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

Catarina Vila-Real, Ana Pimenta-Martins, Ana Maria Gomes, Elisabete Pinto, and Ndegwa Henry Maina

Universidade Católica Portuguesa, CBQF - Centro de Biotecnologia e Química Fina – Laboratório Associado, Escola Superior de Biotecnologia, Rua Arquiteto Lobão Vital, Porto, Portugal; Instituto de Saúde Pública, Universidade do Porto, Porto, Portugal; Division of Food Technology, Department of Food and Environmental Sciences, University of Helsinki, Helsinki, Finland

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 in African countries, studies aiming to assess a particular nutrient/specific 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.

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 - Regional 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
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...
| Author                        | Country                 | Study Design       | Study Population                                                                 | Number of recalls | Determination of Portion Sizes                                                                 | Tools for Dietary Analysis                                                                 |
|------------------------------|-------------------------|--------------------|-----------------------------------------------------------------------------------|-------------------|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| (Zeba et al. 2014)           | Burkina Faso            | Cross-sectional    | 110 Adults (25–6 years-old)                                                        2 non-consecutive | Local kitchen utensils, Standardized food models | Malian FCT<sup>1</sup>; C-SIDE<sup>2</sup> (Iowa State University, 1996)                        |
| (Kim et al. 2014)            | Tanzania                | Cross-sectional    | 80 Pregnant and/or Lactating Women (>18 years-old)                                  2 non-consecutive | Photographs of local alcoholic beverage | 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           | N.A.<sup>3</sup> | 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.<sup>3</sup> | Tanzanian FCT Harvard University School of Public Health                                        |
| (Oldewage-Theron et al. 2014)| South Africa            | Cross-sectional    | 722 Women (19–90 years-old)                                                         ≥ 3               | Food models, household utensils                 | FoodFinder<sup>9</sup> (Grant et al. 1992)                                                   |
| (Powell et al. 2013)         | Tanzania                | Cross-sectional    | 274 Women                                                                          2 non-consecutive | Local serving sizes aids | Programme CANDAT (Gordin, 2007); Tanzanian FCT, FAO FTC, USDA Database (US Department of Agriculture, Agricultural Research Service, 1996) |
| (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    | 137 Adults (>19 years-old)                                                          2 non-consecutive | 3D food models; local household utensils       | Nutribase (CyberSoft, 1986)                                                                  |
| (Walton et al. 2012)         | Kenya                   | Cross-sectional    | 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 (Semhi, 1993); USDA database<sup>4</sup> (US Department of Agriculture, Agricultural Research Service, 1996) |
| (Termote et al. 2012)        | Democratic Republic of Congo | Cross-sectional    | 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    | 1008 Women (15–60 years-old)                                                        Single          | Dietary assessment kit comprising life-size drawings and generic food models | FoodFinder<sup>9</sup> (Grant et al. 1992)                                                   |
| (Pereko et al. 2012)         | Ghana                   | Cross-sectional    | 252 Adults (20–50)                                                                 3 non-consecutive | N.A.                                         | ESHA Food Processor<sup>8</sup> (Davison & Mandible, 1994) and the Ghanaian FCT                |
| (López et al. 2012)          | Morocco                 | Cross-sectional    | 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    | 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 (18–42 years-old)                               4 non-consecutive | Volume of cups, bowls and plates               | FoodFinder<sup>9</sup> (Grant et al. 1992)                                                   |
| (Nyuar et al. 2012)          | Sudan                   | N.A.               | 113 Women (18–42 years-old)                                                         Single          | Household measures                            | Foodbase Nutritional Program<sup>6</sup>                                                     |
| (Boumaiza et al. 2012)       | Tunisia                 | Cross-sectional    | 329 Adults (Mean age of 44.9 years-old)                                              3 non-consecutive | Household measures                            | Dietetik<sup>8</sup> and Nutrilog<sup>9</sup> (SAS, 2007)                                   |
| Year  | Country                  | Study Type               | Sample Size | Methodology                                                                 | Validation Tool(s)                                                                 |
|-------|--------------------------|--------------------------|-------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| 2011  | Kenya                    | Cross-sectional study    | 1050 Women  | Single, Photographs, life-size drawings food models                           | FoodFinder® (Grant et al. 1992)                                                   |
|       |                          |                          | (15–60 years-old) |                                                                             |                                                                                   |
|       | South Africa             | Cross-sectional study    | 162 Adolescents | 3 non-consecutive, Household measures; Pictures from the Dietary Assessment and Educational Kit®, MRC Food Quantities Manual. | FoodFinder® (Grant et al. 1992)                                                   |
|       |                          |                          | (12–16 years-old) |                                                                             |                                                                                   |
|       | Malawi                   | Cross-sectional study    | 80 Pregnant Women | 3 non-consecutive, N.A.                                                      | Malawian FCT                                                                        |
|       |                          |                          | (14–45 years-old) |                                                                             |                                                                                   |
|       | Kenya                    | Cross-sectional study    | 1163 Adults  | 2, Real food items/Paper models, utensils from the local market               | GIES®                                                                             |
|       |                          |                          | (18–68 years-old) |                                                                             |                                                                                   |
|       | Ghana                    | Cross-sectional study    | 70 Pregnant and/or Lactating Women | 3 non-consecutive, Household measures, weigh portion made at home or bought | ESHA Food Processor® (Davison & Mandible, 1994) and published food composition information |
|       |                          |                          | (18–42 years-old) |                                                                             |                                                                                   |
