Luke et al., 2011; Steyn et al., 2011; Mbochi et al., 2012; Steyn et al., 2012; Haileslassie et al., 2013; Powell et al., 2013) by environmental or individual factors, such as social strata, income, living in rural or urban area, age or sex, was performed. In some cases, participants were randomly recruited using advertisements which were placed in different and strategic locations, such as church groups, community centers and universities or even in local newspapers (Charlton et al., 2005; O'Keefe et al., 2007; Goedecke et al., 2009). Subjects were recruited in medical clinics, health centers or day care centers; in some papers random sampling was cited (Mostert et al., 2005; Oldewage-Theron et al., 2006; Jordan et al., 2013; Lukmanji et al., 2013) and in others no sampling method was mentioned (Belgnaoui and Belahsen, 2006; Wiig and Smith, 2007; Oldewage-Theron et al., 2008; Baroudi et al., 2010; Heimburger et al., 2010; Oldewage-Theron et al., 2010; Gibson et al., 2011; Kim et al., 2014).

Convenience sampling was applied in several studies (Abebe et al., 2008; Gibson et al., 2008; Joffe et al., 2012; Termote et al., 2012; Walton et al., 2012). In other cases, authors only mention that the sampling method was not random (Alaofè et al., 2009; Wrottesley et al., 2014).

Discussion

The purpose of this review was to summarize the methodologies and tools used in dietary intake assessment in African countries, in a ten year period, covering steps from the sampling to dietary data analysis.

When we seek to describe the dietary intake of a population, the first required step is to establish a representative sample. Many sampling and subject recruitment methods can be used and these were indeed reflected in the analyzed studies. The major part of the studies applied random recruitment. In the cases in which convenience sampling was performed, various segments of the population were not included and since it is not possible to calculate the total number of excluded people, it is also not possible to determine bias caused by the absence of these individuals in the sample (Gouveia de Oliveira, 2009). Ideally, random methods should be used when the aim is to characterize a population. In the recruitment process, the selected approaches have to be adapted to the population socio-economical and educational capabilities in order to assure adequate response rates and to avoid constraints in participation. The authors of the studies included in this review used some strategies, such as: the description of the study objectives in the population's native language, overcoming language limitations; the possibility to give oral consent for participation in the investigation, overlapping limitations related to high rates of illiteracy; and picking enumerators or volunteers that understood very well the population and their habits aiming to reach their confidence, reducing the possibility of anxiety or suspicion that could be present in such situations (Ngo et al., 2009).

Dietary assessment methods

Implementation of dietary assessment methods may be done in several ways, for instance face-to-face interviews, by telephone, by email, self-administrated or observation when using the weighing method. The selected implementation method is related mainly with social and economic context of the studied areas and the resources available for the research. In this review the majority of the included studies were performed with face-to-face interviews and in two cases, i.e. in South Africa and Cameroon, self-administration was used.

To understand which is the best methodology to choose according to the population and the purpose of the study, and considering that 24hR and FFQ methods rely on respondents' memory, it is important to evaluate the accuracy of memory-based reports. There is cognitive research that confirms that for general people it is easier to describe generic dietary patterns

than to describe a specific dietary meal (Wirfalt, 1998). According to Thompson and Byers (1994), in cross-sectional studies generally the most used methodology is the 24hR, as corroborated by this review. Furthermore, as shown in the analysis performed herein, FFQ was the second most used tool. Both have advantages and disadvantages and should be applicable in specific situations. In their review Pisa et al. (2014) also identified the same top chosen dietary assessment tools.

A single 24hR is an indepth-interview that must be administered by trained people. In some of the studies under revision the interviewer was either a nutritionist, a dietitian or a nutrition student who had been previously trained by experts to collect dietary data. Such extensive expert training of the interviewer in state-of-the-science methodology is of extreme importance for obtaining valid and reliable assessments and analyses of dietary intakes. Furthermore, the need for a broad perception and issue awareness is needed to successfully fulfill collection of dietary data using this method which is dependent on the subject's memory. A well-trained interviewer will create the need and relaxed atmosphere for the subject, as well as ask key questions that help subjects remember their intake easily (Willet, 1998). According to Wirfalt (1998), and also Smith and colleagues (Smith, 1991; Smith et al., 1991), more important than closeness of time or number of assessed days are the cues presented to the respondent, which influence aspects of the memory structure that are accessed or activated. There is evidence that the presence of cues prior to method implementation and probes during the assessment, two strategies that were done in the majority of the reviewed interviews, may increase reliability given by individual dietary reports (Smith, 1991; Smith et al., 1991; Thompson and Byers, 1994; Wirfalt, 1998). This was one of the reasons why experts in the area were selected to duly perform the analysis of dietary intake. However, not all studies across different countries could guarantee the collection of data by an expert, probably due to availability of these professionals. Another review, carried out in Africa, also pointed out this limitation (Pisa et al., 2014), referring that in some African countries there is a lack of well-trained nutritionists and dieticians, which makes it challenging, perhaps compromising, the transfer of knowledge and training of interviewers.

