

# Anthropometric and Dietary Indicators Applied in Population-based Surveys: a Systematic Review.

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## Research

**Keywords:** Nutrition Surveys, Population surveys, Food Consumption, Anthropometry, Systematic Review

**Posted Date:** December 21st, 2020

**DOI:** <https://doi.org/10.21203/rs.3.rs-130914/v1>

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## Abstract

**Background:** Anthropometric and food consumption indicators are important in dietary, nutritional, and health status conditions assessment and monitoring of the population, as a mechanism to identify changes or trends in consumption and to understand the relationship between dietary exposure and varied health outcomes. The aim was to identify population-based health and nutrition surveys, conducted with adults and the elderly, and performed in the Americas, Europe, and Oceania, in order to investigate the more common anthropometric and food consumption methods used, their applicability, and their limitations.

**Methods:** Electronic databases (LILACS, PubMed, and SCOPUS) were systematically searched for studies published between 1997 and 2017 in Portuguese, English or Spanish. Forty-five studies (49% carried out in the Americas) met the eligibility criteria and were included in the review. The data were analysed in 2018.

**Results:** The methodological quality of most of the studies (64.4%) was classified as moderate, according to the Agency for Healthcare Research and Quality checklist for cross-sectional studies and the Newcastle-Ottawa scale for cohort studies. Forty percent of the articles evaluated only food consumption, 31% just anthropometry, while 29% evaluated food consumption and anthropometric measurements. The most used food survey methods were food record (31% of studies) and the 24-hour dietary recall (22% of studies). Body mass index (BMI) was the most used indicator for anthropometric nutritional status assessment. Although most of the studies used the World Health Organization classification criteria, these studies did not adopt the different cut-off points for BMI classification for adults and the elderly.

**Conclusion:** BMI and methods that record current consumption, such as the food record and the 24-hour dietary recall, were the main methods of assessing nutritional status, taking into consideration the easy application, low cost, and good reproducibility.

Systematic Review Registration: PROSPERO CRD42017071392

## Background

The demographic, epidemiological and nutritional changes, occurring worldwide, in recent decades have resulted in significant transformations in morbidity and mortality patterns. In this context, population-based health and nutrition surveys have been applied since the 1960s in developed countries, and are currently experiencing an increase in many developing countries, with the objective of monitoring the health status of populations[1].

The health and nutrition surveys are essential for health surveillance, in addition to enabling the analysis of inequalities. These surveys provide updated and reliable information that may contribute to the development of health programs and services in the most diverse population groups, serving as important instruments for public policies planning and evaluation [2–5].

In most cases, population-based surveys are part of cohort or cross-sectional surveys, and aggregate a set of sociodemographic characteristics, variables of lifestyle factors and health outcomes, data collection methodology, and periodicity. A periodic update on survey is important for the consolidation of the information collected, which becomes the basis for population references, enabling surveillance of chronic noncommunicable diseases (NCDs) and their causes[6].

Health-related behaviours, which have a greater impact on the demand for health services and on the quality of life of people, or that address risk factors for NCDs are the most studied, owing to their influence on population morbidity and mortality. Thus, surveys have gained considerable importance in the assessment of lifestyle factors such as smoking, alcohol consumption, physical activity, sedentary behaviour, diet quality, overweight/obesity, hypertension, diabetes, violence, accidents, and mental disorders[2, 4].

The use of surveys including anthropometric indicators and food consumption are relevant in the assessment and monitoring of the dietary, nutritional, and health status conditions of the population[5], data widely described in the literature[7]. In the case of dietary patterns, monitoring is an important mechanism to identify changes or trends in consumption and to understand the relationship between dietary exposure and varied health outcomes, as well as providing information relating to food, along with considering the nutritional interactions involved. The pattern of food consumption can also be used as an indirect indicator of nutritional status[8].

Some of the more common dietary surveys used in the identification of dietary patterns are the food record or diary, direct weighing of food, 24-hour dietary recall (R24h), dietary history, and the food frequency questionnaire (FFQ). There is no 'gold standard' method because each has its advantages and limitations. Therefore, the choice of method will depend on the characteristics of the population assessed and the objectives of the study[5, 7–10].

For anthropometric assessments, a direct method of assessment of nutritional status, population surveys have frequently utilized measurements of weight and height, owing to the ease of assessment and low cost of the equipment used, as well as the simplicity of the method, the use of non-invasive techniques, the reduced time to validate measures, the ease of training of personnel for data collection, and the reliability, when measured and evaluated properly by trained professionals[5, 11, 12].

Another advantage attributed to anthropometry is the easy comparison of measurements obtained with population and international standards used in the diagnosis of nutritional status, according to sex and age range, or the comparison between measurements, for the verification of changes in the dimensions and body composition of individuals[13]. On the other hand, the limitations of this method are related to their validation and accuracy, because it depends not only on the adequate training of field staff, but also on the use of calibrated equipment and standardization of the measures[5].

The reliability in the application of the method, the standardization of measures, and the possibility of international comparisons influence the reliability of the data and the reproducibility of the studies. Thus, this study aimed to perform a systematic review of population-based health and nutrition surveys, conducted with adults and the elderly in the Americas, Europe, and Oceania, to identify which anthropometric and food consumption methods were most frequently used, along with their applicability and limitations. These continents were selected because the dietary habits of Western populations are similar, in that there is a growing inclusion in the diet of foods high in calories, fat, and refined sugars, while they have low consumption of fruits and vegetables and fiber, in contrast to the diets in Eastern (Arab and Asian) and African countries.

## Methods

### Design

This was a systematic review of original studies, prepared according to the recommendations of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2009[14], designed with the objective of guiding the dissemination of systematic reviews and meta-analyses in health field. The review was registered in the international prospective register of systematic reviews (PROSPERO) under the number 2017: CRD42017071392.

