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Methodology Series Module 3: Cross-sectional Studies

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Abstract

Cross-sectional study design is a type of observational study design. In a cross-sectional study, the investigator measures the outcome and the exposures in the study participants at the same time. Unlike in case–control studies (participants selected based on the outcome status) or cohort studies (participants selected based on the exposure status), the participants in a cross-sectional study are just selected based on the inclusion and exclusion criteria set for the study. Once the participants have been selected for the study, the investigator follows the study to assess the exposure and the outcomes. Cross-sectional designs are used for population-based surveys and to assess the prevalence of diseases in clinic-based samples. These studies can usually be conducted relatively faster and are inexpensive. They may be conducted either before planning a cohort study or a baseline in a cohort study. These types of designs will give us information about the prevalence of outcomes or exposures; this information will be useful for designing the cohort study. However, since this is a 1-time measurement of exposure and outcome, it is difficult to derive causal relationships from cross-sectional analysis. We can estimate the prevalence of disease in cross-sectional studies. Furthermore, we will also be able to estimate the odds ratios to study the association between exposure and the outcomes in this design.

Key Words: *Cross-sectional studies, design, limitations, strengths*

Introduction

Cross-sectional study design is a type of observational study design. As discussed in the earlier articles, we have highlighted that in an observational study, the investigator does not alter the exposure status. The investigator measures the outcome and the exposure(s) in the population, and may study their association.

Design

In a cross-sectional study, the investigator measures the outcome and the exposures in the study participants at the same time. Unlike in case–control studies (participants selected based on the outcome status) or cohort studies (participants selected based on the exposure status), the participants in a cross-sectional study are just selected based on the inclusion and exclusion criteria set for the study. Once the participants have been selected for the study, the investigator follows the study to assess the exposure and the outcomes.

After the entry into the study, the participants are measured for outcome and exposure at the same time [Figure 1]. The investigator can study the association between these variables. It is also possible that the investigator will recruit the study participants and examine the outcomes in this population. The investigator may also estimate the prevalence of the outcome in those surveyed.

Examples of Cross-sectional Studies

Antibiotic resistance in Propionibacterium acnes strains (Sardana et al., 2016)

A study by Sardana *et al*. evaluated the antibiotic resistance in isolates of *Propionibacterium acnes* in a tertiary care hospital in India. They recruited 80 patients of acne vulgaris, collected specimen for isolation from open or closed comedones. These specimens were then cultured, the growth identified, and antibiotic susceptibility and resistance were assessed.

They isolated *P. acnes* 52% of the cases. In these isolates, resistance for erythromycin, clindamycin, and

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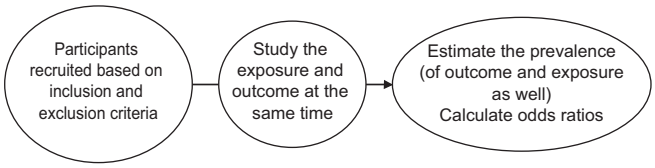

Figure 1: Example of a cross-sectional study

azithromycin was observed in 98%, 90%, and 100% of the isolates, respectively. However, sensitivity for tetracycline, doxycycline, minocycline, and levofloxacin was observed in 69%, 56%, 98%, and 90% of the isolates, respectively. We will discuss this study briefly later in the manuscript as well.

HIV and male sex workers (Shinde et al., 2009)

The authors presented a cross-sectional analysis to assess the prevalence of HIV and risk behaviors in male sex workers. They also evaluated the association between HIV and sociodemographic factors. The data were collected by interviewer-administered questionnaires (for sociodemographic and behavior data), clinical evaluation for sexually transmitted infections (STIs), and serological evaluation for STIs (including HIV).

The authors reported that the prevalence of HIV in male sex workers was 33%. They also found that male-to-female transgendered people were significantly more likely to be HIV-infected compared with males (odds ratio [OR]: 3.5, 95% confidence intervals: 1.0, 11.7). Similarly, they also found that HIV prevalence was higher among those in whom sex work was the main occupation compared with those in whom sex work was not the main occupation (40% vs. 7%, $P = 0.02$).

There are numerous cross-sectional studies in the literature. We encourage the readers to go through some of these studies to understand the design and analysis of cross-sectional studies.

