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CHAPTER

DESIGN OF OBSERVATIONAL NUTRITION STUDIES

1

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CHAPTER OUTLINE

1.1 INTRODUCTION TO OBSERVATIONAL NUTRITION STUDIES

The science of human nutrition that is frequently described as "nutrition science" or "nutrition" is *the science of food, the nutrients and other substances therein, their action, interaction and balance in relation to health and disease, and the processes by which the human organism ingests, absorbs, transports, utilizes and excretes food substances* [1,2].

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Systematic observation along with accurate and systematic measurement has been the basis for the development of science in various fields from mathematics and physics to sociology and medicine. Although nutrition science is relatively young compared with others, it has been firmly tied to observation and the measurement since the mid-1950s, when the first evidence-based conclusions regarding the association of nutrition and health were determined [1−13].

As part of nutrition science, nutritional epidemiology incorporates valuable information related to the methodologies and techniques of observation and measurement applied to generate evidence-based conclusions regarding the interaction between diet and health, among others. A considerable proportion of dietary risk factors for various diseases have been identified and studied through epidemiological health and nutrition studies.

An observational nutrition study may be defined as the detailed investigation and analysis of information provided by a retrospective or prospective systematic observation and measurement of a sample's dietary factors (exposures) and health characteristics (outcomes), in which the researcher does not willingly influence the collected information.

Observational nutrition studies have an epidemiological character and aim to generalize conclusions derived from the investigation and analysis of sample data from the reference population [6,14]. They are often named population-based studies. According to the nature of the collected data, they are divided into retrospective and prospective studies [6,14,15]. Types of retrospective surveys include ecological, cross-sectional, and case−control studies whereas prospective surveys include follow-up and longitudinal studies, which are generally labeled cohort studies.

All of these study designs provide valuable descriptive information about adherence to dietary patterns, the consumption of foods and nutrients, the presence of certain dietary behaviors, and other dietary characteristics in a population base. In addition, they aim to test hypotheses related to the association of dietary exposures with health outcomes. Although by themselves these studies are not enough to prove a cause-and-effect relationship between a dietary factor and a health outcome, associations observed mainly in cohort surveys assign the potential existence of causality. In these cases, further investigation through intervention trials and meta-analysis is essential when it is ethically and technologically feasible.

Evidence-based nutrition science or practice is well-promoted as the preferable and most accurate methodology to make decisions in all related disciplines; it aims to maintain or improve the health of individuals, groups, and populations [10]. Observational nutrition studies are a first and important step in the evidence-based concluding chain of nutrition science.

All of the various types of observational nutrition studies have certain advantages and limitations that derive from their nature, and which should be considered throughout the stages of the survey (i.e., design, implementation, analysis, presentation, and publication of results and conclusions). In addition, the methodology of the collection, the management and statistical analysis of data, and the presentation and interpretation of the results vary among the different designs. These issues are addressed in other chapters of the book (i.e., Chapters 3−8).

The following sections offer an overview of the various types of observational nutrition studies illustrating their basic concepts and design methodologies, providing survey examples from the literature.

1.2 ECOLOGICAL NUTRITION STUDIES

1.2.1 DESCRIPTION

An ecological nutrition study is the first level of systematic and comparative observation and measurement of the dietary characteristics of large populations (mainly geographically oriented), usually in parallel with the systematic and comparative observation and measurement of health-related indices in the same populations [6]. The experience of variations in an index of health status between populations with variations in the average value of a dietary factor introduces the concept of the potential association between the dietary exposure and the health outcome. This remains to be confirmed in other observational and experimental settings.

Implementation of this type of survey requires at least that a population-based measure of a dietary factor and an index of health status be available for two or more populations. For instance, a country with 20% per capita intake of calories from fats has a lower incidence of colon cancer than does a country with 45% per capita intake of calories from fats. This introduces the concept that the consumption of fat in these populations may have a role in explaining the variation presented in their incidences of colon cancer.

Although the major aim of ecological studies is to characterize populations over a dietary factor and an index of health status rather than evaluating the association between a dietary exposure and a health outcome [14]. More often, this survey type is used to explore geographical differences in the diet and health of large populations. It is also used to compare changes in diet and the health status of populations over time. Sometimes an ecological study is the only design that can be planned if the dietary data of the study population are unavailable at an individual level.