### Search strategy

A virtual search was performed in the LILACS, PubMed, and Scopus databases, for original articles published between 1997 and 2017. The following search strategy was used in PubMed: ('Health Surveys' OR 'Nutrition Surveys' OR 'Diet Surveys') AND ('Nutritional Status' OR 'Nutrition Assessment' OR 'Nutrition, Public Health') AND (adult OR adults OR aged OR elderly) AND ('cross-sectional studies' OR surveys) AND ('nationwide survey' OR 'national nutrition monitoring' OR 'national survey'). In the Scopus database, the key words used were: TITLE-ABS-KEY ('Health Surveys' OR 'Nutrition Surveys' OR 'Diet Surveys') AND TITLE-ABS-KEY ('Nutritional Status' OR 'Nutrition Assessment' OR 'Nutrition, Public Health') AND TITLE-ABS-KEY (adult OR adults OR aged OR elderly) AND TITLE-ABS-KEY ('cross-sectional studies' OR surveys) AND TITLE-ABS-KEY ('nationwide survey' OR 'national nutrition monitoring' OR 'national survey'). In LILACS the following combination of terms was used: (*Inquérito* OR *pesquisa*) AND (*saúde* OR *nutrição* OR *dieta* OR *consumo alimentar* OR *estado nutricional* OR *antropometria* OR *"composição corporal"*) AND (*nacional* OR *populacional*). The searches were performed from April to July 2017 and confined to articles published between January 1997 and July 2017, in Portuguese, English, or Spanish. Data were analysed in 2018.

### Inclusion and exclusion criteria

The papers were considered eligible when they met the following inclusion criteria: 1) Observational studies; 2) Performed in adult and/or elderly populations; (3) Surveys carried out over the last 20 years (1997 to 2017); 4) Conducted in Europe, Americas, and/or Oceania; and 5) Available in Portuguese, English, or Spanish. Systematic reviews, meta-analyses and studies involving pregnant women were excluded from the study.

### Synthesis and comparison of results

Initially, two evaluators independently reviewed the titles and abstracts to verify if those met the proposed eligibility criteria. Then, the complete texts of the papers were read. Subsequently, each evaluator completed, independently, a data mining spreadsheet, including, in addition to the evaluation of the methodological quality, the following items: 1) Characteristics of the studies: authors, year of publication, place of study (country and continent), and the evaluation of the methodological quality score. The population of each study was described according to the number and age of participants. 2) Characteristics of surveys: name, year, variables, method, frequency of application of the nutritional survey, and evaluation criteria of the anthropometric nutritional status and the respective cut-off points. Discrepancies in the evaluation were resolved through discussion between the evaluators, and, in case of doubt, a third reviewer was consulted.

### Evaluation of the methodological quality of the studies

The methodological quality of the selected papers was evaluated and scored according to the recommendations of the Newcastle-Ottawa quality assessment scale (NOS) for cohort studies, and the Agency for Healthcare Research and Quality (AHRQ) checklist for cross-sectional studies. The NOS evaluation consists of eight questions, which include items such as: selection of participants, comparability between the subjects and verification of exposure. The papers are scored as 'Good', 'Adequate', or 'Poor', in accordance with the score received on each item of the scale (items are identified with one or no stars). The sum of these items (stars) classifies the article. The AHRQ consists of 11 items, with the options 'Yes', 'No', or 'Unclear'. A score '0' is attributed to items evaluated with 'No' or 'Unclear', and score '1' for those evaluated with 'Yes' [15].

To better present the results, the score evaluated by NOS was converted into quality categories, based on the document from the AHRQ[16]. Based on these results, three categories for evaluation were established: 0–3, 4–7, and 8–11, indicating low, moderate, and high quality, respectively.

### Criteria for evaluation of methodological quality of primary studies

The following indicators of anthropometric evaluation and assessment of habitual consumption were considered as standard in the assessment of the methodological quality of the primary studies: 1) BMI: two or more measurements; 2) food surveys: at least two applications (for 24-hour dietary recall and food record), as recommended in the literature[17]. To check the quality of the anthropometric data collected, we investigated if the papers mentioned calibration of anthropometric instruments and training of the interviewers.

## Results

The search recovered 615 documents. In addition, another 22 articles were added by manual search. 52 documents of the 637 were duplicated and for this reason were excluded, resulting in 585 abstracts. After reading the title and abstract, 496 articles were excluded. Thereafter, after considering the inclusion and

exclusion criteria of 89 articles read in full, 45 studies were included in the review (Fig. 1).

## Methodological quality and characteristics of the studies

Given the criteria for the classification of methodological quality, for the 45 studies included, 29 were classified as moderate quality (64.4%) and 16 as high quality (35.6%). Regarding the continent where the study was implemented, 49% (n = 22) were conducted in the Americas[18, 19, 28–37, 20, 38, 21–27], 44% (n = 20) in Europe[39, 40, 49–57, 41–48], and 7% (n = 3) in Oceania[58–60]. In relation to countries, Brazil contributed 16% (n = 7) of the publications[21–26, 36]; Spain[39–41, 52, 61], the United States[18–20, 38, 62], and England[42–45, 49] contributed five each; Mexico[27, 28, 32, 35] four; Australia[58–60] and France[46, 47, 53] three; Canada[31, 34], Colombia[29, 30], and Luxembourg[50, 51] two; Germany[55], Cuba[37], the Netherlands[54], the United Kingdom[48], Sweden[56], Switzerland[57], and Uruguay[33] contributed one study each.

The studied population ranged from 273[56] to 215,354[38] individuals. In relation to the nutrition variables analysed, 29% (n = 13) of the papers evaluated food consumption and anthropometry, 40% (n = 18) only food consumption, and 31% (n = 14) only anthropometry.