The Automated Multiple Pass Method (AMPM), cited by some authors as the reference tool to apply the 24hR, has been tested in different types of populations (Johnson et al., 1996; Jonnalagadda et al., 2000; Conway et al., 2003; Conway et al., 2004) and it has been used in the continuing National Health and Nutrition Examination Survey (NHANES). A single day does not represent the usual consumption because of day-to-day variation and for that reason several studies conducted multiple recalls. The more recalls are conducted, the greater similitude to usual consumption is obtained and, consequently, better accuracy is achieved. According to Thompson and Byers (1994), the 24hR and the WR,, usually done multiple times, estimate with quantitative accuracy daily food and nutrients intake, while frequency methods, such as FFQ, are limited by their lack of quantitative accuracy. In the reviewed studies, when multiple recalls were applied, they were distributed in non-consecutive days, in order to include week-days and weekend. Ideally all the 7 days of the week should be assessed in order to better represent usual consumption and to avoid possible systematic differences on dietary intake in different days of the week (Willet, 1998). However, the chosen number of days should be considered and decided considering the size of the sample, the purpose of the study, the accuracy desired, the monotony or variety of the diet, as well as the variability of nutrients and foods being assessed (Willet, 1998). Yunsheng and colleagues (Ma et al., 2009) studied how many 24hR are required to describe an individual's intake and they concluded that three is the sufficient number of recalls, since with less than three significant differences in energy estimation were observed and with more than three this parameter did not significantly improve. In some cases there was no possibility of conducting a multiple recall. According to the perception of some authors, the monotony of the diet (Steyn et al., 2011; Nyuar et al., 2012) or the large number of respondents (Kamau-Mbuthia and Elmadfa, 2007) meant that a single recall was enough. In other cases the lack of time and other resources, such as labour and finances were the main causes (Wiig and Smith, 2007; Maruapula and Chapman-Novakofski, 2008).

Validity of the 24hR is usually done by comparison between the reports of the respondents in the recall and the measures recorded or weighed by trained and expert observers. An experiment carried out in Ethiopia (Alemayehu et al., 2011) concluded that in the evaluated setting the 24hR was not an accurate substitute of WR. They concluded that the lack of agreement regarding the number and type of foods between the two methods, caused by memory lapses, and inaccuracies in portion size estimation were the main sources of error. Nevertheless, Gewa et al. (2008) used a to a similar comparison and got different conclusions, supported by higher values of agreement coefficients. In this case, 24hR could be an acceptable alternative to weighing method, however they considered that it was necessary to improve the recall procedure.

Twenty-four hours recall does not cause a huge burden to the respondents as the food records do. Besides, the recall is less likely to modify eating behavior of the respondents, because it is implemented after they have eaten and it does not require literacy, which is necessary to perform a correct, informative and complete food record. In the studied populations this was the major strength of the 24hR and a common reason cited by authors for choosing the recalls rather than the food records. Notwithstanding, when compared with frequency methods these two methods have weaknesses in common, since they are not likely to represent the usual consumption of individuals as reflected in frequency methods.

Therefore, FFQ gives a better idea about the usual consumption because the retrospective period is larger. This period could be since the preceding seven days to the preceding year, for instance. The decision about the ideal time frame is related with two issues, the metabolism of the dietary factor being studied and the physiology/pathophysiology of the outcome (Willet, 1998). If the preceding year is used as time frame the researchers assess the dietary intake throughout the whole year, covering both seasons usually referred as dry season and harvest season. When the reference time frame is shorter, the effect of seasonality is not considered, which was a limitation mentioned by several authors. Nevertheless, some of them

mentioned that seasonality probably does not induce major dietary modifications, even though seasonality is believed to have significant effects on the diet and nutritional status. In the context of Africa, especially in rural areas, seasonality is in fact an important issue since the production and consequent consumption of some foods, such as fruit, vegetables and cereals, are directly affected by weather conditions that characterize both dry and wet seasons (Savy et al., 2006; Asombang et al., 2013; Msaki and Hendriks, 2014). These diet modifications can lead to different intake in some nutrients such as vitamins and fat (Faber and Laubscher, 2008; Mitchikpe et al., 2008; Wiesmann et al., 2009; Masibo, 2013). More than half of the studies that used FFQ as dietary assessment tool did not specify FFQ's time frame, although the preceding year was the most cited.

