# The choice between a panel and cohort study design

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# WORK PACKAGE 4: THE CHOICE BETWEEN A PANEL AND COHORT STUDY DESIGN

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## Executive Summary

The UK has a long and rich history of longitudinal studies, including cohort studies and longitudinal panels, and we summarise the main studies and their key features. We go on to identify the key differences between cohort and panel approaches, in the population coverage and whether refreshment samples are expected; what types of questions can be used; the sample design and sample size; and the choice of spacing of waves. Over a long period panels and cohorts collect similar amounts of information, but in a single cohort there is no way to measure the cohort effect separately from time effects. Early in the studies, the differences are greater. Cohort studies can have questionnaires much more tailored to the age and expected life course events of the respondents than a panel study, which must cater for many ages.

Accelerated cohort designs offer an intermediate solution, where the collection can be tailored, but where cohort effects can be estimated, as long as there is some overlap between the ages in the cohorts. There are several additional factors to consider in an accelerated cohort design.

Making choices about which features are important in a new cohort study depends on the answers to many questions about what the intended analytical outcomes are, and how long the study will run.

## Goal of work package

Longitudinal surveys all follow the same people over time to document change. If the group of people being followed over time is large enough, longitudinal studies do not only allow the study of change at the level of the individual, but also at the level of a population. Existing longitudinal studies in the United Kingdom and elsewhere study a diverse set of populations, comprising for example households, patients, newborns or elderly. Some of these studies take measurements multiple times a year, whereas others only measure change every decade. Some studies are conducted in the entire United Kingdom, whereas others focus on a rather small geographic area.

This chapter documents the types of designs that exist for longitudinal studies. It gives a broad overview of the design of the most important longitudinal studies that are of relevance to social sciences and adjacent fields of research. It will in particular contrast two broad approaches to the design of longitudinal studies: cohort studies follow people identified by specific characteristics in a defined time period, whereas panel studies aim to cover the whole population.

After first discussing key design aspects of existing longitudinal studies with a focus on the United Kingdom, we discuss the particular strengths, advantages, challenges and limitations of a panel study or cohort study approach. There are relations to other issues discussed in different reports. In particular, the question of how to study "small populations" covered in work package 2 is relevant for

the question of how to design a longitudinal survey. Ultimately, the decision on the particular design of a longitudinal study depends on what particular questions need to be answered for which particular populations. We will also discuss analytical advantages of both cohort and panel study designs for the analysis of change. We will contrast the types of questions and analyses which can be undertaken with these different types of data, and with hybrids such as accelerated designs (eg Brüderl *et al*. 2018).

We are only discussing the design of longitudinal surveys which aim to follow people for a potentially indefinite period of time. Some surveys, such as the European Labour Force Survey (Eurostat, 2012) or the American SIPP study are rotating panels (U.S. Census Burau, 2009). Respondents are recruited and interviewed several times within a relatively short time-span (often 1 year). After this, a new rotation of the panel study starts with a fresh sample of respondents. In a way, such rotating panels are a hybrid between a repeated cross-sectional survey (such as the European Social Survey (Jowell et al., 2007)) where a new sample is drawn every wave, and true longitudinal designs, which are the topic of this chapter. For more information on design decisions in rotating panel surveys, see Lynn & Lugtig (2017). For more information on the repeated cross-sectional design, and a broader overview we refer to Smith *et al*. (2009) or Ployhard and Vandenberg (2010).

**Existing longitudinal studies and their designs**

The United Kingdom has a long and rich history of longitudinal studies. Of particular relevance, both nationally and internationally, are the various birth cohort studies that date back to the 1940s. Of the cohort studies which are currently still active, the MRC National Survey of Health and Development (NSHD) is the oldest (Wadsworth *et al*, 2006; Hartaigh *et al* 2014). It started in 1946 with a sample of 5,362 babies born in England, Scotland and Wales, who have been measured 24 times since. Measurements were most frequent during school years and between the ages of 15-30, with less frequent measurements taken before school age, and after the age of 30. Over the course of time, the sample size has decreased due to mortality and panel dropout for a range of other reasons. In the 2015 wave for example, 2,149 sample members remain (Kuh *et al*. 2016). The topics in the various surveys have changed over the years focusing on topics that were deemed to be most relevant for the particular life phase cohort members were in. The study has also studied offspring of most of the sample members twice, at ages 4 and 8.