The main population surveys on nutrition and health that served as the basis for the papers, alone or in comparison with other surveys, were: the National Health and Nutrition Examination Survey (NHANES; USA)[18–20, 38, 62], with five derived studies; Anthropometry, Intake and Energy Balance in Spain (ANIBES; Spain)[39–41, 61] and National Survey of Health and Development (NSH; England)[42–45] with four articles each; Italian National Food Consumption Survey (INRAN-SCAI; Italy)[41, 63, 64], Brazilian Household Budget Survey/Pesquisa de Orçamentos Familiares (Brazil)[21–23] with three publications; National Demography and Health Survey/Pesquisa Nacional de Demografia e Saúde (PNDS; Brazil)[24, 25], Encuesta Nacional de Salud y Nutrición (ENSANUT; Mexico)[27, 28], Encuesta Nacional de Situación Nutricional (ENSIN; Colombia)[29, 30], Individual and national study on food consumption (INCA 2; France)[46, 47], British National Diet and Nutrition Survey (NDNS; UK/England)[48, 49] and Observation of Cardiovascular Risk Factors in Luxembourg (ORISCAV-LUX; Luxembourg)[50, 51] with two publications each. The following served as a basis for one publication each: Dutch National Food Consumption Survey (DNFCS; Netherlands)[65], NutriNet-Santé Dataset (France)[41], ENDS (Colombia)[29], Australian Health Survey (Australia)[58], Estudio Nacional de Salud y Envejecimiento en México (ENASEM; Mexico)[32], Encuesta Nacional de Ingesta Dietética (ENIDE; Spain)[52], Étude nationale nutrition santé (ENNS; France)[53], Segunda Encuesta Nacional de Sobrepeso y Obesidad (ENSO 2; Uruguay)[33], Food Habits of Canadians Survey (Canada)[34], Mexican National Health and Nutrition Survey 2006 (Mexico)[35], National Screening on Malnutrition (Netherlands)[54], Nielsen Media Research (Australia)[59], National Nutrition and Physical Activity Survey (NNPAS; Australia)[60], German National Nutrition Survey (NVS II; Germany)[55], German National Nutrition Monitoring (NEMONIT; Germany)[55], National Health Research/Pesquisa Nacional de Saúde (PNS; Brazil)[36], Research Social Dimension of Inequalities/Pesquisa Dimensão Social das Desigualdades (PDSD; Brazil)[24], Segunda Encuesta Nacional sobre Factores de Riesgo y Afecciones Crónicas no Transmisibles de la Población Cubana (Cuba)[37], Study to Help Improve Early Evaluation and Management of Risk Factors Leading to Diabetes (SHIELD; USA)[38], The National Survey Riksmaten (Sweden)[56] and The Swiss Health Survey (Switzerland)[57].

## Methods used for assessment of food consumption and anthropometry

Food record was the more frequent survey method, used in 16 studies[21, 22, 48, 49, 56, 61, 63, 64, 23, 40–44, 46, 47], followed by the R24h, used in 11 studies[18, 19, 65, 31, 33, 52, 53, 55, 58, 60, 62], the FFQ, included in seven articles[27, 36, 50, 51, 56, 57, 59] and, finally, the food diary, applied in three studies[39, 41, 53]. The application frequency varied according to the type of food survey conducted. The number of food records ranged from two to seven days, the R24h was applied from one to five times, and the food diary was used for three days, in all studies.

Nine of the 14 articles that used the food record performed four or more assessments [21, 42–44, 46–49, 56]. Along with the R24h, 11 papers applied this method, at least two applications were performed in at least seven studies [32, 34, 55, 58, 60, 62, 65], as recommended by the National Cancer Institute[66]. The evaluation of habitual consumption, dietary pattern, ingestion of foods or food groups, energy, and macro and/or micronutrients, were the purpose of the application of the R24h in nine studies[18, 19, 34, 52, 55, 58, 60, 62, 65]. The R24h was used to evaluate consumption of alcohol and breakfast (being a consumer or not) in two other papers [31, 53].

In relation to anthropometry, BMI was the indicator used in all 30 studies designed to assess anthropometric nutritional status[18, 20, 30–33, 35–38, 41, 43, 21, 45, 48, 53, 54, 57, 58, 60, 63–65, 22, 24–29], with the exception of the study of Tande et al.[19], which evaluated only waist circumference. Some of the studies also evaluated other body measurements, such as waist circumference[25, 35, 37, 41, 58] and waist-hip ratio<sup>26</sup>. About the BMI evaluation, 20 papers used the classification proposed by the World Health Organization (WHO)[18, 20, 30–33, 35–38, 41, 43, 21, 45, 48, 53, 54, 57, 58, 60, 22, 24–29]. The studies of Melano-Carranza et al.[32], Nissensohn et al.[41], Pot et al.[43], Cooper et al.[45], Sluik et al.[67], Sette et al.[64], and Leclercq et al.[63] only reported the mean BMI values in the population studied. Acosta et al.[37] used the classification of the Food and Agriculture Organization of the United Nations[68]. The study by Barr et al.[31] did not describe the classification used. Other studies used classifications of other international institutions such as the International Obesity Task Force[33] and the National Institutes of Health Clinical Guidelines[38].

With regard to the quality of the measures for composition of BMI, 11 papers reported that interviewers/researchers were trained to perform the measurements[20, 25, 53, 27, 28, 30, 31, 33, 35, 43, 45], four studies reported the calibration of equipment[25, 27, 30, 37], and only two articles[25, 26] reported performing two repetitions of each measurement of weight and height, as standardized by the WHO for collection of these data. Only the study of Meller et al. [25] reported all the information about the survey (training of the interviewers, calibration of equipment, and replication of anthropometric measures).

Table 1. Characteristics of the studies and population-based surveys on health and nutrition, performed in the Americas, Europe, and Oceania, from 1997 to 2017.

