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Population health surveys: An introduction to basic concepts

Geoffrey Waghorn, Chris Lloyd

Background: *Population health surveys are a subset of general survey research methods that overlap with epidemiology, a research domain that has been defined as the study of the distribution of disease in populations, rather than the study of disease processes in affected individuals. Population-based surveys in health, therapy or rehabilitation differ in fundamental ways from other research methods which may involve interventions, experimental designs or non-representative surveys.*

Content: *This article introduces some basic concepts in population survey design so that health professionals can better assess and use information from this source. The different types of population-based survey designs are described, and an overview of sampling methods is provided. The concepts of prevalence and incidence are examined, and methods of diagnostic assessment, reliability estimation, and of survey and data set evaluation are described.*

Conclusions: *Population surveys need to be methodologically sound and reported in sufficient detail for close replication. The strengths and limitations of the design need to be critically discussed with reference to the population in scope and the aims of the study. This article can be used by health professionals to classify the potential strength of a particular population survey with respect to its intended purpose and population in scope.*

Key words: ■ health surveys ■ population surveys ■ methodology

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Population health surveys are a sub-type of general survey research methods that overlap with epidemiology, a health science that has been defined as the study of disease in populations, rather than the study of disease processes in affected individuals (Lilja et al, 2008; Ma et al, 2008). Population based approaches to human diseases are essential for establishing the relative disease burden in terms of mortality and morbidity of different health conditions; information which is needed to set national and international disease management priorities (Buka, 2008). In addition, epidemiology often provides breakthroughs in the identification of causal mechanisms, risk factors and effective treatments. This information is then used to set directions for future research to develop optimal disease management strategies.

Population-based surveys in health, therapy or rehabilitation are fundamentally different from other research methods (which involve interventions, experimental designs, smaller scale surveys and longitudinal studies) and from forms of research which involve relatively small samples recruited from a limited geographical area (Mitchell and Jolley, 2007). The aim of population level research is typically to improve the health of populations, by understanding the distribution of health conditions and treatment effects in populations, to identify the individual characteristics, disorder features and environmental correlates of specific health conditions at a population level (Jamison et al, 2006; Baumeister and Harter, 2007; Scott et al, 2008). Of focal interest are estimates of the frequency of people in the population in scope affected or unaffected by a particular health condition. The term 'population in scope' acknowledges the fact that a population must be defined sufficiently well to reduce the gap between the ideal or theoretical population, and the actual population that can be realistically represented by the survey.

Much research and research training in health disciplines focuses on individual level health conditions and the impact of rehabilitation interventions. These research designs typically aim to

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monitor change in the health status of particular individuals, and to identify the most effective health care and rehabilitation interventions. However, population level research is needed to understand the broader context in which health conditions occur in a defined population. This context can reveal much about the individual, environmental and disorder-related correlates of these conditions. Population-based health research overlaps with epidemiology, a health science designed to study disease in human (Borrell, 2009; Duggleby et al, 2009) and animal populations (Carroll et al, 2009; Robinson et al, 2009). Population level information complements research about the efficacy of treatment and rehabilitation for particular health conditions in small samples of individuals.

In intervention studies the gold standard for research design is a randomized controlled trial. In health surveys, well designed population-based surveys are considered the gold standard for identifying health-related issues at a population level. Population surveys need to be methodologically sound and reported in sufficient detail for close replication. The strengths and limitations of the design need to be critically discussed with reference to the population in scope and the aims of the study.

AIMS

Population level studies are particularly important to government policy makers who need to know about the distribution of health conditions in the population as well as the relative burden of disease of each health condition in the wider community (Gilbert and Ellwein, 2008; Okawa et al, 2008; Scott et al, 2009). Policy makers need such information to monitor and improve population health, to fund research to discover causes for health conditions, to prevent national epidemics, and to prioritize resources according to the severity and prevalence of health conditions and the interventions representing the best value for public money. In addition, they are important for health practitioners who also need to understand the population distributions of relevant health conditions to select the most effective interventions for a particular sub-population. This article introduces some basic concepts in population survey design to assist health professionals and other users to critically assess and use information from population surveys.