Measurements in a Cross-sectional Study

1. Cross-sectional study designs may be used for population-based surveys
   Example: We are interested to know the prevalence of vitiligo in a village. We design a population-based survey to assess the prevalence of this condition. We go to all the houses that were supposed to be included in the study and examine the population. The total sample surveyed is 5686. Of these, we found that 98 individuals have vitiligo. Thus, the prevalence of vitiligo in this community is:
   Prevalence = 98/5686 or 17.23/1000 population
2. Cross-sectional studies may also be used for estimating the prevalence in clinic-based studies.
   Example: Research question – What is the prevalence of HIV in patients presenting with an STI?
   We evaluate 300 patients with an STI clinic. We record this history, clinical examination, and test them for HIV antibodies (using ELISA) during their first visit to the clinic. We find that 60 of these individuals are HIV infected. Thus, we have detected a prevalence of 20% HIV infection among our STI patients. This type of study will be classified as a cross-sectional study. Kindly note that this being a clinic-based study, it may have all the limitations of a clinic-based study. Thus, the prevalence from these data may have limited generalizability. Nonetheless, this type of study design will be classified as a cross-sectional study.
3. Cross-sectional studies may also be used to calculate the ORs
   For example, if we wish to understand the association between gender and HIV status, we will able to create a 2 × 2 table for the above-mentioned cross-sectional study. Of the 300 individuals evaluated, we have recruited 200 male and 100 female participants. Of the 60 HIV-infected individuals, 50 are males and 10 are females. The 2 × 2 table will be as follows:

	HIV positive	HIV negative	Total
Males	50	150	200
Females	10	90	100
	60	240	300

   The OR (as discussed in the earlier methodology series – II case–control studies) is AD/BC or 50*90/10*150. Thus, the OR is 3.0. The interpretation of this OR is that males had a higher odds of being HIV infected compared with females. Since the OR is >1, the outcome is more likely in those exposed (males) compared with those who are not exposed (females). However, we will require confidence intervals to comment on further interpretation of the OR.

Strengths of a Cross-sectional Study

1. Cross-sectional studies can usually be conducted relatively faster and are inexpensive – particularly when compared with cohort studies (prospective)
2. These are studies are conducted either before planning a cohort study or a baseline in a cohort study. These types of designs will give us information about the prevalence of outcomes or exposures; this information will be useful for designing the cohort study
3. These study designs may be useful for public health planning, monitoring, and evaluation. For example, sometimes the National AIDS Programme conducted cross-sectional sentinel surveys among high-risk groups and ante-natal mothers every year to monitor the prevalence of HIV in these groups.

Limitations of a Cross-sectional Study

1. Since this is a 1-time measurement of exposure and outcome, it is difficult to derive causal relationships from cross-sectional analysis
2. These studies are also prone to certain biases. For example, we wish to study the relation between diet and exercise and being overweight/obese. We conduct a cross-sectional study and recruit 250 individuals. We assess their dietary habits, exercise habits, and body mass index at one point of time in a cross-sectional survey. However, individuals who are overweight/obese have started to exercise more or altered their feeding habits (eat more salads). Hence, in a cross-sectional survey, we may find that overweight/obese individuals are also more likely to eat salads and exercise more. Thus, we have to be careful about interpreting the associations and direction of associations from a cross-sectional survey
3. The prevalence of an outcome depends on the incidence of the disease as well as the length of survival following the outcome. For example, even if the incidence of HIV (number of new cases) goes down in one particular community, the prevalence (total number of cases – old as well as new) may increase. This may be due to cumulative HIV positive cases over a period. Thus, just performing cross-sectional surveys may not be sufficient to understand disease trends in this situation.

Additional Points

As briefly discussed earlier, multiple cross-sectional surveys are used to assess the changes in exposures and outcomes in a particular population.

1. The National AIDS Control Organisation's Sentinel

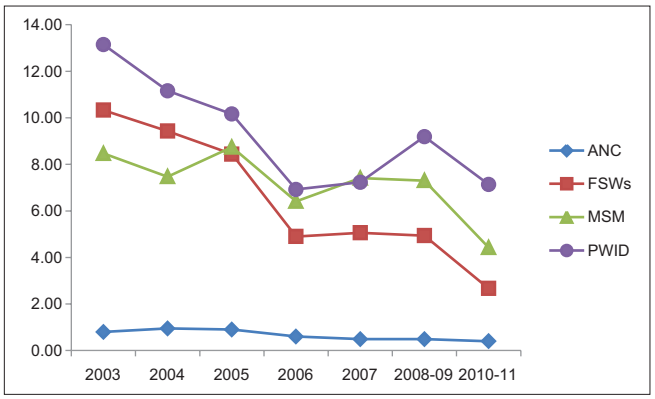

Figure 2: Data from National HIV Sentinel Surveillance (2003–2011)*. *Graph generated from data in the National HIV Sentinel Surveillance