Table 1  
 Characteristics of the studies and population-based surveys on health and nutrition.

| Characteristics of the Studies        |      |           |         |                 |  | Characteristics of surveys  |                   |                               |   |                                  |
|---------------------------------------|------|-----------|---------|-----------------|--|---|-------------------|-------------------------------|---|----------------------------------|
| Author                                | Year | Continent | Country | Study Design    | n  | Main  | Age range (years) | Score/ Methodological quality | Survey  | Value                            |
| Sichieri R. et al[22]                 | 2015 | Americas  | Brazil  | Cross-sectional | 34,003*<br>(26,862 adults/<br>elderly)     | To identify major food group contributors of energy intake.   | > 10              | 9 (high)                      | Brazilian Household Budget Survey (2008–2009) | BM<br>25<br>Fo<br>co             |
| Ferreira R.; Benício M[26]            | 2015 | Americas  | Brazil  | Cross-sectional | 11,961                                     | To determine the influence of reproductive history on the prevalence of obesity in Brazilian women and effect of socioeconomic variables on the association between parity and excess weight. | 20–49             | 6 (moderate)                  | PNDS (2006)                                   | BM                               |
| Velasquez-Melendez G.; Mendes M. [36] | 2015 | Americas  | Brazil  | Cross-sectional | 34,362                                     | To evaluate the prevalence of cardiovascular health in the Brazilian population.  | > 18              | 9 (high)                      | PNS (2013)                                    | BM<br>Fo<br>co                   |
| Pereira R. et al[23]                  | 2014 | Americas  | Brazil  | Cross-sectional | 34,003*<br>(26,522 adults/<br>The elderly) | To examine the patterns of consumption of foods high in solid fats and added sugars in the first Brazilian nationally representative individual dietary survey.                               | > 10              | 6 (moderate)                  | Brazilian Household Budget Survey (2008–2009) | Cc<br>of<br>an<br>Cc<br>of<br>su |
| Meller F. et al[25]                   | 2014 | Americas  | Brazil  | Cross-sectional | 14,101                                     | To evaluate the association between waist circumference and body mass index of Brazilian women of childbearing age studied in the National Demographic and Health Survey, in 2006.            | 18–49             | 6 (moderate)                  | PNDS (2006)                                   | BM                               |
| Pavão A. et al[24]                    | 2013 | Americas  | Brazil  | Cross-sectional | 12,324                                     | To investigate the association between self-rated health and social and demographic factors, health behavior, and morbidity.  | > 20              | 7 (moderate)                  | PDS (2008)                                    | BM                               |

| Characteristics of the Studies |      |          |          |                 |                                  | Characteristics of surveys  |                 |              |  |                |
|--------------------------------|------|----------|----------|-----------------|----------------------------------|---|-----------------|--------------|--|----------------|
| Bezerra I; Schieri R[21]       | 2011 | Americas | Brazil   | Cross-sectional | 33,393                           | To evaluate whether a diversity of healthy foods in a household would decrease the availability of unhealthy foods and to evaluate the association between a healthy dietary diversity score and nutritional status among adults. | 20–65           | 8 (high)     | Brazilian Household Budget Survey (2002–2003)  | BM<br>Fo<br>co |
| Barr S. et al[31]              | 2016 | Americas | Canada   | Cross-sectional | 12,337                           | To examine the association of breakfast consumption, and the type of breakfast consumed, with body mass index and prevalence rates and odds ratios of overweight/obesity among Canadian adults.                                   | > 18            | 7 (moderate) | Canadian Community Health Survey Cycle 2.2 (2004)  | Di<br>BM       |
| Gray-Donald K. et al[34]       | 2000 | Americas | Canada   | Cross-sectional | 1,722*<br>(1,544 adults/elderly) | To monitor whether changes in dietary intake have occurred since the last Canadian dietary survey, conducted a generation ago (1970).   | 13–17 and 18–65 | 7 (moderate) | Food Habit of Canadians survey (1997–1998)   | Fo<br>co       |
| Acosta K. [29]                 | 2013 | Americas | Colombia | Cross-sectional | 150,733                          | To calculate obesity concentration indices among adults in Colombia.  | 18–64           | 7 (moderate) | ENDS (2005) and ENSIN (2010)   | BM             |
| Kordas K. et al[30]            | 2013 | Americas | Colombia | Cross-sectional | 3,267*<br>(2,612 adults)         | To investigate the association among iron deficiency (ID), anemia, and weight status among nonpregnant Colombian females aged 13–49 y.  | 13–17 and 18–49 | 7 (moderate) | ENSIN (2005)   | BM             |
| Acosta S. et al[37]            | 2005 | Americas | Cuba     | Cross-sectional | 19,519                           | To evaluate the nutritional status of the resident population in the urban area of Cuba and compare evolutionarily the changes experienced in relation to the previous survey.  | > 20            | 6 (moderate) | Segunda Encuesta Nacional sobre Factores de Riesgo y Afecciones Crónicas no Transmisibles de la Población Cubana (2000–2001) | BM<br>CC<br>CC |
| Ponce X. et al[27]             | 2013 | Americas | Mexico   | Cross-sectional | 15,675                           | To characterize the health and nutritional status of the Mexican population in all age groups.  | 19–59           | 8 (high)     | ENSANUT (2006)   | BM<br>Fo<br>co |

| Characteristics of the Studies |      |          |         |                 |         | Characteristics of surveys   |                |              |  |                            |
|--------------------------------|------|----------|---------|-----------------|---------|--|----------------|--------------|--|----------------------------|
| Barquera S. et al[28]          | 2010 | Americas | Mexico  | Cross-sectional | 14,630  | To describe the prevalence of hypertension among Mexican adults, and to compare to that observed among Mexican-Americans living in the US.   | > 20           | 8 (high)     | ENSANUT (2006)   | BM                         |
| Barquera S. et al[35]          | 2009 | Americas | Mexico  | Cross-sectional | 33,023  | To estimate the prevalence of overweight, obesity and central adiposity in Mexico, and to explore trends compared to the previous Mexican National Health Survey and to Mexican-Americans.   | > 20           | 8 (high)     | Mexican National Health and Nutrition Survey (2006)  | BM<br>CC                   |
| Melano-Carranza E. [32]        | 2008 | Americas | Mexico  | Cross-sectional | 2,029   | To determine factors associated with failure to adhere to treatment for diagnosed hypertension among a representative sample of older Mexican adults living in the community.  | > 65           | 7 (moderate) | ENASEM (2001)  | BM                         |
| Pisabarro R. et al[33]         | 2009 | Americas | Uruguay | Cross-sectional | 900     | To evaluate prevalence of obesity, its comorbidities and predisposing factors through the Second National Survey on Overweight and Obesity in Uruguay in people between 18 and 65 years, or older, carried out in 2006.                    | 18–65 and > 65 | 6 (moderate) | ENSO 2 (2006)  | BM                         |
| Cifelli C. et al[62]           | 2016 | Americas | USA     | Cross-sectional | 17,387* | To use national survey data to model different dietary scenarios to assess the potential effects of increasing plant-based foods (and concomitantly decreasing animal foods) or dairy foods on macronutrient intake and nutrient adequacy. | 2–18 and > 19  | 7 (moderate) | NHANES (2007–2010)   | Fo<br>dic<br>co            |
| Kant A. et al[18]              | 2015 | Americas | USA     | Cross-sectional | 62,298  | To examine time trends in the distribution of day's intake into individual meal and snack behaviors and related attributes in the United States adult population.  | 20–74          | 9 (high)     | NHANES (1971–74, 1976–1980, 1988–1994, 1999–2000, 2001–2002, 2003–2004, 2005–2006, 2007–2008, and 2009–2010) | Fo<br>co<br>of<br>sn<br>BM |