DEFINING A POPULATION

The first step in designing a population survey is to define the population in scope (Mitchell and Jolley, 2007). Suppose the primary research question concerns the impact of different health conditions on labour force activity. In this case, the relevant population in scope will be limited to a particular country owing to the country-specific nature of labour markets, health and welfare systems. The population scope will also be limited to people of working age because the results are not applicable to those required by law to be in school, or to people of retirement age. In addition, the scope needs to be limited to community residents because people in prison, long-stay hospitals, nursing homes or those who require constant clinical supervision, are not usually able to access the labour force.

It is not always easy to sample the defined population in scope. For instance, most population surveys do well at sampling household residents in a defined geographical area, but may not adequately capture homeless people, people living in mobile accommodation, illegal immigrants, indigenous residents, minority cultural groups, people living in remote geographical areas, tourists, transient residents, foreign diplomatic personnel, and members of foreign governments and foreign defence forces. For this reason, it is useful to distinguish between the theoretical population in scope and the actual population sampled (Trochim, 2006). The onus is on investigators to report how well, or otherwise, the sampling strategy captured all relevant sub-groups of the population of interest. Authors often acknowledge these difficulties by describing population surveys in qualified terms such as 'urban community survey', where the population in scope has been restricted to population sub-groups that were adequately sampled.

WHEN IS A POPULATION SURVEY NEEDED?

Once a research question is identified, it is important to first consider carefully whether the question is appropriate to investigate at a population level (Schwabe et al, 1977). If the answer to this is yes, the next issue to consider is whether or not there are existing data sets of sufficient research quality that could reveal the information sought. Existing data sources may include previously conducted population health surveys, but may also include data from population health surveillance systems, such as cancer registries, or health service information systems, such as hospital morbidity collections. Care must be taken when considering administrative data sets for research purposes because the data may be invalid and unsuitable for a research quality secondary analysis (Drake and McHugo, 2003). If there are no adequate existing data sets, the next question is whether it is feasible or appropriate to undertake a population health survey to collect the required data. Population surveys can be very costly to design and administer. To anticipate costs, the design must be

specified in sufficient detail to ensure that all elements—such as ethical requirements, study promotion and recruitment, staff training, data collection, quality control, data analysis and report writing—are taken into account.

TYPES OF POPULATION SURVEYS

There are three main types of population level health studies: cross-sectional studies, prospective studies and retrospective studies.

Cross-sectional studies

Cross-sectional studies attempt to examine factors that influence the incidence and prevalence of health conditions at a particular point in time (Shaughnessy et al, 2007). By design, cross-sectional studies are limited to revealing simultaneous correlations among variables. This is because determining causation requires much more, beginning with the time order of events. The causal event (or events) must precede the effect event (or events), and time order of these events cannot be established in a cross-sectional survey. Although a study may be classified as cross-sectional, sometimes particular measures (e.g. diagnostic) involve a retrospective assessment. For instance, sometimes health conditions are assessed retrospectively for lifetime occurrence of a health condition.

Prospective surveys

Prospective surveys include longitudinal designs which follow individuals for a period of time and may involve repeated data collections. This type of survey can be used to explore causation, through a capacity to observe the time order of hypothesized causal factors and predictors of interest. However, prospective population surveys can be costly owing to the time series of data collections required, and the need to maintain contact with participants between data collections to minimize attrition bias.

Retrospective studies

Retrospective studies involve the retrospective collection of case information, either by interviewing individuals about their health and treatment history, or by examining existing health records for historical information (Mitchell and Jolley, 2007). A disadvantage of retrospective studies is that the quality of the information available depends on participants' current memory and knowledge, or in the case of documented health records, the accuracy of the information previously collected. Retrospective studies can be used to explore causal hypotheses, although this capacity is also limited by the quality of the retrospective data collected.

SAMPLING METHODS

The ideal form of population health survey is a national census of health records (e.g. Barengo et al (2008) and Hu et al (2008) in Finland) collecting all medical diagnoses and treatments on 100% of the citizen population from birth to death, to a research standard. However, owing to the extensive resources required, this approach is rarely possible and is rare among member countries of the Organisation of Economic Cooperation and Development (OECD). However, countries in the OECD routinely conduct, every 4–5 years, a census of community residents and their social and demographic characteristics. This is usually undertaken by the central government because of the extensive resources required and the legal authority requiring all citizens to participate.