|       | Tanzania                 | Case Control Study       | 171 Adults   | Single, Real food items; Kitchen utensils; Serving dishes                     | ESHA Food Processor® (Davison & Mandible, 1994)                                   |
|       |                          |                          | (Mean age of 38 years-old) |                                                                             |                                                                                   |
|       | 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.) |
|       | Ethiopia                 | Cross-sectional study    | 68 Women     | Single, Weigh of the estimated portion consumed (using a spoon); households measures and actual food samples purchased in markets. | Ethiopia FCT and USDA database (US Department of Agriculture, Agricultural Research Service, 1996) |
|       |                          |                          | (15–49 years-old) |                                                                             |                                                                                   |
|       | South Africa             | Cross-sectional study    | 131 Adolescents | 7 non-consecutive, Validated food portion photograph book (Venter et al. 2000) | FoodFinder® (Grant et al. 1992)                                                   |
|       | Mozambique               | Cohort Study             | 106 Adults   | Single, Food models and images of portion sizes                              | FAO FCT for Africa and Mozambique®                                                |
|       | Burkina Faso             | Cross-sectional study    | 182 Women    | 3, Household measures                                                        | C-SIDE Software (Iowa State University, 1996); Malian FCT; INFOODS® database (Senegal), USDA Database (US Department of Agriculture, Agricultural Research Service, 1996) |
|       |                          |                          | (19–49 years-old) |                                                                             |                                                                                   |
|       | South Africa             | Cross-sectional study    | 235 Elderly  | 2 non-consecutive: 2nd 59% of the sample, Food Models                         | Food Models                                                                        |
|       |                          |                          | (≥ 60 years-old) |                                                                             |                                                                                   |
|       | Benin                    | Cross-sectional study    | 656 Adolescents | 2 non-consecutive, Household utensils.                                       | Malian FCT; FCT for use in Africa; East African FCT.                              |
|       |                          |                          | (≥ 13 years-old) |                                                                             |                                                                                   |
|       | Cameroon                 | Cross-sectional study    | 227 Adolescents | 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                                               |
|       |                          |                          | (12–16 years-old) |                                                                             |                                                                                   |
|       | Zambia                   | Cohort Study             | 874 Adults   | 4 non-consecutive, N.A.                                                      | Nutrition Data System for Research (Nutrition Coordinating Center’s University of Minnesota n.d.) |
|       |                          |                          |               |                                                                             |                                                                                   |
| 2010  | Mozambique               | Cohort Study             | 106 Adults   | Single, Food models and images of portion sizes                              | FAO FCT for Africa and Mozambique®                                                |
|       | Burkina Faso             | Cross-sectional study    | 182 Women    | 3, Household measures                                                        | C-SIDE Software (Iowa State University, 1996); Malian FCT; INFOODS® database (Senegal), USDA Database (US Department of Agriculture, Agricultural Research Service, 1996) |
|       |                          |                          | (19–49 years-old) |                                                                             |                                                                                   |
|       | South Africa             | Cross-sectional study    | 235 Elderly  | 2 non-consecutive: 2nd 59% of the sample, Food Models                         | Food Models                                                                        |
|       |                          |                          | (≥ 60 years-old) |                                                                             |                                                                                   |
|       | Benin                    | Cross-sectional study    | 656 Adolescents | 2 non-consecutive, Household utensils.                                       | Malian FCT; FCT for use in Africa; East African FCT.                              |
|       |                          |                          | (≥ 13 years-old) |                                                                             |                                                                                   |
|       | Cameroon                 | Cross-sectional study    | 227 Adolescents | 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                                               |
|       |                          |                          | (12–16 years-old) |                                                                             |                                                                                   |
|       | 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  | Algeria                  | Cross-sectional study    | 46 Adults    | 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                       |
|       |                          |                          | (Mean age: 24 years-old) |                                                                             |                                                                                   |
|       | Benin                    | Cross-sectional study    | 200 Adults   | 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) |
|       |                          |                          | (25–60 years-old) |                                                                             |                                                                                   |
|       | Burkina Faso             | Cross-sectional study    | 394 Pregnant and/or Lactating Women | Single, Validated booklet with food photographs | Malian FCT; ESHA Food Processor® (Davison & Mandible, 1994)                      |
|       |                          |                          | (15–45 years-old) |                                                                             |                                                                                   |
|       | Benin                    | Quasi experimental       | 68 Adolescents | 48HR (single) 24HR (3), Food models, portion-size models, containers and photographs of foods | Nutrifiq® software, DANA-NIFRE FCT used in Benin®                                 |
|       |                          |                          | (12–17 years-old) |                                                                             |                                                                                   |