| Characteristics of the Studies |      |          |         |                 |                                   | Characteristics of surveys  |                               |              |  |                 |
|--------------------------------|------|----------|---------|-----------------|-----------------------------------|---|-------------------------------|--------------|--|-----------------|
| Guendelman S. et al[20]        | 2013 | Americas | USA     | Cross-sectional | 979                               | To examine actual and perceived weight in national cohorts of Mexican-origin adult men in Mexico and the United States (US).  | 20–59                         | 7 (moderate) | NHANES (2001/2006) and ENSANUT (2006)                          | Ca<br>BM<br>pe  |
| Tande D. et al[19]             | 2009 | Americas | USA     | Cross-sectional | 15,658                            | To describe relationships between the Health Eating Index and abdominal obesity among adults.   | > 20                          | 7 (moderate) | NHANES III (1988–1994)   | CC<br>Inc<br>he |
| Bays H. et al[38]              | 2007 | Americas | USA     | Cross-sectional | 215,354                           | To explore the relation between body mass index and prevalence of diabetes mellitus, hypertension and dyslipidaemia; examine BMI distributions among patients with these conditions; and compare results from two national surveys. | > 18                          | 7 (moderate) | SHIELD (2004)<br>NHANES (1999–2002)                            | BM              |
| Pot G. et al[42]               | 2015 | Europe   | England | Cohort          | 989                               | To describe changes in food consumption patterns and food availability in an ageing population.   | 36, 43, 53, 60–64             | 8 (high)     | NSHD (cohort 1946)   | Fo<br>co        |
| Pot G. et al[43]               | 2014 | Europe   | England | Cross-sectional | 1,768                             | To study associations between irregular consumption of energy intake in meals and cardio-metabolic risk factors.  | 53                            | 8 (high)     | NSHD (cohort of 1946 - the year 1999 was used for this study). | BM<br>Dir       |
| Cooper R. et al[45]            | 2014 | Europe   | England | Cross-sectional | 2,229* (1,511 adults/elderly)     | To examine the associations of body mass index from age 15 years onwards with low muscle mass, strength, and quality in early old age.  | 15, 20, 26, 36, 43, 53, 60–64 | 6 (moderate) | NSHD (data from 1946 cohort)                                   | BM              |
| Whitton C. et al[49]           | 2011 | Europe   | England | Cross-sectional | 4,321* (2,158 adults and elderly) | To report dietary intakes and main food sources of fat and fatty acids from the first year of the National Diet and Nutrition Survey rolling programme in the UK.   | 4–64                          | 7 (moderate) | NDNS 2008–2009   | Fo<br>dic<br>co |
| Prynne C. et al[44]            | 2009 | Europe   | England | Cohort          | 4,028                             | To quantify more precisely the meat intake of a cohort of adults in the UK by disaggregating composite meat dishes.   | 43 and 53                     | 8 (high)     | NSHD (cohort of 1946)  | Inc<br>me       |
| Tressou J. et al[46]           | 2016 | Europe   | France  | Cross-sectional | 2,624                             | To explore in details the fatty acids intakes in French adults using the most recent available data.  | Adults                        | 7 (moderate) | INCA 2 (2006–2007)   | Co<br>of<br>ma  |

| Characteristics of the Studies |      |        |            |                 |        | Characteristics of surveys  |                |              |  |                       |
|--------------------------------|------|--------|------------|-----------------|--------|---|----------------|--------------|--|-----------------------|
| Gazan R. et al[47]             | 2016 | Europe | France     | Cross-sectional | 1,918  | To examine the association between drinking water intake and diet quality, and to analyse the adherence of French men and women to the European Food Safety Authority 2010 Adequate Intake.   | > 18           | 7 (moderate) | INCA 2 (2005–2007)                             | Co of an              |
| Vernay M. et al[53]            | 2009 | Europe | France     | Cross-sectional | 3,115  | To describe disparities in the prevalence of overweight and obesity across socioeconomic status groups in 18–74 year-old French adults.   | 18–74          | 7 (moderate) | ENNS (2006–2007)                               | Fo co<br>BM<br>Ca ris |
| Gose M. et al[55]              | 2016 | Europe | Germany    | Cohort          | 1,840* | To assess changes in food consumption and nutrient intake in Germany.   | 14–65 and > 65 | 8 (high)     | NVS II (2005/2007)<br>NEMONIT (2008–2012/2013) | Di co                 |
| Sette S. et al[64]             | 2011 | Europe | Italy      | Cross-sectional | 2,830  | To describe energy and nutrient intakes in Italy.   | > 18           | 7 (moderate) | INRAN-SCAI (2005–2006)                         | En an mi<br>Ak<br>MI  |
| Leclercq C. et al[63]          | 2009 | Europe | Italy      | Cross-sectional | 2,831  | To present the main results of the Italian National Food Consumption Survey INRAN-SCAI 2005–06.   | > 18           | 8 (high)     | INRAN-SCAI (2005–2006)                         | Fo co<br>BM           |
| Alkerwi A. et al[50]           | 2015 | Europe | Luxembourg | Cross-sectional | 1,352  | To examine the association between nutritional awareness and diet quality, as indicated by energy density, dietary diversity and adequacy to achieve dietary recommendations, while considering the potentially important role of socioeconomic status                                      | 18–69          | 7 (moderate) | ORISCAV-LUX (2007–2008)                        | Fo co                 |
| Alkerwi A. et al[51]           | 2015 | Europe | Luxembourg | Cross-sectional | 1,351  | To compare the ability of five diet quality indices, namely the Recommendation Compliance Index, Diet Quality Index-International, Dietary Approaches to Stop Hypertension, Mediterranean Diet Score, and Dietary Inflammatory Index, to detect changes in chronic disease risk biomarkers. | 18–69          | 7 (moderate) | ORISCAV-LUX (2007–2009)                        | Fo co                 |