An advantage of this survey type is that the average population-based diets and the per capita consumption of food tend to be stable over time [14]. Moreover, the indices of diseases are mainly derived from large samples and are under limited biases. For these reasons, it can be hypothesized that variations in health indices and dietary factors in the studied populations may have longer time of preoccurrence.

However, a serious limitation is that the same variations can also be attributed to determinants of disease other than dietary, such as genetic, environmental, clinical, and lifestyle. This poses a major disadvantage of ecological studies along with the limited opportunity to reproduce results, especially for international surveys.

Despite the inability of this study design to validate a cause-and-effect relationship between a dietary exposure and a health outcome, it has been proved to be effective in generating scientific hypotheses for further observational and experimental studies.

1.2.2 CHALLENGES

Among the major concerns for the designers of an ecological nutrition study is the identification of appropriate population-based measures of the dietary characteristics and health status of the populations under investigation.

Estimates of the population dietary intake are often retrieved from preexisting data generated by systematic measures and evaluations performed for other reasons (i.e., economic studies, census). Sources of dietary information include national and international data about the per capita

consumption of foods, data from household surveys, and individual survey data from representative sample populations.

An important consideration for the survey's investigators is a study of the methodology used for data collection and management. The use harmonized national and international population-based dietary data ensures their comparability. This purpose is assisted by using common data collection and management methodologies.

Another challenge to conducting an ecological study is evaluating the level of accuracy of population-based dietary data. Biases related to the methodology of data acquisition should be limited. For instance, frequently, the data for the per capita consumption of food in a country are retrieved by economic studies for food sales, imports, and exports. Because of their aims and methodology, these surveys cannot control for the amount of food that is wasted. It may be true that a significant amount of food that has been sold to consumers was not actually consumed. The percentage of wasted food among countries with different socioeconomical standings may vary significantly. This may lead to biased conclusions regarding variations observed in food consumption and the health status of populations under investigation.

1.2.3 EXAMPLE OF ECOLOGICAL STUDY ON DIET AND CANCER

In 1975, Armstrong and Doll published findings of their ecological study on the association of dietary factors with the incidence of various types of cancer and cancer mortality rates [16]. This was one of the first observational studies on the topic, and despite the methodological limitations derived from its design, it has been a reference work for further studies on the topic (i.e., more than 1700 citations in Scopus Metrics).

The researchers used data on the incidence rate of 27 cancer types in 23 countries for individuals aged 35–64 years, derived from the Union for International Cancer Control in 1966 and 1970 [17,18]. Data on the cancer mortality rates for 14 cancer types in 32 countries were taken from Segi et al. and the World Health Organization (1967–69, 1970) [19–21]. This information was studied in association with data on the international per capita consumption of various foods derived from various reference sources.

The results of the study were presented grouped by the type of cancer, and graphs showing related trends were used. Various correlations were noted between dietary variables and cancer incidence or mortality. The researchers pointed out in their conclusions that the most strong associations were of meat and total fat with colon, rectum, and breast cancer. Interestingly, they also stressed the limitations of their study and noted that other population characteristics might act as confounding factors in some of the observed associations.

1.3 CROSS-SECTIONAL NUTRITION STUDIES

1.3.1 DESCRIPTION

Cross-sectional nutrition studies are often named descriptive surveys; they are a basic type of observational study. They mainly collect and analyze dietary and health data from a sample population at the certain time point in the participants' recruitment [22,23]. For this reason, information provided by participants is a snapshot of the sample's dietary or other characteristics at the time of recruitment.

Cross-sectional studies in nutrition science provide descriptive results for the degree of exposure to dietary factors of a sample population. They evaluate current dietary habits of participants and offer valuable information about the consumption of foods and other dietary components. Energy, water, and nutrient intake, adherence to dietary patterns, and other dietary factors can be estimated [6,24−27]. Moreover, by collecting biological samples and biobanking [28,29], markers of food and nutrient bioavailability and metabolism can be measured in the sample population base. Frequently, participants undergo anthropometric screening and the related information is collected and analyzed [30−32].

Because these studies run in parallel with other health-related studies, they provide important information for the prevalence of a disease or health condition [33]. It is crucially important that the diagnostic criteria used in the survey are the most up-to-date and in accordance with the recent literature. There are several expressions of prevalence; a simple one is:

$$\text{Prevalence} = \frac{\text{Number of diagnosed cases of a disease or a health condition at a certain time point in the sample population}}{\text{sample size}} \times 100$$

For example, when we read that the prevalence of obesity was 25% in November 2015 in a sample population, we may understand that of the 100 participants who were screened at that specific time point, 25 were obese.