(Continued on next page)
| Author | Country          | Study Design          | Study Population | Number of recalls | Determination of Portion Sizes | Tools for Dietary Analysis |
|--------|------------------|-----------------------|------------------|------------------|-------------------------------|----------------------------|
| (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 | Weighing of a replica, measure of the volume, use of calibrated household measures, portion sizes or price | VBS Food Calculation System (KOMEET, VBS MANAGER, ORION and FOOD GROUPS) |
| (Becquey et al. 2009) | Burkina Faso | Cross-sectional study | 182 Women (17–49 years-old) | 3 non consecutive | Specifi FCT based on USDA Database (US Department of Agriculture, Agricultural Research Service, 1996). | Malian FCT; Worldfood FCT for Senegal; USDA Database |
| (Kennedy et al. 2009) | Mali         | Cross-sectional study | 102 Women (15–49 years-old) | 2 non consecutive | Weighing of a replica, measure of the volume, use of calibrated household measures, portion sizes or price | VBS Food Calculation System (KOMEET, VBS MANAGER, ORION and FOOD GROUPS) |
| (Becquey et al. 2009) | Burkina Faso | Cross-sectional study | 182 Women (17–49 years-old) | 3 non consecutive | Specifi FCT based on USDA Database (US Department of Agriculture, Agricultural Research Service, 1996). | Malian FCT; Worldfood FCT for Senegal; USDA Database |
| (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 | Weighing of a replica, measure of the volume, use of calibrated household measures, portion sizes or price | VBS Food Calculation System (KOMEET, VBS MANAGER, ORION and FOOD GROUPS) |
| (Becquey et al. 2009) | Burkina Faso | Cross-sectional study | 182 Women (17–49 years-old) | 3 non consecutive | Specifi FCT based on USDA Database (US Department of Agriculture, Agricultural Research Service, 1996). | Malian FCT; Worldfood FCT for Senegal; USDA Database |
| (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 | Weighing of a replica, measure of the volume, use of calibrated household measures, portion sizes or price | VBS Food Calculation System (KOMEET, VBS MANAGER, ORION and FOOD GROUPS) |
| (Becquey et al. 2009) | Burkina Faso | Cross-sectional study | 182 Women (17–49 years-old) | 3 non consecutive | Specifi FCT based on USDA Database (US Department of Agriculture, Agricultural Research Service, 1996). | Malian FCT; Worldfood FCT for Senegal; USDA Database |
| (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 | Weighing of a replica, measure of the volume, use of calibrated household measures, portion sizes or price | VBS Food Calculation System (KOMEET, VBS MANAGER, ORION and FOOD GROUPS) |
| (Becquey et al. 2009) | Burkina Faso | Cross-sectional study | 182 Women (17–49 years-old) | 3 non consecutive | Specifi FCT based on USDA Database (US Department of Agriculture, Agricultural Research Service, 1996). | Malian FCT; Worldfood FCT for Senegal; USDA Database |