The next best and more common approach is typically a national health or community survey designed from methods developed in the national census. If repeated every few years, this type of health and community survey can accumulate a wealth of population level knowledge of health conditions and relevant social and demographic information. The result is sometimes called a probability sample or a population sample. Although this non-mathematical article avoids the fundamental, and extensive, mathematical probability theory that underpins the theory and practice of population surveys, some recommended technical references are Kendall and Stuart (1968), Cochran (1977) and Särndal et al (1992).

The sampling methods may include stratification, multi-stage sampling, systematic sampling, randomization, purposive sampling, and other sampling methods designed to maximize the accuracy of the population estimates. If the sampling is sufficiently adequate, population weights can be calculated as an individual level variable to increase the accuracy of estimates, for example, to compensate for the inability to similarly sample residents of remote and very remote geographical regions. Size alone does not determine the adequacy of a sample for representing a population. A large and poorly designed sampling strategy is just as potentially misleading as a smaller survey with a non-representative sampling method.

Stratification

This sampling technique involves considering the population to be sampled as consisting of a collection of defined sub-samples (strata), each of which needs to be adequately represented (Shaughnesssy et al, 2007). Stratification is needed when random sampling directly from the whole population is unlikely to lead to a balanced representation of the essential strata. For instance, in a national survey of university students, the on-campus stage of the study may target students by age, sex and ethnicity. The sample can

be stratified by these three variables to ensure that majority *vs* minority ethnic groups are sampled in proportion to their actual prevalence in the population, and that each age sub-group includes near equal numbers of males and females. Once the essential strata are identified they can each be sampled randomly, until the obtained sample is similar in proportion to the distribution in the defined population.

Multi-stage sampling

Multi-stage sampling refers to sampling a population in different stages where the sampling unit may differ at each stage (Shaughnessy et al, 2007). For example, in a national survey of health conditions and labour force activity, the first stage may involve designing a sampling strategy for private dwellings (houses and apartments) by geographical location. A second stage and a different strategy may be needed to sample non-private dwellings, such as hotels, boarding houses, caravan parks, group homes and cared accommodation (e.g. nursing homes and long-stay hospitals) establishments. The probability of random selection of non-private dwellings can then be weighted by the number of potentially eligible residents, to improve the representativeness of the sample.

Systematic sampling

This is a valid alternative to random sampling where the study may require one in every n^{th} person or household to be sampled (Shaughnessy et al, 2007). This is advantageous when the population size is unknown or constantly changing, and when it is impractical to randomly select households or individuals. The disadvantage is that the nth case may be associated with some feature of the population unknown to the researchers. Researchers can avoid this problem by monitoring the sample for any consistent associations with the selection method.

Random sampling

Random sampling can be used in combination with multi-stage sampling and stratification (Mitchell and Jolley, 2007). For example, once the participating households are identified, eligible adults can be selected randomly from each household for an in-depth interview. Alternatively, a health screening tool could be administered to all household members, and a random sample could then be selected for more in-depth interview to represent:

- Those affected by a particular health condition
- Those affected by other health conditions
- Those not affected by any health condition.

Purposive sampling

Purposive sampling can be used to specifically target the population of interest to ensure that sufficient numbers of people with focal characteristics are included (Shaughnessy et al, 2007). For instance a population survey of homeless people may need to target particular inner city areas where homeless people are often found, or target people in touch with welfare services for homeless people. In Australia, purposive sampling is needed to adequately capture homeless people, prisoners, indigenous people, temporary residents, and people receiving public funded treatment for particular health conditions. A risk with this type of sampling is a lapse into convenience sampling which can introduce sampling bias. Convenience sampling involves collecting participants from a nearby local source, often for researcher convenience or owing to resource restrictions, rather than being based on a planned sampling strategy where alternative participant sources are considered.

