Schnohr CW, Molcho M, Rasmussen M, Samdal O, de Looze M, Levin K, Roberts CJ, Ehlinger V, Krølner R, Dalmasso P, Torsheim T.

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Eur J Public Health. 2015 Apr;25 Suppl 2:7-12. doi: 10.1093/eurpub/ckv010.

Trend analyses in the health behaviour in school-aged children study: methodological considerations and recommendations

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ABSTRACT

This article presents the scope and development of the Health Behaviour in School-aged Children (HBSC) study, reviews trend papers published on international HBSC data up to 2012 and discusses the efforts made to produce reliable trend analyses. Methods: The major goal of this article is to present the statistical procedures and analytical strategies for upholding high data quality, as well as reflections from the authors of this article on how to produce reliable trends based on an international study of the magnitude of the HBSC study. HBSC is an international cross-sectional study collecting data from adolescents aged 11–15 years, on a broad variety of health determinants and health behaviours. Results: A number of methodological challenges have stemmed from the growth of the HBSC-study, in particular given that the study has a focus on monitoring trends. Some of those challenges are considered. When analysing trends, researchers must be able to assess whether a change in prevalence is an expression of an actual change in the observed outcome, whether it is a result of methodological artefacts, or whether it is due to changes in the conceptualization of the outcome by the respondents. Conclusion: The article present recommendations to take a number of the considerations into account. The considerations imply methodological challenges, which are core issues in undertaking trend analyses.

Introduction

Research into adolescents' health and health behaviours, as well as into the factors that influence them, is essential for the development of effective health education and health promotion policy, programs and practice targeted at young people. It is important that young people's health is considered in its broadest sense, encompassing physical, social and emotional well-being.[1] Further, and in accordance with the World Health Organization (WHO), health should be acknowledged as a resource for everyday living.[2,3] Thus, research into adolescents' health needs to investigate not only modifiable risk factors associated with ill-health, but also identify factors that promote young people's well-being.

History of HBSC

The WHO collaborative cross-sectional Health Behaviour in School- aged Children (HBSC) survey collects data on health and well-being, social environments and health behaviours from 11-, 13- and 15- year-old school going children every 4 years. The study was initiated in 1983 in 5 countries and developed into a large cross-national study including 43 countries and regions by the 8th data collection in 2009/2010 (see fig. 1).

This article takes on a methodological view of the 30-year-period since the inception of the HBSC study, in particular reflecting on methodological aspects in performing trend analyses. The article does so by presenting the challenges and considerations encountered in collecting data consecutively and analysing trends. More in-depth information on scientific rationale, partnerships and policy implications of the study has been published elsewhere [1,4–7]

The initial idea to conduct a cross-cultural study was developed by researchers from Norway, Finland and England, who found a lack of comparability of smoking measures in existing surveys. This led to collaboration on the development of a cross-national survey using an internationally standardized protocol and questionnaire in each country, to ensure high comparability[2,3]. With the expansion of the HBSC study, there has been a natural increase in the number of HBSC network members, who brought a broad range of backgrounds and various professional views on methodological perspectives in setting the research agenda and in the development of specific items. This broad internal expertise forms the basis for achieving the original aim; to ensure high comparability in spite of the increased complexity due to the increasing numbers of participating countries and repeated survey rounds. The HBSC study Protocol is core in achieving this aim.

HBSC study protocol

Data are collected using a standard methodology outlined in the HBSC protocol created and agreed by all participating countries[4,5]. Each country uses random cluster sampling with classes or schools as the primary sampling unit, selecting approximately 1500 adolescents in each of the three age-groups (i.e. 11, 13 and 15 years), ensuring that the sample is representative of the target population. Data collection takes place in four-year intervals, and in the most recent survey, data were collected from approximately 200000 adolescents through a self-completion questionnaire, filled out during a school lesson. After data collection, national datasets are submitted to an international databank that checks the quality of the data collected, performs appropriate cleaning of the data and merges national data sets into an international data file.