| Characteristics of the Studies |      |        |             |                 |                               | Characteristics of surveys  |       |              |  |                   |
|--------------------------------|------|--------|-------------|-----------------|-------------------------------|---|-------|--------------|--|-------------------|
| Sluik D. et al[65]             | 2014 | Europe | Netherlands | Cross-sectional | 2100                          | To investigate associations between alcoholic beverage preference and dietary intake in The Netherlands.  | 19–69 | 7 (moderate) | DNFCS  | En Fr ab co of BM |
| Kruizenga H. et al[54]         | 2003 | Europe | Netherlands | Cross-sectional | 7,606                         | To determine the prevalence of disease-related malnutrition in The Netherlands in all fields of medical care and to investigate the involvement of the dietitian in the treatment of malnutrition.  | > 18  | 8 (high)     | National Screening on Malnutrition (2001)  | BM                |
| Nissensohn M. et al[41]        | 2017 | Europe | Spain       | Cross-sectional | 99,111                        | To compare the average daily consumption of foods and beverages in adults of selective samples of the European Union population to understand the contribution of these to the total water intake, evaluate if the EU adult population consumes adequate amounts of total water according to the current guidelines, and to illustrate the real water intake in Europe. | 18–75 | 6 (moderate) | ANIBES (Spain – 2013); INRAN-SCAI Dataset (Italy – 2005–2006); NutriNet-Santé Dataset (France – 2009–2010) | BM CC Co of be    |
| Nissensohn M. et al[39]        | 2016 | Europe | Spain       | Cross-sectional | 2,007* (1,784 adults/elderly) | To quantify the total water and beverage intake, and to explore associations between the types of beverage consumed and energy intake.  | 9–75  | 8 (high)     | ANIBES (2013)  | Co of be          |
| Ruiz E. et al[40]              | 2016 | Europe | Spain       | Cross-sectional | 2,009* (1,861 adults/elderly) | To analyze dietary macronutrient intake and its main sources according to sex and age.  | 9–75  | 6 (moderate) | ANIBES (2013)  | Co of be Di       |
| Ruiz E et al[61]               | 2015 | Europe | Spain       | Cross-sectional | 2,009* (1,861 adults/elderly) | To contribute to updating data of dietary energy intake and its main sources from food and beverages, according to gender and age.  | 9–75  | 6 (moderate) | ANIBES (2013)  | Co of nu Fo co    |

| Characteristics of the Studies |      |         |             |                 |                                   | Characteristics of surveys   |       |              |   |              |
|--------------------------------|------|---------|-------------|-----------------|-----------------------------------|--|-------|--------------|---|--------------|
| Beltrán-de-Miguel B. et al[52] | 2015 | Europe  | Spain       | Cross-sectional | 3,000                             | To assess the intake of the individual components of vitamin A and major dietary sources in the Spaniards using data on food consumption from Spanish National Dietary Intake Survey (2009–2010).  | 18–64 | 6 (moderate) | ENIDE (2009–2010)                         | Co of        |
| Bjermo H. et al[56]            | 2013 | Europe  | Sweden      | Cross-sectional | 273                               | To examine the body burden of lead, mercury, and cadmium in blood among Swedish adults and the association between blood levels, diet and other lifestyle factors.   | 18–80 | 8 (high)     | The National Survey Riksmaten (2010–2011) | Fo die co    |
| Meier M. et al[57]             | 2010 | Europe  | Switzerland | Cross-sectional | 1,786                             | To assess whether Swiss residents aged 15–24 years follow current nutritional guidelines and whether differences exist according to gender and weight status.  | 15–24 | 9 (high)     | The Swiss Health Survey (2007)            | BM Fo co     |
| Marcenes W. et al[48]          | 2003 | Europe  | UK          | Cross-sectional | 949                               | To review the major findings from a large representative and comprehensive national survey in Great Britain to which the numbers of teeth and dentures affected older people's ease of eating, nutrient intake, nutritional status, and body mass index. | > 65  | 6 (moderate) | NDNS (1998)                               | BM Fo die co |
| Lei L. et al[60]               | 2016 | Oceania | Australia   | Cross-sectional | 8,202* (6,326 adults and elderly) | To examine the AS and free sugar intakes and the main food sources of AS among Australians.  | > 02  | 8 (high)     | NNPAS (2011–2012)                         | BM Fo co     |
| Bell L. et al[58]              | 2015 | Oceania | Australia   | Cross-sectional | 2,415                             | To identify dietary patterns in Australian adults, and to determine whether these dietary patterns are associated with metabolic phenotype and obesity.  | > 45  | 6 (moderate) | Australian Health Survey (2011–2013)      | BM CC Fo co  |
| Mohr P. et al[59]              | 2007 | Oceania | Australia   | Cross-sectional | 20,527*                           | To identify key predictors of fast-food consumption from a range of demographic, attitudinal, personality and lifestyle variables.   | > 14  | 6 (moderate) | Nielsen Media Research (2004–2005)        | Fo co        |

## Discussion

Food consumption surveys are used to collect information about the preparation and consumption of food, through observations by skilled personnel[10]. In the present analysis, the food record was the most frequently used nutritional survey to assess food consumption in large population surveys, followed by the R24H. Some countries have used this type of dietary inquiry, including Brazil [21–23], as well as developed countries such as Spain[40, 41, 61], England[42, 44, 49, 69], France[46, 47], the United Kingdom[48], and Switzerland[56].