PREVALENCE AND INCIDENCE

Population surveys are an extension of the small observation surveys often conducted by therapists and health service providers. Where usual surveys may consist of three methods: questionnaires by mail, telephone interviews, and face-to-face interviews (Shaughnessy et al, 2007); population surveys are more likely to consist of several face-to-face interviews with each individual selected for participation. Another key difference is that population surveys are designed to calculate reliable estimates of population norms for social and demographic information, and can be used to estimate the prevalence of particular health conditions.

Prevalence refers to the number of people in a population who are currently affected by a health condition. Whereas incidence refers to the number of new cases of a health condition reported in a defined period. Prevalence is usually estimated as at least one of three variables (Saha et al, 2005):

- Point prevalence
- 12-month prevalence
- Lifetime prevalence.

The type of prevalence reported depends on the nature of the health condition question. For instance, 12-month prevalence is addressed by the question: *Did you experience back pain in the last 12 months?* Point prevalence usually refers to experiencing a set of symptoms or a health condition currently or in the past month, and lifetime prevalence refers to at any time currently and previously in a person's lifetime. Incidence refers to the number of new cases identified in a particular period (usually 1 year) and is typically addressed by survey questions such as: *Were you first diagnosed with this condition in the past 12 months?*

DIAGNOSTIC ASSESSMENT

Diagnostic assessment for many health conditions can be costly and time consuming. Standardized tests are often required that can only be reliably completed by a qualified health professional. Hence, in a large population health survey, decisions about diagnostic assessment may involve a trade-off between available resources, sample size, and the depth of diagnostic assessment required. The larger the required sample, the less likely it will be feasible to apply gold standard forms of diagnostic assessment. There are several ways to address this problem in practice. One method is to conduct a two-stage survey where in the first stage, a brief form of diagnostic assessment or diagnostic screening is conducted with all participants. The second stage can involve the random selection of a manageable number of participants for more in-depth diagnostic assessment.

Another method uses standardized self-report measures or interview-based diagnostic classification systems with known reliability and validity. An example is the International Classification of Diseases (ICD-10) classification system (World Health Organization, 1993). Non-medically trained lay interviewers can be trained in the use of this system in the field, often using laptop computers and computer-based pick lists. Regardless of diagnostic method used, the onus is on the authors to discuss its reliability and validity for the intended purpose.

RELIABILITY OF ESTIMATES

The reliability of any parameter estimates obtained in a population survey can be gauged by the standard deviation of particular parameters in the survey and the sample size related to a particular estimate. The reliability is typically assessed by the standard error statistic (SE) which can be theoretically calculated for each population survey (Altman and Bland, 2005). The standard error is the standard deviation for the distribution of sample estimates from the population. According to the central limit theorem, the distribution of unbiased sample estimates from a population approaches normality with increasing sample size. Elementary methods for calculating standard errors are given in most statistical textbooks, although elementary methods are rarely adequate in well conducted population health surveys. Standard errors are often calculated using statistical software and a method called 'jack-knife replication' (Kish and Frankel, 1970; Shao and Tu, 1995). Alternatively, tables of standard errors for estimates of different sample sizes may be provided by the survey authors. A sample table from a population survey presenting estimates and their standard errors is shown at *Table 1*.

Once estimates and their standard errors are obtained in a population-level survey incorporating population weights, statistically significant differences can be assessed from Z-scores and their standard errors for continuous variables, or chi-square for

TABLE 1.
Earning and learning by health status and age group among Australian community residents of working age in 2003.