Contributions of the HBSC study

The HBSC study has had an important lifelong partner in the WHO Regional Office for Europe, making use of HBSC data as a valuable source of knowledge on social and behavioural issues in Europe, supplementing existing data on morbidity and mortality indicators[8]. The value of HBSC as a database for the monitoring of child health is topical for trend analysis, particularly as the study now has been undertaken over numerous survey waves in many countries. Sixty-eight peer-reviewed papers were published between the initiation of the study in 1983 and 2002[9]. Since then between 20 and 30 papers have been published annually in peer-reviewed journals, including a total of 10 international and 30 national trend papers. The production of the aforementioned papers, and in particular the trend papers, has led to a number of methodological considerations and discussions within the HBSC network. Most of the papers produced are a result of the conclusions reached on how to optimize validity when working with international data spanning over time. A brief overview of these issues is presented here.

Methodological considerations

The objectives of trend analysis

Trend analysis serves several objectives. Importantly, describing trends in outcomes 'within countries' is a relevant question; e.g. did smoking increase in a given country between 1994 and 2010? Trend analysis can also be used to summarize trends between countries and examine the heterogeneity 'between countries'; e.g. has there been an overall increase in smoking across countries, and did some countries change more than others? In addition to

these descriptive objectives, trend analysis may also examine causal 'mechanisms', and for example identify factors that moderate the magnitude of trend; to what extent did the magnitude of trend change in countries with smoke-free legislation, in comparison to countries without smoke-free legislation? Related to causal mechanisms, another objective of trend analysis can be the changing magnitude of 'associations'; if and how did social inequality in smoking change over time?

A review of international trend analysis papers

This article provides a brief review of some of the international trend papers published, to provide hands-on examples of some of the analytical approaches that were used. For the purpose of this article, international papers comparing two or more countries, over three or more cycles of data collection, are considered. Most of the HBSC trend papers to date have examined time trends in risk behaviours, such as drinking,[10,11] smoking1[2,13] and fighting,[14] while others investigated time trends in bullying behaviours,[15,16] television viewing and physical activity.[17] In some papers, trends were determined based on graphical/visual differences backed by confidence intervals,[13,16,17] and in others more complex analyses were performed. Simons-Morton et al.[10] used Cochran-Mantel- Haenszel test for trends including time as a categorical variable, Pickett et al.[14] used Poisson regression including time as a covariate, and Zaborskis et al.[11] used multiple logistic regression with survey year as a covariate, an approach also used by de Looze et al.[12] Elgar et al.[15] aggregated all data at country level and used a Pooled-Time Series Analysis with country-years as the unit for analysis using linear regression to predict the outcome. This brief overview of different methods in reporting trends demonstrates the variety of possibilities in analysing trends. This variety in the approaches used reflects both emergence of new statistical tools and techniques to perform more advanced analyses, but also a general lack of clarity in the literature regarding a recommended, or even appropriate, trend analysis. To our knowledge, no consistent approach has been developed for trend analyses, which may depend both on the particular research question and the educational background and theoretical views of the research team of authors. This article includes examples of what are considered common methodological issues independent of the particular authors or research question.

Methodological considerations of trend analyses: and how the HBSC study has dealt with them

Different research areas and disciplines emphasize different theoretical and statistical approaches, as well as different methodological criteria. While challenging, meaningful agreement across disciplinary areas can be reached through establishment of a definition of common standards. While Heath and colleagues' focus was cross-country comparisons, issues relating to the handling of data are also relevant for time trend analyses.[18] Heath and colleagues suggest that methodological problems arise from either errors of non-observation or errors of observation. Encompassed in the latter is an error in the equivalence of meaning, which follows from changes in perceptions of the variables measured and not only from which and how many observations are included. Hence, methodological development can be led by an overall aim to achieve equivalence of meaning across time and country hereafter called 'functional equivalence'.

Errors of non-observation and response bias

Existing research around non-observation has explored general questions such as the relation between response rate, and response bias[19] and questions on whether data are representative. Variation in sampling methods, modes of data collection and response rates is likely to result in various non-response biases.[18] To illustrate, due to the existence of different ethical requirement across countries, countries can have different requirements for parental consent. In some countries, active (opt-in) consent is required, while in others passive (opt-out) consent suffices. Countries with active consent procedures are likely to have a lower response rate compared to those where passive consent is used. Even when steps in the design phase do not vary, it is necessary to check how far the observed variation over time (and country) in the given outcome might be due to some standard (and investigable) sources of non-observation and/or observation error.[18] Taking the example of the consent process, there may or may not be differences in outcome, e.g. smoking, across countries that may be associated with who gives (active) consent and who does not. These variations are plausible and can often be investigated, and adhering to the HBSC protocol in practice, documenting data and being clear about the data cleaning process helps to minimize problems arising from such methodological challenges.