Some of the FFQ utilized by the reviewed authors were specifically created for those studies, hence they included the elaboration of the food list besides other steps. Regarding the food list, the way of organizing food items in a questionnaire determines the answer of the respondent. Wirfalt (1998) cited some studies that had better results regarding reproducibility and validity when food items were organized according to the type of meals they usually consumed rather than when they were organized according to food groups. Most of the reviewed studies that used FFQ organized their dietary information in terms of food groups.

As it is possible to observe from the results section, among the studies developed in other countries besides South Africa, few of them used FFQ as one of the selected tools. In these studies authors had to create a new FFQ because in countries such as Kenya, Mozambique, Uganda, Tanzania, Botswana, Morocco or Ethiopia there is no population-specific FFQ. This shows the need for developing new food frequency tools within the majority of African countries.

Validity of a FFQ is not a very practical and easy process to perform, because it requires a noninvasive observation of total diet of the respondents during a long period, and these validation studies have not yet been done (Thompson and Byers, 1994). What is currently and usually done is the comparison of results from FFQ with that from recalls and records (Thompson and Byers, 1994), a process which for some authors should be called calibration instead of validation (Willet, 1998).

Some of the presented studies were also tested for reproducibility. The previous referred THUSA questionnaire was tested for reproducibility by other authors (Wentzel-Viljoen et al., 2011) in a different population, with Seatswana-speaking adults. They concluded that this questionnaire was reproducible.

Besides these reported cases there is still a lack of validated methods for use in a specific population, and thus the need of updating the validated dietary assessment methods across African countries is emergent. When a validation study is performed, researchers have more confidence in their method since it means that it can actually measure the aspects of diet that it was designed for (Willet, 1998), as long as the study is well-performed.

Estimation of food portion size

Estimation of foods portion size is one of the challenging aspects of the recall tools (Thompson and Byers, 1994; Willet, 1998; Venter et al., 2000). In several households within rural settings it is common that all the family eat from a shared bowl, hampering the estimation process (Hudson, 1995; Huybregts et al., 2008; Pisa et al., 2014). There are visual aids which are used to help respondents to accurately report the amounts of food items consumed. In the reviewed studies several tools were used, such as household measures, food models (two-dimension or three-dimension), food photographs and pictures, containers, real food items, among others. Within the studies that used 24hR, some did not mention how this estimation was done leaving less margin to evaluate the associated effectiveness (Mostert et al., 2005; Mounir et al., 2007; O'Keefe et al., 2007; Maruapula and Chapman-Novakofski, 2008; Oldewage-Theron et al., 2008; Heimburger et al., 2010; Gibson et al., 2011; López et al., 2012; Pereko et al., 2012; Changamire et al., 2014; May et al., 2014). In fact, there is little data concerning the accuracy of portion size estimation tools. A study of Byrd-Bredbenner and Schwartz (2004) evaluated if using portion size measurement aids (PSMAs) had effect on portion size estimation accuracy, in a group of young adults. The PSMAs were two: one was a life-size card containing pictures of both tennis and golf balls and the other one were both real tennis and golf balls. They concluded that even if the estimation accuracy was improved by the use of PSMAs, estimation errors still remain. In Burkina Faso an album of food photographs was validated for use on food portion size estimation of frequently consumed food items (Huybregts et al., 2008). This validated album, with four photos per one of the eight evaluated food items, could be used in 24hR as a valuable and accurate tool in West African rural settings. Another example of advances in this area is the book of food photographs developed and tested by Venter et al. (2000), with the purpose to be used in the THUSA study. A more recent work (Lombard et al., 2013), also carried out in rural areas of South Africa, focused on the development of a food photography series, mainly geared toward oesophageal cancer patients.

In FFQs, portion size of the food items may either be or not be assessed; in this latter option it can be assumed a common portion size for all subjects. There were few papers among the many reviewed in which authors, having collected the amounts consumed by the respondents, did not report how it was done (Belgnaoui and Belahsen, 2006; Jackson et al., 2007; Vorster et al., 2007; Tessier et al., 2008; Delport et al., 2011; Baroudi et al., 2014; Botha et al., 2014). The most used tools to estimate portion size were household measures, food models (two-dimension or three-dimension) and food photographs, including the validated food photo manual (Venter et al., 2000). Implementation of the FFQ by mail or by telephone was not used in the reviewed studies. Although these possibilities are considered or applied many times in European or American dietary surveys, the socio-economical, political or geophysical conditions found in many African countries may entail natural communication barriers.