Independent variables		Dependent variables (mutually exclusive) describing earning and learning activity. Percents and (standard error percents) shown within rows.					
Health status	Age	1. Employed and not learning	2. Employed and learning	3. Looking for work and not learning	4. Looking for work and learning	5. Not in the labour force and not learning	6. Not in the labour force and learning
Any psychiatric disorder	15-19	15.72 (3.93)	28.25 (5.55)	1.89 (**1.45)	11.65 (*3.22)	7.48 (*2.41)	35.02 (5.09)
	20-29	41.63 (5.01)	9.82 (1.68)	9.80 (1.81)	2.60 (*1.03)	31.05 (3.02)	5.10 (*1.28)
	30-64	39.92 (1.96)	3.28 (0.55)	4.04 (0.69)	0.27 (**0.18)	49.87 (2.21)	2.61 (0.44)
Unwell controls	15-19	11.58 (2.85)	21.87 (4.78)	3.40 (*1.50)	6.42 (*2.43)	7.96 (*2.51)	48.78 (6.15)
	20-29	52.23 (4.96)	18.42 (2.64)	5.22 (*1.55)	1.06 (**0.87)	19.74 (2.61)	3.33 (*0.89)
	30-64	48.33 (1.44)	4.34 (0.35)	2.71 (0.35)	0.42 (*0.13)	43.14 (1.44)	1.07 (0.20)
Well controls	15-19	13.38 (0.73)	35.58 (1.14)	4.04 (0.49)	5.63 (0.45)	2.80 (0.40)	38.56 (1.05)
	20-29	58.40 (0.78)	21.06 (0.55)	4.18 (0.44)	1.16 (0.20)	8.70 (0.55)	6.51 (0.63)
	30-64	75.14 (0.55)	5.81 (0.24)	2.26 (0.17)	0.23 (0.05)	15.44 (0.28)	1.12 (0.11)

Row categories are mutually exclusive. Learning includes both studying full-time or part-time in higher education, or still at school, or both.
*The standard error for this estimate represents 25-50% of the estimate value; **The standard error for this estimate exceeds 50% of the estimate value.

categorical variables, to compare estimates among comparable sub-groups. The Australian Bureau of Statistics publishes a technical manual for its larger community surveys (Australian Bureau of Statistics, 2005), which discusses the relative sizes of standard errors for adequate reliability. A relative standard error of 25% or less of the estimate value is considered reliable for most purposes. A relative standard error of 25–50% is considered of questionable reliability, and standard errors of over 50% of the relevant estimate value are considered too unreliable for most purposes.

EVALUATING QUALITY OF POPULATION SURVEYS AND DATA SETS

The relative quality of population surveys can be assessed using a decision making framework to determine how well each answers the research question of interest, and how well it characterizes the defined population. This step may be particularly useful when conducting a literature review. There is a need to define study standards to classify candidate studies according to preset inclusion criteria. The information in this report can be used to construct such a framework as shown in *Table 2*. The first step involves assessing the purpose of the data collection; was it an administrative data set designed for a different purpose such as recording health insurance claims, or was it designed with population level research in mind? Various aspects of the method can then be assessed and each candidate study can be ranked according to how well the criteria specified are met.

CONCLUSIONS

This non-technical report introduces some of the key concepts needed to understand the utility, quality and strength of information available from well designed population surveys. Although a technical discussion of the theory and practice of population sampling has been avoided, this article can be used by health professionals to classify the potential strength of a particular population survey with respect to its intended purpose and population in scope. IJTR

Conflict of interest: none

Table 2.
Evaluating the quality of population surveys and data sets (continued overleaf)

Survey or data set characteristic	High quality example	Low quality example	Comments
Purpose for the original data collection	The survey is designed to investigate specific research questions relevant to the current investigation	The data set is an administrative data set designed for another unrelated purpose	The data set designed for administration purposes may not be of sufficient quality for research applications
Population in scope	Limits to the population in scope are clearly defined. For example, household residents of a particular country, aged 15-64 years, who have received medical treatment in the past year	Limits to the population in scope are not clearly defined or are too narrowly defined. For example, all people currently living in the UK (residential status not defined), or limited to males aged 15-24 years (too narrow in scope if the research question applies to all males)	Narrow definitions of the population in scope reduce the capacity to compare the focal group to its complement sub-group, or to other population sub-groups
Relevance of data items to current research questions	Survey data items cover a range of focal variables and co-variates that are particularly relevant to the current research question	There are insufficient data items to capture the focal variables of interest and their known co-variates	A large administrative data set can produce misleading results and conclusions if it has few data items relevant to the current research question
Representativeness of the survey	The survey is sufficiently recent and attempts to represent the population in scope by following established methods for population surveys in that country	The survey does not follow established methods for administering similar population surveys. The data are out-of-date and no longer represent the defined population	OECD countries have an official agency that conducts a population census and other population surveys on a regular basis. Census knowledge informs the design of other population surveys
Sampling method	The sampling method involves multiple strategies of stratification, multi-stage sampling, systematic sampling, random selection, or purposive sampling	Only one sampling method is used in a limited geographical area	Population sub-groups can be concentrated by geographic location, socio-economic status, type of housing, ethnicity, citizenship status, language spoken, health condition, age and sex. The sampling strategy needs to take these variations into account