Errors of observation and functional equivalence

Functional equivalence is defined here as a methodological challenge associated with high levels of cultural, economic and historical diversity between regions constituting the HBSC study. This diversity is for obvious reasons complex to define, and existing research about compliance to questionnaires has explored general questions such as social acceptability bias or the different use of response categories depending on relevance in a national context.[15] The key concern is whether items have the same meaning across different contexts. These concerns can be tested through qualitative studies and following data collection, further statistical explorations to look for clues of bias due to compliance are recommended.[18] A thorough approach should include questioning whether the observed variations in the extent to which respondents over time and in each country subscribe to the conceptions in the given outcome, represents 'real' differences or whether one should treat some of the variation as essentially methodological artifacts.[18] With an overall aim to obtain functional equivalence it is beneficial to discuss and document (e.g. in a research protocol) which of those two interpretations are most likely or whether it is a combination.

Methodological recommendations

Statistical considerations of trend analyses

The consideration of analytical strategy is always an important part of a statistical study, but in a cross-national or trend analyses, this choice is critical, since it can potentially modify the findings.[20] This article suggests a number of preconditions, which are specifically proposed to be included as initial steps of trend analyses in order to increase validity in a broad sense, and should act as an aid in defending the modelling decisions made. The steps are divided into (i) preparation, (ii) analyses and (iii) interpretation.

Preparation of data

The following steps are recommended in order to assure sufficient data quality to do comparative and trend analyses. The importance or urgency of each step is dependent on the particular data used and research question posed, but the list may serve as a check-list for authors of trend papers in general.

The HBSC Data Management Centre performs a general check and cleaning of data before including a national sample in the international file, in which several of the steps listed in

table 1 are included. However, as odd patterns can be seen in comparisons between groups, it is worthwhile to work through the steps to ensure sufficient data quality to perform each specific comparative and trend analyses.

Response rates and the variation within and between countries could be subject to a specific paper in itself. Within each country, there are particular challenges in the calculation of response rates; whether it is based on school level, class level, individual level or a combination of these. Within the HBSC, there is a special focus on developing consistency on this important methodological issue.

Table 2 illustrates the response rates for the participating countries in the past three survey rounds, and it illustrates substantial differences. The large variation is partly due to how data is oversampling in some countries. The lack of standardization of some of the sampling issues therefore makes it very difficult to compare responses across countries presently, as well as the challenge in collecting correct population data split by school and class level. This area is presently receiving a lot of attention within the network, to document the variation in responses within and between countries. As national data on population and sample size improve the quality of the response rate calculations increases.

Analysing data

With regression models as a starting point for trend analysis, variation in the dependent variable is a function of discrete or continuous time. In the 'discrete time' approach, each study year is represented by a separate model parameter, describing the difference with a reference time point, commonly the first time point in the series of data. A positive feature of modelling time as discrete is that it makes no assumptions of a continuous gradient between time points, allowing for any shape of relationship to be modelled.

In a 'continuous time' approach, the population trend is parameterized as a gradient or continuous slope of change per time unit. A positive feature of modelling time as continuous is that the pattern can be summarized through a single parameter: the slope of change over time. A negative feature is that the constant slope of change is biased when the true population trend is non-linear, e.g. if there is a steep change between time points. Nonlinear trends can be accommodated through quadratic and cubic terms, or through orthogonal polynomials.

When the analyses include several countries, the researchers must make a number of

decisions, both in modelling the trend, and how to model cross-national differences in the trend. Three potential approaches ('the stratified approach', 'the fixed effect approach' and 'the random effect approach') modelling trends are outlined here using a prototypical example with use of the HBSC data from 35 countries across five study cycles.

'The stratified approach' implies running a series of regression analyses, with time as an independent variable in each country. The prototype example would require reporting 35 countries of 5 parameters. Notably, for the stratified approach, there is no statistical criterion for evaluating the overall trend or the heterogeneity, but inference about single countries can be made. Using this approach, only a narrative synthesis of the overall trend and the heterogeneity of trends can be made, as there are no statistics for the between country differences.