1FCT: Food Composition Table
2C-SIDE: Software for Intake Distribution Estimation
3N.A.: Information not available
4Lukmanji et al. 2008; Wu Leung 1968
5US Department of Agriculture-Agriculture Research Service (2007) USDA National Nutrient Database for Standard Reference version 4, Institute of Brain Chemistry and Human Nutrition, London Metropolitan University
6Steyn and Senekal, 2002
7Steyn and Senekal, 2002
8GIES: General Intake Estimation System Program, GIES; National Food Institute, Seborg, Denmark
9Repartição de Nutrição (1991) Tabela de Composição de Alimentos Maputo: MISAU
10INFOODS: International Network of Food Data Systems
11DANA-INFRE: Direction de l'alimentation et de la nutrition–Institut national pour la formation et la recherche en education
12Bas Nutrition Software, Arnhem, The Netherlands, www.bware.nl.
13AOAC: Association of Official Agricultural Chemists
14Nutritionist 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; Nyuari 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; Alaofé et al., 2009; Becquey et al., 2009; Kennedy et al., 2009; Lamri-Senhadji et al., 2009; Sodjinou et al., 2009; Becquey and Martin-Prevé, 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; Boumaïza 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; Alaofé et al., 2009; Becquey et al., 2009; Sodjinou et al., 2009; Wiesmann et al., 2009; Becquey and Martin-Prevé, 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-Skhirì 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; Jordan et al., 2013; Lukmanji et al., 2013; Sheehy et al., 2013; Baroudi et al., 2014; Botha et al., 2014; Wrottesley et al., 2014),
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.    | South Africa    | Cross-sectional    | 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 logiciel²                  |
| (Botha et al. 2014)   | South Africa    | Cross-sectional    | 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    | 81 Adults (19–79 years-old)       | QFFQ                              | 71                   | N.A.                  | Not tested for reproducibility or validated against 7-day WR and biomarkers | 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 against 7-day WR and biomarkers | Standard utensils and Food Models | Tanzanian FCT¹                    |
| (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. Standardized Portions pictures and utensils (cups, teaspoons) | 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 | Food models and food photographs | South African Food Composition Database_MRC⁶ |
| (Kruger et al. 2012)  | South Africa    | Cross-sectional    | 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 book⁵; Household measures | FoodFinder® (Grant et al. 1992) |
| (Pisa et al. 2012)    | South Africa    | Cross-sectional    | 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    | 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    | 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) |
| Study | Country | Design | Sample Size | Data Collection | Reproducibility | Validation Methods |
|-------|---------|--------|-------------|-----------------|-----------------|-------------------|
| (Anderson et al. 2011) | Cameroon | Cross-sectional study | 1790 Adults (24–74 years-old) | QFFQ (Sharma et al. 1996) | Preceding year | N.A. | Wooden food models and cutlery | Several FCT® and Micronutrient 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) | 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, 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; FoodFinder® III (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; Household measures; Food models. | FoodFinder® (Grant et al. 1992) |
| (2007) Ogunjibewo et al. 2007 | South Africa | Cross-sectional study | 35 Adults (18–65 years-old) | QFFQ (MacIntyre et al. 2001b; MacIntyre et al. 2001a) | 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) |