The National Child Development Study (NCDS) (Power & Elliott, 2005) is currently the second-oldest running cohort in the UK. It was started in 1958 and resembles NHDS in many ways. One difference is that NCDS is larger. It follows about 17,000 people born in the UK in 1958. So far 10 waves of data collection have been conducted, with the 11th wave starting in 2020. Intervals between waves are a bit irregular, but average about 6 years. The 1970 British Cohort Study (BCS70) (Elliott and Shephard, 2006) used a similar design. Intervals between waves were slightly shorter than the NCDS, with 10 waves being conducted in 50 years.

In 2004, a further cohort study called the Longitudinal Study of Young People in England (LSYPE1) (Schoon, 2014; Skaliotis, 2009) started on the basis of a sample of adolescents born in 1989-1990. Cohort members were thus aged 14-15 at the start of the study. The cohort size is 16,000 and interviews were held annually until 2010 when cohort members turned 20. A follow-up wave was conducted in 2015.  LSYPE1 is now better known as Next Steps to distinguish it from the LSYPE2 study which was started in 2013 (Lessof *et al*, 2016). LSYPE2 also used a cohort of 14-year olds, who were thus born around the year 2000 and are interviewed annually. LSYPE2 is now called 'Future Steps' to distinguish it from LSYPE1.

The Millennium Cohort Study (Connelly & Platt, 2014) also started in 2000 with a sample of newborns and interviews about 18,000 cohort members every 2-3 years. LSYPE2 and the Millennium Cohort Study thus cover a very similar population, but the LSYPE2 study was recruited about 14 years after MCS started.

Growing up in Scotland is a study consisting of three cohorts of children (Parkes, Sweeting & Wright, 2016; Skafida, 2012). The first cohort was recruited between June 2004 and May 2005, first interviews were with families when the children were 10 months old, and after this annually. A second cohort was started in 2010-2011 with children being interviewed every two years. A third (child) cohort was started in 2005 sampling children about 3 years old, but was abandoned several years later. The Child Benefits register was used as a sampling frame for all cohorts.

The British Household Panel Study (BHPS) (Rose, Buck & Corti, 1991; Buck et al. 2006) was started in 1991 with about 9400 respondents in 5000 households, and was extended in 2008 with the Understanding Society study (Buck & McFall, 2012), which increased the number of households to 30,000 and respondents to 50,000. Every household member is normally interviewed every year using face-to-face interviewing, and in recent years often using self-completion (web) (Jäckle et al 2015). One of the major reasons for the increase in sample size was the urge to study small populations (such as ethnic minorities), or people who experience a particular event. For example, the estimated number of females within Understanding Society who give birth in a particular year is now about 500 based on the UK birth rate in 2017, and was only about 60 in the BHPS. This makes it possible to study these smaller groups in a much better way.

Apart from the birth cohorts, several other studies follow people with specific characteristics, or within a particular geography. The English Longitudinal Study of Ageing began in 2002 as a panel study of the English population over 50 (Steptoe *et al* 2012). It was sampled from respondents who had participated in the Health Survey for England (HSE) between 1998-2001. Respondents are normally interviewed every two years. ELSA included refreshment samples from HSE at several waves between 2002 and 2019.

The Hertfordshire Cohort Study (HCS) was initiated in 1998 as a cohort of people who were born in Hertfordshire between 1931-1939 and who were registered with a GP in Hertfordshire in 1998; these formed the target population. In the 1930s details of newborns were extensively documented in Hertfordshire, and later digitized to allow for study of infant circumstances on mortality. After it was found that mortality was linked to several factors early in childhood, a decision was taken to try to follow up those with a birth record and still alive in Hertfordshire. 3225 persons took part in the first interview. After this, cohort members were invited for several follow-up face-to-face interviews, and participated in different types of medical tests. (Syddall *et al*, 2005). Currently, children and grandchildren of the original study members are being studied as well. The HCS focuses on medical histories and issues. There are many other prospective medical cohort studies that do this, or have done this (e.g. the British Doctor Survey (Doll & Hill, 1956), Framingham Heart Study (Dawber & Kannell, 1958) and Nurses Health Study (Golditz, Manson & Hankinson, 1997)), and even more studies where groups of patients (e.g. cancer patients) are followed over time to study their lives post cancer-treatment (NIH, 2019). These studies often see patients of routine check-ups at hospitals, and their design is often guided by the number of people getting a particular disease at a particular hospital, or receiving a particular treatment. We therefore choose not to discuss these studies here in detail.