'The fixed effect approach suggests' model trends and heterogeneity of trends through specification of main and interactive effects of time and country. The overall main effect of time and the interaction effect of time by country can be tested in omnibus tests of model fit, such as the likelihood ratio test (LRT). Inference can be made when assessing the main effect of time, where a statistically significant estimate would imply an overall trend. A statistically significant interaction between time and country would indicate heterogeneity across the overall trend. As a supplement to an omnibus test, inference about single countries can be done through linear composites of the estimates.

'The random effects approach suggests': This approach suggests modelling an average trend with time as a fixed effect. Cross-national differences in such trends need to be parameterized through random components as functions of continuous or discrete time. Treating time as a nominal variable with five time points implies specification of five random variance components and ten covariances. If time is treated as continuous, the random effects approach requires specification of only three covariances; one for the random intercept, one for the random slope component, and one for the intercept–slope covariance. In the random effect model, the fixed average of trend could be tested using LRT. However, inference on cross-national differences requires restricted maximum likelihood test for each added variance component, and a restricted LRT for nested models. Notably, this model does not provide separate estimates for each country, but single country estimates can be obtained through prediction of shrunken country-level random effects.

Interpreting data

When interpreting the findings from time trend analyses, in most cases it is important to include statements about the overall trend as well as the heterogeneity in trends. Often in trend papers, patterns are discussed and compared to parallel developments such as changes at a national level in legislation or other national level variables such as inequality measures like the Gini-coefficient. When interpreting changes in data from individual to a national and even international level, conclusions should be drawn with utmost caution. Ecological studies offer only limited evidence for causal relationships, and may be included as a support to known causal relationships.

The second issue relates to the scaling of the trends, and whether absolute and relative differences are found. It is important to differentiate between the two when measuring differences over time because interpretation of findings can vary when one or the other is used. An example may be where the prevalence of an outcome, has increased 3-fold (in relative terms) but in absolute terms the increase is from 0.03 to 0.09%, still a very small proportion. The importance of considering both absolute and relative changes is particularly pertinent when measuring differences between countries, over time or in any association studies. For example, in studies of socioeconomic health inequalities over time, absolute inequalities (the gap between rich and poor) may be reduced, while relative inequalities (a comparison of the ratio of change) may increase. Oliver et al.[21] provide examples where stand-alone statistics of relative or absolute inequalities result in ambiguous conclusions. In order to draw meaningful conclusions, analyses of time trends, and trend differences by country, SES or other groupings, should report both absolute and relative changes over time.

Discussion

The unique potential of the HBSC study to conduct trend analyses brings along a number of methodological challenges that need to be addressed before data can be used. This article has presented some of the challenges, alongside recommendations on how to deal with them. The HBSC network comprises of a large number of researchers from different disciplines; sociologists, psychologists, pedagogues, medical doctors and statisticians. The broad spectrum of experience and knowledge is combined and provides a true trans-disciplinary approach to the field of adolescent public health both from a scientific and a methodological point of view.[18] Central to the HBSC study is a standardized protocol ensuring data are collected using a prescribed methodology, which allows comparison of data across countries

and through time.

Apart from the challenges described by Heath and colleagues,[18] which are discussed here, repeated questionnaire studies must continuously improve and adapt the content of the questionnaire.[5] A key challenge here is the dilemma between leaving items unchanged in order to monitor trends vs. continuous improvement as new evidence of validity and reliability is produced, which may suggest that improvements are possible.[4] Such careful forethought and expertise in producing a research protocol enhances the status of a survey through meeting scientific and methodological standards, and ensuring robust comparisons between survey year and countries.

Over the 30 years of its existence, efforts to ensure that observed trends are not merely methodological artifacts, and that HBSC data have functional equivalence across countries and over time have been led by the pioneering work from the original researchers who initiated the study in 1983. By assuring a collaborative base using a common protocol and development of a data instrument with high comparability, these efforts continue to the current day. HBSC is a valuable international data source in the field of adolescent health research, and is a unique source of comparative research. This aim since the early development of the HBSC, has been maintained, and will continue in the future, as the HBSC consists of frontline re- searchers developing and adhering to high methodological standards.