(Continued on next page)
| 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 |
|-------------------------|---------|--------------|------------------|------------------------------------|----------------------|----------------------|--------------------------|-------------------------------|---------------------------------|
| (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; Food quantities manual; Household measures | South African Food Composition Database \_MRC; SAS software FoodFinder (Grant et al. 1992) |
| (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. | South African Food Composition Database MRC; SAS software 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. |
| (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) |
| (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\(^9\) |
| (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. Bilnut 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 ressources alimentaires du Cameroun: Répartition Écologique, 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
| Year | Author(s) | 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<sup>1</sup> 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<sup>2</sup> (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<sup>3</sup> |
| 2006 | Oldewage-Theron et al. 2006 | South Africa | Cross-sectional study | 357 Women | N.A. | N.A. | 1 | Food Models | Dietary Manager Program<sup>3</sup> |
| 2005 | Waudo et al. 2005 | Kenya, Tanzania | Cross-sectional study | 612 Women | N.A. | Previous 7-day | 1 | Water and measuring cylinders | Food Meter UK 07 |
|   | Faber & Kruger, 2005 | Uganda, 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<sup>3</sup> |
|   | Oldewage-theron et al. 2005 | South Africa | Cross-sectional study | 409 Women | N.A. | N.A. | 1 | Food Models | N.A. |

<sup>1</sup>FCT: Food Composition Table
<sup>2</sup>Bilnut: SCDA Nutrisoft, Cerelles, France
<sup>3</sup>Medical Research Council
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; Goedcke 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 Kesha 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 (Franceschì 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

| Year | Author | Country | Study Design | Study Population | Number of days | Other collected information | Tools for Dietary Data Analysis |
|------|--------|---------|--------------|------------------|----------------|---------------------------|-------------------------------|
| 2012 | (Olayiwola et al., 2012) | Nigeria | Cross-sectional study | 240 Elderly (≥60 years-old) | 3 consecutive days | Description of what was eaten on the day before | FAO FCT, Total Dietary Assessment Software (NUTRIDATA) (Pirone & et al. 1993) |
| 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 FCT¹ |
| 2008 | (Gibson et al., 2008) | Ethiopia | Cross-sectional study | 99 Women (Mean age: 27.8 years-old) | 1 day | N.A. | Ethiopian FCT |
| 2008 | (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 |

¹FCT: Food Composition Table
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 24 hR in order to obtain more qualitative information, related to food brand names and food preparation methods. Waudo et al. (2005) used 24 hR 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; Huybrechts et al., 2009; Addo et al., 2011; Pereko et al., 2012) and C-SIDE (Sodjinou et al., 2008; Sodjinou et al., 2008; Becquey and Martin-Prevèil, 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 Nutrifocc, based on the Canadian Nutrient File (Alaöfe 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 KOMET (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 Elmadafa, 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 Data bank 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 (Boumaïza 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
| WESTERN AFRICA | Benin | Burkina Faso | Ghana | Mali | Nigeria |
|----------------|-------|--------------|-------|------|---------|
| Nutritional tools used in Dietary Data Analysis | Nutrifig (Alaoof et al. 2009) | USDA Database (Becquey & Martin-Prel 2010) | ESHA Food Processor<sup>6</sup> (Addo et al. 2011; Wig & Smith, 2007; Pereko et al. 2012) | VBS Food Calculation System (Kennedy et al. 2009) | Nutridata (Olaiwola et al. 2012) |
| Nutritional tools used in Dietary Data Analysis | C-SIDE<sup>1</sup> (Sodjinou et al. 2009; Sodjinou et al. 2008) | FCT<sup>2</sup> for use in Africa (Nago et al. 2010) | ESHA Food Processor<sup>6</sup> (Addo et al. 2011; Wig & Smith, 2007; Pereko et al. 2012) | VBS Food Calculation System (Kennedy et al. 2009) | Food analysis methods (Jarotimi & Keshinro, 2008) |