The Northern Ireland Longitudinal Study (NILS) is a data-linkage study, that has been carried out about every 10 years since 1981. It links record from the census to Health Card Registrations and then to administrative records on for example marriages, widowhood, births and deaths, and contextual data about the area where a person lives. The study is relatively large – it contains 28% of the population of Northern Ireland, but only contains register data. It does not collect survey data (O'Reilly *et al*, 2011). Scotland and England have set up similar studies, but these are relatively smaller in both size and scope.

Two further English panel studies focus on small geographical areas. The Avon Longitudinal Study of Parents and Children (ALSPAC) is a panel study that was started in 1991 with a sample of 14,500 babies (Golding *et al* 2014; Boyd *et al,* 2012). Particular about this study is that it samples newborns in the former county of Avon only, bringing advantages in fieldwork. Although this study was initiated as a cohort study, in recent years it has also been extended to follow babies born to any of the original sample members.

The Southampton Women's Survey (SWS) is a cohort study of babies born in the area of Southampton between 1998 and 2002 (Crozier *et al*, 2002; Baird *et al*, 2012). Unique to this study is the fact that it recruited about 2000 prospective mothers. After an initial interview, they were followed up when they became pregnant, and several interviews were performed during pregnancy. Children are followed up after birth about every 2 years. The SWS has been successful in interviewing the mothers, partly due to the fact that a local centre was set up, and the study recruited woman over an extended period of time. It is unique in that it studies mothers before birth, and then their newborns. There is considerable dropout of mothers and infants, but the study has interviewed mothers 8 times after birth, and has taken additional biomedical measures.

The United Kingdom has a particularly rich history of longitudinal surveys, but other countries conduct longitudinal studies too. Household Panel studies similar to the BHPS/Understanding Society exist in for example the United States, Germany, Australia and The Republic of Korea. Similarly, there are cohort studies of newborns in many countries, and even a European cross-national study (Cocchi, Giovinazzi & Lynn, 2019). Similarly, the Survey of Health and Retirement in Europe (SHARE) studies the over 50s with a panel study in more than 25 European countries.

**Differences in designs between the various longitudinal studies**

Although every study is set up in its own way, there are particular aspects that many studies just discussed have in common, and issues that set them apart. There are fundamental differences that are important in designing longitudinal studies. Panel and cohort studies often deal with these issues in a different way.

1. <u>The population under study</u>
   Cohort studies aim to follow a specific population that is defined by geography and time. The last aspect is what sets cohort studies apart from panel studies. Birth cohorts typically define the population as all the newborns within a particular week/month. As babies grow older, the population theoretically stays the same, except when people die. People moving out of the UK would remain part of the population, and should therefore be followed[1]. Migrants moving into the UK are never part of the population. There is therefore no need for following rules, although it is

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[1] In practice people moving out of the population (e.g. abroad, or into institutions) are not followed in either cohort or panel studies. However, when members move back to the UK, they are part of the population again, and should be interviewed.

very important to keep track of where cohort members live. The data from cohort studies pertain to the population at the time the cohort study was initiated.