Acknowledgements

The HBSC study is an international study carried out in collaboration with WHO Europe. The international coordinator was Professor Candace Currie from the University of St. Andrews, and the databank manager was Professor Oddrun Samdal from the University of Bergen. A complete list of participating countries and researchers is available on the HBSC website (http://www. hbsc.org). The data collection for each HBSC survey is funded at the national level. The authors also wish to acknowledge the work of the principal investigators (PI's) in 43 regions, who hold personal responsibility of the conduction of the survey. The authors are grateful for the insightful and constructive comments of the reviewers

Conflicts of interest: None declared.

Key points

The main messages in this article are:

- To describe challenges faced when working with large cross- national surveys
- To advise researchers working with comparative analyses, whether it be comparing between countries or over time
- To present basic statistical procedures forming reliable trend analyses
- To advise on providing reliable comparisons in large inter- national studies, thereby providing more valid information to public health practice

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Table 1. Steps for checking the sufficiency of the data quality to do comparative and trend analyses

Response rates	Check reported response rates to assure that no country has an unusually high or low response rate, e.g. if the response rate is either 100% or close to zero. Also note whether response rates have varied substantially over time within the same country. Examine and document noteworthy results
Sampling procedures	Check that the countries included in the trend analyses have not made substantial changes to their sampling procedures or use of weights, particular for countries where earlier survey rounds were regional samples (and thereby no nationally representative sample). If this is the case, the early phase regional data cannot be included for comparison with later nationally representative samples
Wording	Check whether all countries have used identical questions and response-categories both across countries and survey years. Implications of different wordings or changes in response categories should be discussed in the article
Odd patterns	Check missing responses, look for and evaluate odd patterns in the answers both across countries and within countries for each survey year. If roof/ceiling-effects are observed between and/or within countries, they should be reported in the article as part of the description of the data set (methods section or discussion of strengths and weaknesses)
Odd patterns within items/categories	Check the consistency of related items, e.g. the two separate items on lifetime smoking and current smoking respectively, to make sure that no one has responded that they had never started smoking on one item, but reported current smoking to be daily. Inconsistencies are often dealt with during the standardized cleaning procedures. In the example above a conclusion of which response is more correct would be supported by a question on number of cigarettes smoked per day, week etc. If a number higher than 0 is given, the ‘‘never’’ answer can be considered wrong. If only two questions are available for evaluation of inconsistency a principle of the most extreme response either positive or negative as valid is often used to decide whether an inconsistency can be solved. In the example, ‘‘Have you ever smoked?’’ the response would be changed to yes, if the respondents later report to smoke. In cases where guidelines of most extreme response cannot be used, both variables need to be coded as missing
Use of weights	Examine the extent of weighting in the selected countries and survey years, and evaluate the consequences of use/no use of weights in comparisons done in the analyses. A rule of thumb is that weights need to be used for analyses of prevalence, whereas they are not required for analyses of associations
Clustering	Examine the extent of sample clustering and take account of observed clustering in the analyses
Basic demo graphics	Examine the prevalence of basic demographic variables (age, gender, urbanization etc.) in the population and differences in these demographic statistics over time

Table 2. Response rates (percentages based on school-, class- or individual level)

Country	2005/06	2009/10
Armenia	–	100
Austria	88	64
Belgium(French)	97	60
Belgium(Flemish)	–	29
Canada	92	44
Croatia	–	69
Czech Republic	100	87
Denmark	94	46
England	66	40
Estonia	100	87
Finland	89	70
France	79	77
Germany	47	86
Greece	96	87
Greenland	NA	45
Hungary	98	69
Iceland	–	89
Ireland	99	61
Israel	–	–
Italy	–	83
Latvia	98	80
Lithuania	100	89
Luxembourg	–	73
Malta	–	–
Macedonia	–	98
Netherlands	–	47
Norway	68	49
Poland	100	83
Portugal	100	85
Romania	–	83
Russian Federation	82	78
Scotland	66	65
Slovakia	–	78
Slovenia	–	84
Spain	–	58
Sweden	90	77
Switzerland	86	88
Turkey	–	79
Ukraine	–	81
USA	–	59
Wales	66	60

NA Not Applicable

Figure 1: Partecipating regions in the HBSC