| EASTERN AFRICA | Ethiopia | Kenya | Tanzania | Uganda | Zambia | Zimbabwe | Mozambique |
|----------------|----------|-------|----------|--------|--------|----------|------------|
| Nutritional tools used in Dietary Data Analysis | USDA Database (Alemayehu et al. 2011) | WorldFood Dietary Assessment System (Gewa et al. 2008; Walton et al. 2012) | NutriSurvey Program (Jordan et al. 2013) | USDA database, NutriSurvey Program (Mupere et al. 2012; Namagumya & Muyanja, 2011) Food Meter UK 07 (Waudo et al. 2005) | Foodbase Nutritional Program (Nyuar et al. 2012) | NutriSurvey Program (Korkalo et al. 2014) | Foodbase Nutritional Program (Nyuar et al. 2012) |
| Nutritional tools used in Dietary Data Analysis | ESHA Food Processor<sup>6</sup> (Becquey & Martin-Prel 2010) | NutriSurvey Program (Mbuchi et al. 2012; Mala et al. 2012; Kamaau-Mbuthia & Elmdad, 2007) GIES<sup>3</sup> (Hansen et al. 2011) FoodFinder<sup>5</sup> (Steyn & Nel, 2006; Steyn et al. 2011; Steyn et al. 2012) Food Meter UK 07 (Waudo et al. 2005) | ESFA Food Processor<sup>6</sup> (Irvine et al. 2011) Programme CANDAT (Kim et al. 2014; Changamire et al. 2014; Lukmanji et al. 2013) Food Meter UK 07 (Waudo et al. 2005) | 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; Namagumya & Muyanja, 2011) Food Meter UK 07 (Waudo et al. 2005) | USDA Food Processor<sup>6</sup> (Merchant et al. 2005) | 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 (Amri-Senhadji et al. 2009) | Egyptian FCT, Nutrition Institute (Mounir et al. 2007) | Bilnut Software (Nutrisoft) (Baroudi et al. 2010) DIAL Programme<sup>5</sup> (Lopez et al. 2012) | Foodbase Nutritional Program (Nyuar et al. 2012) | FCT for Africa and FCT for Mozambique (Scarcella et al. 2011) |
| Nutritional tools used in Dietary Data Analysis | Egypt FCT (Mounir et al. 2007) | Egyptian FCT (Mounir et al. 2007) | Egyptian FCT, Nutrition Institute (Mounir et al. 2007) | Egyptian FCT, Nutrition Institute (Mounir et al. 2007) | Egyptian FCT, Nutrition Institute (Mounir et al. 2007) |

| 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<sup>8</sup> (Jackson et al. 2012) | FoodFinder<sup>8</sup> (Wrottesley et al. 2014; Oldwage-Theron et al. 2014; Padathakis & Pearson 2012; Pretorius et al. 2012; Joffe et al. 2011; Oldwage-Theron et al. 2010; Zingoni et al. 2009; W. H. Oldwage-Theron et al. 2008; Oguntibeju et al. 2007; Charlton et al. 2005; Rankin et al. 2011; Oldwage-Theron & Kruger, 2011; Joffe et al. 2010; Faber & Kruger, 2005; Wentzel-Viljoen et al. 2011; Kruger et al. 2011; Mostert et al. 2008; 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 Oldwage-Theron et al. 2008; WH Oldwage-Theron et al. 2008) Nutribase (Kolahdooz et al. 2013; Sheehy et al. 2013) Dietary Manager Program<sup>9</sup> (Kesa & Oldwage-Theron, 2005; Oldwage-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; MacKewon et al. 2007; Faber & Kruger, 2005) | Microdiet (Anderson et al. 2011) Becel Software (Dap et al. 2010) | Lucile food analysis software (Termote et al. 2012) | Microdiet (Anderson et al. 2011) Becel Software (Dap et al. 2010) | Lucile food analysis software (Termote et al. 2012) |

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

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).
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; Jarotimi 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 of the population, in several cases creation of clusters was 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 and in others no sampling method was mentioned (Belgnaoui and Belahsen, 2006; Wig 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 (Alaoëf et al., 2009; Wrottesley et al., 2014).

**Discussion**

The purpose of this review was to summarize the methodologies and tools used in dietary 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).
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 (Willett, 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 (Willett, 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 (Willett, 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 (Willett, 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 con-
sumption 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 question-
aire determines the answer of the respondent. Wirfalt (1998)
cited some studies that had better results regarding reproduc-
ibility 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 valida-
tion 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 (Thomp-
son 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 reproduc-
ibility. The previous referred THUSA questionnaire was tested
for reproducibility by other authors (Wentzel-Viljoen et al.,
2011) in a different population, with Setswana-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 Afri-
can countries is emergent. When a validation study is per-
formed, 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; Huy-
bregts 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 estima-
tion 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 concern-
ing the accuracy of portion size estimation tools. A study of
Byrd-Bredbenner and Schwartz (2004) evaluated if using por-
tion 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 fre-
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 advan-
ces 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
(Belgnouai 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 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.

**ORCID**

Catarina Vila-Real [http://orcid.org/0000-0002-1352-6525]

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