During a cross-sectional nutrition survey, the degree of exposure to various potential risk factors such as lifestyle, socioeconomic, environmental, genetic, and clinical is usually measured in parallel at the same time point of the study sample's recruitment [8,34−36]. The choice of the factor that will be assessed depends on the aims of the survey. It is highly essential that all screening tools used to assess the risk factors be valid and accurate.

The time frame of a cross-sectional study is limited to a time point, so it is impossible to identify cause-and-effect relationships between dietary exposures and health outcomes [33,37,38]. The definition of causality in an observed association requires at least that the dietary exposure occurred before the diagnosis of a disease or health condition [6,14,15]. This condition is not confirmed by a cross-sectional design.

Statistical methodologies are available to evaluate the association of a dietary exposure and a health outcome and they are also widely used by researchers, such as linear regression modeling and generalized linear modeling (see Chapter 5). However, the interpretation of significant associations in cross-sectional settings should be limited by the study's inability to express causality. When these associations are supported by literature data (i.e., in vitro or other studies) that offer biological plausibility, they may guide further hypothesis testing and studies in other survey designs (i.e., cohort studies, meta-analyses, and randomized control trials).

Weakness points of this type of observational study also relate to dietary assessment methodologies and tools, which sometimes fail to evaluate the dietary habits of participants accurately. In particular, bias related to the recall of dietary information from sample members is evident whereas potential alterations of long-term dietary habits resulting from the previous presence of a disease or a health condition cannot be thoroughly investigated. Thus, the observed statistical associations between dietary exposures and health outcomes may be biased. These issues are addressed in detail in Chapter 3, where the collection and management of dietary data are discussed.

Despite the limitations presented by the cross-sectional design, the data extracted by this type of nutrition study provide useful information for public health professionals. In fact, cross-sectional surveys offer comprehensive screening of the nutritional and health status of sample populations at certain time points. For this reason, many health institutions worldwide regularly plan, fund, conduct, analyze, and publish this type of study (related examples are presented in Section 1.3.4).

1.3.2 SAMPLING

Given the importance of cross-sectional nutrition surveys in public health perspectives, the need exists to generalize cross-sectional results derived by analyzing sample data to the reference population [39]. The proper choice of the reference population and the methodology for recruiting a representative sample are crucial.

The process of selecting the reference population requires a precise definition of the main hypothesis testing, dietary exposures, health outcomes, and other studied factors (Fig. 1.1). The calculation of the sample size, which will ensure the statistical power of the study's results, is the next important step [40]. There is available free or paid software that allows these calculations with a certain level of accuracy.

When the reference population and the sample size have been well-defined, a decision should be made about the sampling methodology or sample design. This is the method that will be used for the representative selection of sample members from the reference population. Sample members can be individuals, couples, households, or even schools. The finest approach is to use random sampling [15]. In this method, theoretically the probability of a member of the population being included in the study's sample is the same for all members of the population. In this scenario, possible selection biases are limited [33].

Several sample designs are available: simple random sampling, systematic sampling, multistage sampling, and stratified sampling [6,15,23]. Application of the sampling methodology depends on available resources and the decisions of the investigators regarding how the sample will best represent the reference population.

Simple random sampling is a sample design that requires an available comprehensive sample frame (i.e., a list of all potential sample members of the reference population) [41,42]. For instance, a

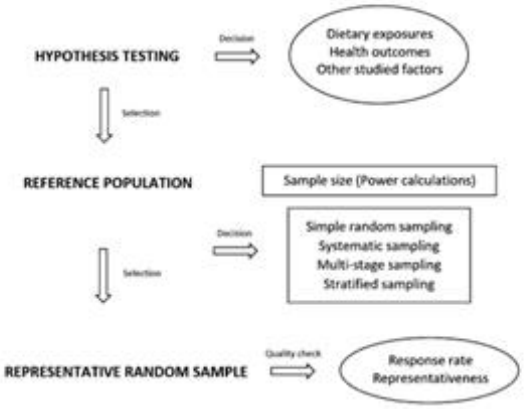

FIGURE 1.1

Sampling of cross-sectional nutrition studies.