Although allowing a detailed assessment of food consumption, the food record dispenses with the interviewer and does not feature respondent bias. However, it does present some limitations such as the requirement for literacy and high motivation[10]. It is possible that preference for its use in European countries is due to the easier application since an interviewer is not necessary. In this sense, it reduces the costs of the research. It should be emphasized that use of this method has greater reproducibility in populations with a high level of education.

Wide variations in the type of equipment used for data collection were observed in these studies, such as the use of tablets, digital cameras, photographic recordings, telephone interviews, and printed forms, which require a certain degree of skill for their use. It is also interesting that most papers that used the food record applied it for four or more days[21, 42–44, 46–49, 56]. Accordingly, the choice of this method over a long period of time requires some skills from the interwire, such as: good collaborative ability, motivation, and an understanding of the importance of the study. These avoid possible biases resulting from delay in the implementation of the method, such as underreporting or overestimation, as well as withdrawal of the interviewer[70].

The R24h also provides details of food intake and offers greater convenience to the respondent than food record. However, there is a possibility of both respondent and interviewer bias, and the method requires trained interviewers. In this review, only four articles described the training of the interviewers[18, 31, 52, 58]. As all the papers were based on national surveys, generally using secondary data from databases, it is assumed there was a lack of information on interviewer training. Furthermore, the information was not available in the database, but was described in the survey methodology.

Both the food record and the R24h require multiple days of evaluation to estimate habitual intake[10]. Recording of several days of consumption when using short-term records, such as the R24h and the food record, is necessary to remove intrapersonal variability, reducing the random error inherent in usual food consumption[71].

In relation to anthropometric measurements, most of the studies used the BMI as an indicator to assess anthropometric nutritional status. The evaluation of body composition may be relevant as it evaluates the role of body components to health, as well as its relations with the emergence of NCDs. There are various methods for the assessment of body composition that are considered accurate and sophisticated, such as hydrostatic weighing and dual-energy x-ray absorptiometry (DEXA). However, their use in epidemiological studies is impractical because of the high cost. Therefore, BMI and waist circumference are widely used for anthropometric indicators in population studies due to their practicality and low cost[72].

In practice, the anthropometric data are compared for the interpretation of anthropometric nutritional status to reference values, which were obtained from specific populations[73]. Thus, it is necessary to consider different cut-off points for the interpretation of distinct life cycles, such as aging.

The WHO[74] defines an aged or 'older person' as an 60 years old individual or older. This definition, according to the WHO, is appropriate for developing countries; however, in some contexts, especially in developed countries, considering the significant increase in life expectancy in recent years, the classification of 65 years or more for an elderly person may be more appropriate.

However, it's considers that chronological age is not necessarily a precise marker in the monitoring of changes related to aging, because there are important differences related to health, participation, and levels of interdependence among people of the same age. Therefore, it is worth emphasizing that for the purpose of formulating public policies (one of the purposes of national surveys), these variations among older people should be taken into account[75].

Despite its wide dissemination in epidemiological studies, the use of BMI for assessment of anthropometric nutritional status of the elderly has been questioned, owing to the changes in body composition resulting from the aging process[76]. Thus, the employment of the same criteria for the classification of BMI in the general adult population and elderly patients in particular is controversial, considering the reduced stature, accumulation of adipose tissue, and reduction of lean body mass and water in the body that occurs in the elderly individual[77].

The criteria of the WHO (< 18,5 kg/m<sup>2</sup> – Underweight; 18,5 to 24,9 kg/m<sup>2</sup> - Normal weight ; 25,0 to 29,9 kg/m<sup>2</sup> - Pre-obesity; >30,0 kg/m<sup>2</sup> - obesity)[78] and those proposed by Lipschitz (< 22 kg/m<sup>2</sup> - Underweight; 22,0 to 27,0 - Normal weight; < 27 kg/m<sup>2</sup> - Overweight)[79] et al. are the most commonly used for the assessment of anthropometric nutritional status of the elderly.

In this systematic review, which aimed to evaluate the population studies conducted with adults and elderly patients, it was observed that in the majority of studies, the cut-off points of BMI classification proposed by the WHO for adults were also used for the elderly [18, 21, 54, 58, 60, 22, 24, 28, 29, 35, 36, 48, 53]. However, unlike the cut-off points proposed by Lipschitz et al.[79], the WHO classification does not consider the changes in body composition of the elderly. Therefore, it is necessary to critically analyse the classifications of BMI in large population surveys and consider the use of other anthropometric indicators for a complementary diagnosis or update of the criteria proposed by the WHO.

35 papers of the 45 papers performed anthropometric measurements. Information on the techniques and protocols used, interviewer training, and replication of anthropometric measures were available in most of these studies or in previous publications. However, in 40.0% (n = 14)[2, 22, 53, 56–58, 60, 24, 29, 33, 35, 37, 43, 46, 48], a lack of clarity was observed in the equipment calibration information, which did not appear in previous publications, nor even in official survey sites or documents investigated.

This review contains some limitations that must be considered, such as the possible non-inclusion of all health and nutrition surveys conducted on the continents surveyed, owing to the fact that not all databases were consulted. However, to circumvent this limitation, a manual search was performed to obtain a greater number of studies for inclusion.

It is worth mentioning this study included articles of high methodological quality; thus, the results presented here depict the more common methodologies used and accepted in the scientific community for assessment of food intake and anthropometric nutritional status, allowing, however, their critical analysis, to improve the reproducibility of health and nutrition studies.