In panel studies, the aim is to represent the entire population. Data from the BHPS can be used to produce statistics of change for the household population of Great Britain in 1991, but also the population in 1999. To this end, different kinds of weights need to be produced to keep account of changes in the population and data. People moving out of the UK should typically be dropped from analysis at wave t when the aim is to represent the population at wave t. Similarly, migrants coming into the UK after the start of the panel, but before wave t should be incorporated, and so should adolescents who become of age (often 16 or 18). In order to accommodate dynamic populations and deal with entrants, there are two strategies that are used in practice in panel surveys to add sample members.

a. Refreshment samples are drawn to top-up the sample size. These refreshment samples can be drawn in ways so that they are likely to draw in recent migrants to the population (Lynn *et al*, 2018; Watson & Lynn 2020). Moreover, the refreshment samples can be designed so as to minimize coverage error only by including new population entrants, or additionally to correct for differential nonresponse. For example, if younger age groups are more likely to drop out, they can be sampled with higher probability provided that there is a sampling frame containing age information.

b. In order to use the panel for cross-sectional inferences, the panel needs to include younger age cohorts, who were too young to be sample members at the start of the panel study. Typically, this is done by including children of original sample members into the study by the time they become eligible (i.e. >16 or >18 years of age) (Smith, Lynn & Elliott, 2009). There is a debate, especially in household panel studies, as to whether all children and temporary household members should be followed in situations where households form or dissolve over the course of the study. If all household members are followed, and new household entrants (e.g. someone moving in) are followed as well, the sample can in theory expand. Theoretically, people who live within households that change often have a larger chance of becoming a panel member. Schonlau & Watson (2011) find however that those people are also more at risk of attrition, and in practice, the rate of attrition outweighs the rate of new sample members being added by following rules. Best practice is to at least follow children born to any female original sample members (Smith *et al*, 2009).

2. <u>The topics under study</u>

All longitudinal studies typically tend to be interested in measures of change, and so a key characteristic of the questionnaires used in longitudinal studies is that the topics, and even the question formulations are stable over time. There are however some differences between panel studies and cohorts.

Because cohort studies follow a homogeneous age group, it is easier to design a questionnaire that is relevant for respondents. For example, a birth cohort that would design a questionnaire for measuring children at age 12 could focus on the transition to secondary school, the onset of puberty or within-family relationships. At age 18, the questionnaire could focus on any further education, entering the job markets, and relationships. Panel surveys on the other hand, study a heterogeneous age group, and so the questionnaire needs to be more generic. At the same time, panel surveys offer the ability to inform policies by providing a picture of society at a specific period of time. Because of this, panel studies are better able to answer short-term policy challenges. Cohort studies on the other hand are better able to study the life course of a particular cohort of respondents.

3. Sample design and size

   For an overview on possible sampling designs for a longitudinal study, please see work package 6. Because cohort studies are homogeneous in terms of age, they are superior to panel studies when it comes to studying specific periods of the life course (such as infancy). Panel studies do contain much smaller samples per age group, but allow the study of age differences, and with time, they do collect larger samples of particular age cohorts (measured in different periods). In this section, we focus on two sampling issues particular to either a panel survey or a cohort survey

   a. When a panel is seen as a collection of separate cohort studies, one way to recruit a new cohort is by boosting the sample of a particular age group or age groups. How sample members should be sampled depends on the particular age group that is to be followed. A challenge to such a design would be how following rules should be designed. A cohort design would typically not add any refreshments or population entrants, but panel studies typically do.

   b. In cohort studies, there is the question whether a sample should be nationally representative or not. As panel studies are used for both longitudinal and cross-sectional inferences, it makes sense to ensure that the panel is UK-representative. For cohort studies, it is less clear that this is the case. In principle, it is of course always a nice idea to be UK-representative, but some successful recent cohort studies, such as the SWS have been successful partly because they have been concentrated in a small geographical area. It is then much easier to coordinate fieldwork, to get and stay in touch with sample members, or with parts of the health system that may be used in sampling and following sample members. The choice between a nationally representative sample, a (purposive) cluster sample, or even a quota sample is elaborated upon in work package 6.

4. The spacing of waves:

   *Time* plays an important role in all longitudinal studies. Cohort studies start with a sample that is homogenous in terms of *cohort* and *period*, and so the primary object of study is the effect of *age*. Panel studies are not homogeneous, and so generally are interested in studying change related to both age, period and cohorts.