Food composition databases

To convert the dietary intake into nutrient intake some components are needed, such as a food composition database, a coding system for matching foods listed with the entries in the food composition database and a software for calculating the nutrients' composition (Thompson and Byers, 1994; Willet, 1998). The right choice of the nutrient database is very important because the estimation of nutrient intake is affected by it. Parameters such as the completeness regarding the included food items and evaluated nutrients are related to the constant updating of the database, so it is imperative to support the analysis on the most recent updated version available (Thompson and Byers, 1994). These nutrient databases are commonly included in computer software programs that process data and calculate individual dietary intake. The choice of the software should be based on the level of specification and detail needed, on the type of foods that are usually consumed by the studied population and on the hardware and software requirements. As mentioned above, and also noted by other reviews (Ngo et al., 2009; Ochola and Masibo, 2014; Pisa et al., 2014), there are few African countries with their own FCT, and countries without their own food table need to use either FCTs from neighboring countries or FAO's FCTs, which decreases reliability of the results. This was one of the most cited limitations by the authors. In this review several softwares were mentioned by the authors, however most of them are composed by the same FCTs, which makes imperative the need of creating updated tools. An example of an effort to improve this lack of country-specific databases is the study of Becquey et al. (2009), who developed a FCT for Burkina Faso bringing together the information of three sources, namely the FCT for Mali, supplemented by the WorldFood FCT for Senegal and the USDA database. This table was complete for energy, macronutrients and eleven micronutrients. The variability within the same continent is huge, and different lifestyles and typical food patterns are found even within the same country, which makes the finding of uniformity in the FCTs quite challenging, and eventually impossible, and so the countries find themselves obliged to create their own tools. In order to fight against the current lack of updating of these tools it is necessary to join forces geared towards the development of both new and country-specific FCTs or at least to complete the existing ones.

Besides the limitations that were mentioned along this discussion, limitations related to the adopted methodologies, to self-reporting, to small size sample were also cited. Furthermore, the traditional way of cooking is another challenging question too, because household's women resort to memory and taste rather than follow standard recipes or measurements to cook their dishes, which may hamper a reliable assessment (Wojtusiak et al., 2011).

Concerning improvements in developed countries according to new-technology based dietary assessment methods, it is envisaged that, in the coming years, these innovative tools could be used in African countries. Examples of these methods are a mobile device food record (Zhu et al., 2008) and a system based on images of foods (Schap et al., 2014). Although Wojtusiak and colleagues (Wojtusiak et al., 2011) defend that some methods based on automated analysis of photos, voice recognition and use of simple graphical symbols representing food could be applied in dietary assessment in African countries, there is still a long way to go before that may become a reality. Africa is comprised by a large part of rural areas, some of which even do not have sanitation or electricity and food insecurity is one of the major problems. Africa has a particular social organization characterized by the co-existence of several ethnic groups and societies each one with its own traditions and habits, hampering its conjoint growth and balanced development.

Conclusions and recommendations

Globally, African countries are crossing a challenging public health crisis, which coupled to both weak and poor social and governmental structure leads to major concerns related to health, food security and socio-economic issues. Aiming to counteract the double health burden, characterized by both communicable and non-communicable diseases, a major effort is emerging toward development of health policies and the planning, development and evaluation of nutritional interventional programs.

Data obtained from this review provided a better knowledge of the research works that have been developed in African countries concerning food habits of individuals, strengthening the need to apply a bigger effort in these many nations. As shown in this review, in African countries, there is a lack of periodical, accurate, reliable and country-specific methodologies to assess dietary intake in adults. Major limitations on dietary assessment in Africa were, on the one hand, the deficiency in validated and standardized methodologies to perform the dietary assessment and, on the other, the usage of country-unspecific food composition databases. So, related to the first it is necessary to proceed with validation studies and test for reliability of the used methods, in order to assure the consistency and accuracy of measurements, as well as the confidence therein. Regarding the second cited limitation there is an emergent need to improve the already existing databases by updating food data and to develop suitable country-specific ones for those countries that don't have their own food composition table.

Countries with better social, financial and health resources evidenced more activity in this field and performed more investigations, providing greater data availability. Due to distinct social organization of the continent, with major problems, such as high rates of inadequate education, illiteracy, food insecurity and a frail global health system, the work on this field should be continued and widened to include other African countries. Once surpassed some of these basic challenges it will be desired to follow developed countries' trends in what concerns the usage of innovative tools.

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