Comparison of observational studies

	Cohort study	Case-control study	Cross-sectional study
Design	Participants are selected based on the exposure status of the individual. They are then followed over time to evaluate for the occurrence of the outcome of interest	Participants are selected for the study based on their outcome status. The investigator then assesses the exposure in both these groups	In a cross-sectional study, the investigator measures the outcome and the exposures in the study participants at the same time
	Prospective cohort study		
	Retrospective cohort study		
Strengths	The temporality between exposure and outcome is well defined	Can be conducted relatively and are inexpensive – particularly when compared with cohort studies (prospective)	Can usually be conducted relatively faster and are inexpensive
	We can study multiple outcomes in the same exposure	Useful to study rare outcomes and outcomes with long latent periods	May be used before cohort studies
	If the exposure is rare, then a cohort design is an efficient method to study the relation between exposure and outcomes	Useful to study multiple exposures in the same outcome	May be used for public health monitoring and planning
Limitations	Time-consuming and costly	It is, in general, not useful to study rare exposures	It is difficult to derive causal relationships from cross-sectional analysis
	In a retrospective cohort study, the measurements of exposure and outcome may not be very accurate or according to our requirements	We are not able to estimate the incidence or prevalence in a case–control study	
		Design is not useful to study multiple outcomes	
	Cohort studies may not be very efficient for rare outcomes except in some conditions	Sometimes, the temporality of the exposure and outcome may not be clearly established	
		They may also be prone to certain biases - selection bias and recall bias	
Analysis	Incidence ratio and rate	Odds ratio	Prevalence
	Incidence rate ratio	Logistic regression models	Odds ratio
	Advanced modeling methods - Cox regression, survival analysis, fixed and random effects models		Logistic regression models

Surveillance of HIV is an example of "serial cross-sectional study" or "serial survey." This may be less expensive compared with a cohort study
Sentinel Surveillance in Antenatal Clinic: The surveillance recruits consecutive consenting pregnant women, aged 15–45 years in these clinics. The exercise has been in place for nearly two decades. The formal annual sentinel surveillance was instituted in 1998. The surveillance provided data on the prevalence of HIV infection in antenatal women, and thus, the trends of HIV infection in this population
Such surveys are also conducted in female sex workers, men who have sex with men, and people who inject drugs, migrants, truckers, and male-to-female transgendered people. Repeated cross-sectional surveys provide useful information on the prevalence of HIV in these groups [Figure 2]. It can be seen that the prevalence has, in general, reduced over the past decade in these groups. Thus, repeated cross-sectional surveys are also useful to monitor the trends over a period

2. We will discuss the previous study by Sardana *et al*. They conducted one cross-sectional survey to assess the resistance patterns in *P. acnes*. If the authors conduct the same study consecutively for two more years, they will provide information on the changing resistance patterns in *P. acnes*. This will be an example of a serial cross-sectional study.

Summary

In a cross-sectional study, the investigator measures the outcome and the exposures in the study participants at the same time. Unlike in case–control studies (participants selected based on the outcome status) or cohort studies (participants selected based on the exposure status), the participants in a cross-sectional study are just selected based on the inclusion and exclusion criteria set for the study. We can measure the prevalence of disease or calculate the OR as a measure of association. These studies are conducted relatively faster and are inexpensive. However, due to the nature of study design, in general, it is difficult to derive causal relationships from cross-sectional analysis.

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Conflicts of interest

There are no conflicts of interest.

Bibliography

1. Hennekens CH, Buring JE. Epidemiology in Medicine. 1st ed. Philadelphia, USA: Lippincott Williams & Wilkins; 1987.
2. Jewell N. Statistics for Epidemiology. Boca Raton, US: Chapman and Hall/CRC; 2004.
3. Rothman KJ, Greenland S, Lash TL. Modern Epidemiology. 3rd ed. Philadelphia, USA: Lippincott Williams & Wilkins; 2008.
4. Kleinbaum D, Kupper L, Morgenstern H. Epidemiologic Research. New York, US: John Wiley and Sons, Inc.; 1982.
5. National AIDS Control Organisation. HIV Sentinel Surveillance 2012-13: A Technical Brief. New Delhi, India: Ministry of Health & Family Welfare, Government of India.
6. Sardana K, Gupta T, Kumar B, Gautam HK, Garg VK. Cross-sectional pilot study of antibiotic resistance in *Propionibacterium acnes* strains in Indian acne patients using 16s-RNA polymerase chain reaction: A comparison among treatment modalities including antibiotics, benzoyl peroxide, and iso tretinoin. Indian J Dermatol 2016;61:45-52.
7. Setia MS. Methodology series module 1: Cohort studies. Indian J Dermatol 2016;61:21-5.
8. Setia MS. Methodology series module 2: Case-control studies. Indian J Dermatol 2016B; 61:146-51.
9. Shinde S, Setia MS, Row-Kavi A, Anand V, Jerajani H. Male sex workers: Are we ignoring a risk group in Mumbai, India? Indian J Dermatol Venereol Leprol 2009;75:41-6.
10. Hulley SB, Cummings SR, Browner WS, Grady D, Hearst N, Newman TB. Designing Clinical Research. 2nd ed. Philadelphia, USA: Lippincot Williams & Wilkins; 2001.
11. Szklo M, Nieto FJ. Epidemiology: Beyond the Basics. Sudbury, MA: Jones and Bartlett Publishers, Inc.; 2004.