## Conclusion

This review identified the food record and BMI as the most common indicators of the evaluation of food consumption and anthropometry in population surveys conducted with adults and the elderly. The food record and the 24-hour dietary recall were the preferred methods for studies in developed countries, where high education levels and motivation of residents facilitate the application of these methods. BMI, owing to the ease of obtaining its component measurements and the wide application of its use, was the method of choice of the studies that performed anthropometric evaluation. Nevertheless, most of the studies did not use different classifications in the BMI assessment of adults and the elderly, disregarding the specificities of the changes in body composition and the physiological process of aging widely reported in the literature. The lack of clarity or omission in relation to information regarding the quality of dietary or anthropometric surveys, such as interviewer training, calibration of equipment, or replication of anthropometric measurements, were also issues observed in this review that should be reported.

Hence, it should be emphasized that, in population studies that assess health and nutrition, it is important to devise a proper study design, by selecting the method of food survey that best fits the objectives, the use of anthropometric indicators feasible in epidemiology, and the use of cut-off points appropriate for the population studied, with a view toward reducing the biases and providing valid data. Population surveys can thus provide reliable guidance for the formulation of public policies consistent with the epidemiological profile identified in these studies.

## Abbreviations

PROSPERO: International prospective register of systematic reviews

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

NOS: Newcastle-Ottawa quality assessment scale

AHRQ: Agency for Healthcare Research and Quality

BMI: Body Mass Index

NHANES: National Health and Nutrition Examination Survey

ANIBES: Anthropometry, Intake and Energy Balance in Spain

NSH: National Survey of Health and Development

INRAN-SCAL: Italian National Food Consumption Survey

PNDS: National Demography and Health Survey

ENSANUT: Encuesta Nacional de Salud y Nutrición

ENSIN: Encuesta Nacional de Situación Nutricional

INCA 2: Individual and national study on food consumption

NDNS: British National Diet and Nutrition Survey

ORISCAV-LUX: Observation of Cardiovascular Risk Factors in Luxembourg

DNFCS: Dutch National Food Consumption Survey

ENASEM: Estudio Nacional de Salud y Envejecimiento en México

ENIDE: Encuesta Nacional de Ingesta Dietética

ENSO 2: Segunda Encuesta Nacional de Sobrepeso y Obesidad

NNPAS: National Nutrition and Physical Activity Survey

NEMONIT: German National Nutrition Monitoring

PNS: National Health Research

PDSD: Research Social Dimension of Inequalities

SHIELD: Study to Help Improve Early Evaluation and Management of Risk Factors Leading to Diabetes

FFQ: Food Frequency Questionnaire

R24h: 24-hour dietary recall

WHO: World Health Organization

NCD: Noncommunicable diseases

DEXA: Dual-energy x-ray absorptiometry

## Declarations

### Availability of data and material:

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

### Competing interests:

The authors declare that they have no competing interests

### Funding:

All authors declare that this work was supported by the Federal University of Rio Grande do Norte, process number 23077.037268/2018-46

### Authors' contributions:

All authors contributed to the study conception and design. NLAC and NPPF performed material preparation, data collection and analysis. NLAC wrote the first draft of the manuscript. NPPF, DFOS, SPC, DMM, SCVCL e COL commented on previous versions of the manuscript. All authors read and approved the final manuscript.

### Acknowledgements:

Not applicable

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## Figures

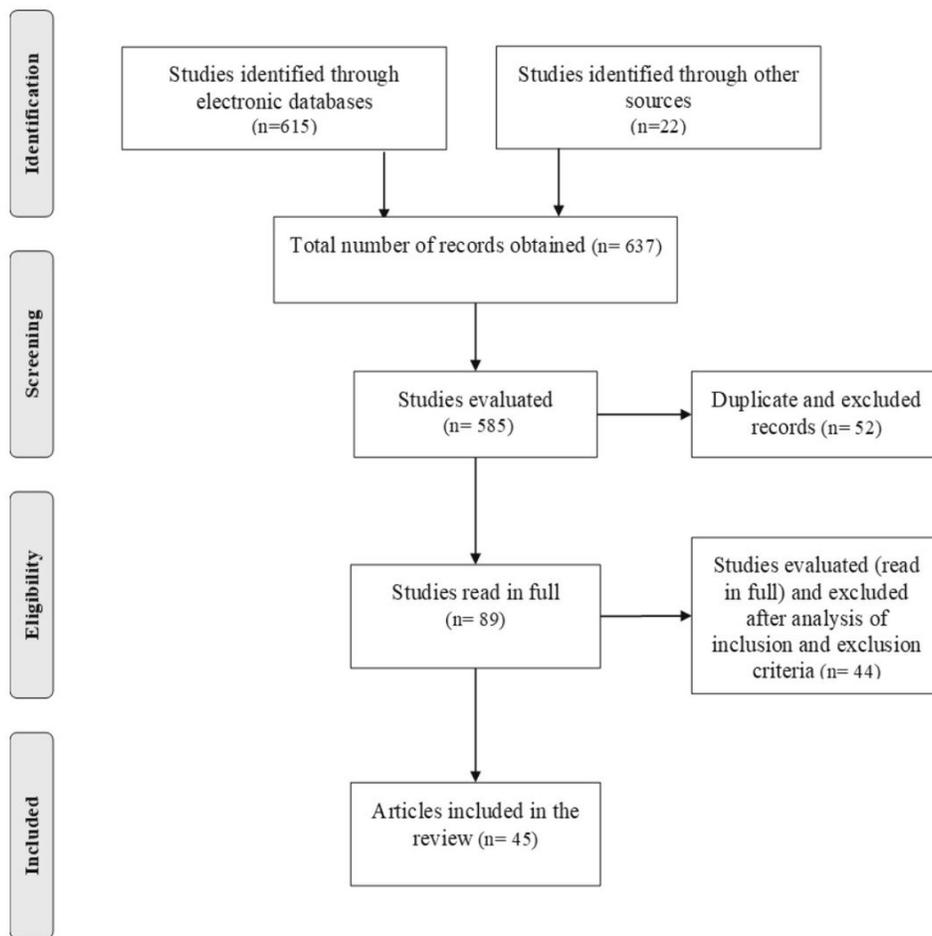


Figure 1

Flowchart of study selection

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