Table 2.
Evaluating the quality of population surveys and data sets (continued)

Survey or data set characteristic	High quality example	Low quality example	Comments
Managing data quality	A strategy for managing data quality is described. Missing data represents a small proportion of recorded data. Missing values are identified and are not substituted. 'Not applicable', or 'could not assess' values are also identified	A strategy for managing or assessing data quality is not described. Missing values are substituted with mean values or by imputing the values from other information collected	Although there are sometimes valid arguments for substituting estimates for missing data, this method introduces a new source of error into the data set. Limits to data quality should be described in detail
Measures	The survey incorporates standardized measures of known reliability and validity	The survey does not incorporate standardized measures of known reliability and validity	Most surveys include sections or sub-scales with known psychometric properties of reliability and validity
Diagnostic assessment	A diagnostic assessment strategy is described based on a recognized and standardized diagnostic protocol. Health conditions are sufficiently disaggregated to allow independent analysis	No formal strategy is used to identify particular health conditions. Category of disability may be identified without any attempt to sufficiently identify and disaggregate underlying health conditions	There are three levels of diagnostic quality: (1) full diagnostic assessment based on a standardized diagnostic protocol; (2) screening assessment based on a standardized screening tool; and (3) self-report based on participant recall of being diagnosed or treated for particular health conditions
Statistical analysis	Population weights are provided as individual level variables. A method for calculating standard errors is recommended. A strategy for avoiding Type 1 errors is provided. Effect sizes or amount of variance explained, are reported. All analyses conducted are reported. Corrections to the significance level (alpha) are made to allow for multiple statistical analyses	Population weights are not provided. A method for calculating standard errors is not recommended. Statistical significance is reported without a measure of effect size or variance explained. Not all analyses conducted are reported. Corrections are not made for multiple statistical analyses	Standard errors of estimates are usually required for publication. Tests of statistical significance are insufficient owing to high risk of Type 1 errors in large samples (effects that are not real). Effect sizes or amount of variance explained, and corrections for multiple statistical analyses, need to be reported to reduce the risk of Type 1 error

OECD= Organisation of Economic Cooperation and Development

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KEY POINTS

- Population health surveys differ in fundamental ways from other research methods which involve interventions and experimental designs.
- While the gold standard for intervention research design is the randomized controlled trial, a well designed population survey represents a gold standard of survey research, which complements information from intervention based research methods.
- The quality of a population survey may be assessed in terms of: the match of study purpose to survey design; the defined population in scope; survey representativeness; the sampling method; how data quality was managed; the diagnostic method for identifying health conditions; whether standardized measures of known reliability and validity were included; and the methods of statistical analysis.

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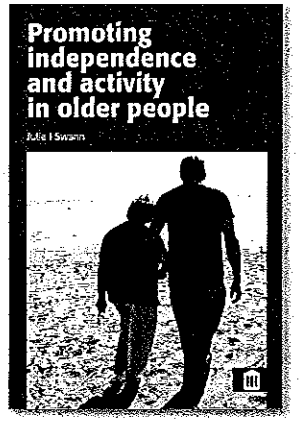
Promoting independence and activity in older people



By Julie I Swann

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This book is centred upon articles published in the practical series of Nursing and Residential Care since 2004. The author focuses on empowering care assistants to make a positive difference to the lives of residents in care homes. The aim is to facilitate independence by utilising different techniques and assistive devices, and by ensuring that the environment promotes independence to maximise residual skills, making tasks easier for residents and carers alike. Several chapters expand on knowledge evidence for S/NVQ levels 2 & 3 in care, providing activity organisers, care assistants and managers with new resources and practical ideas.

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