   In cohort studies, consecutive interviews are often spaced multiple years apart. In practice, we see that the UK cohort studies have used slightly different designs. Some cohort studies measure about every 5 years, while other cohort studies measure about every two years. In all cohort studies we see that the spacing of waves is not equal. Often this has to do with the fact that financing of cohort studies is often on a wave-by-wave basis, meaning that waves of data collection have to be postponed when no funding is available. There are also important substantive reasons why spacing between waves may be unequal. If one is interested in occupational trajectories for example, it makes sense to measure more often in life stages where people are likely to go through important periods of change (e.g. between age 18-30). When one is interested in health, it may be important to measure more often in periods that are important for health development (e.g. at younger and older ages), and measure less frequently when health is relatively stable (between ages 20-50).

   Many panel studies collect data annually. Understanding Society is an example of such a study, but most other household panel studies follow a similar design (Wooden & Watson, 2007). Some panel studies collect data more frequently. The SIPP collects data on the same respondents every four months, while the Dutch LISS Internet panel does so every month. Many national labour force surveys collect data quarterly using a rotating panel design (Eurostat 2012, U.S. Census Bureau, 2009). Collecting data more frequently increases the organizational demands of running the panel survey. Checking and editing data in time to feed it forward for the next wave, whether

for the purposes of dependent interviewing or sample management, is more challenging the shorter the time available for the task. When more frequent data are needed, calendar instruments (Glasner & Van der Vaart, 2009) can be used to complete details of events that occurred between waves. Panel studies often want to date changes in household composition, occupation and income to an exact month. Even better is the use of administrative data in a prospective way. In many countries in Europe, administrative data such as tax and employment records can be used to track sample members over time (Lynn, 2009). In those cases, interviews are mainly held to understand why those changes did occur, and document changes that cannot be inferred from records

An important design decision related to the spacing of waves is the mode in which surveys are conducted. Both panel studies and cohorts have historically used face-to-face (CAPI) interviewing. Interviewers are particularly good at finding respondents, and ensuring respondents participate in waves of the study. Especially when bio-medical data need to be collected as part of the longitudinal study, interviewers can encourage respondents to participate, and help to take the bio-medical measures in a good way. A disadvantage of using interviewers is the fact that they may affect measurements, leading to interviewer effects, and the large impact they have on the costs and planning of fieldwork (Davies *et al* 2010). In more recent years some of the cohort studies (e.g. MCS) and panels (e.g. Understanding Society) have started to use self-administered interviewing through the web as an alternative to Face-to-face interviewing. One of the key advantages of using web interviewing is that fieldwork periods can be dramatically shortened. Another possible advantage is that the Internet opens up new possibilities for measurements.

Since about 2005, a large number of probability-based Internet Panels were founded that interview the same respondents every 1 or 2 months (Scherpenzeel, 2011; Blom *et al* 2015). Most of these panels are primarily designed as a data infrastructure to collect cross-sectional data, but all of them periodically ask the same questions to respondents, so that change can be measured. More recently, the advent of mobile phones, and experience sampling allows for the collection of even more frequent data. In experience sampling (also called Ecological Momentary Assessment), respondents receive multiple very short questionnaires at random times of the day, enabling the study of change (for example in mood) throughout the day. A possible downside of collecting data very frequently, is the occurrence of panel conditioning effects (Warren & Halpern-Manners, 2012). Just asking panel members about a topic frequently will affect both the way they respond to questions, and possibly their real behaviours and attitudes. This is one important reason why labour force surveys, and several other panels surveys have implemented a rotating panel design.

The transition of longitudinal surveys from face-to-face to Internet interviewing opens opportunities to ask questions more frequently, possibly to a subset of respondents who are of particular interest (e.g. those transitioning to a new job). There are currently few or no longitudinal studies that routinely use techniques like Experience Sampling, despite the fact that in the methodological literature, such Measurement Burst Designs have been suggested for some time (Sliwinski *et al* 2008). One reason for this is that it is operationally complex to combine regular interviewing at long intervals with such measurement bursts using new technologies. There are also open questions about the potential effects of using such designs on nonresponse error due to dropout, or how data should be integrated and analysed. There are also questions on how between wave procedures for staying in touch with respondents should be adapted.

**The analysis of cohort and panel data**

In all longitudinal studies, the main aim is to measure change in time. Change can be measured as the difference between two consecutive measurements on the same dependent variable. Longitudinal studies therefore need to collect at least two measurements before meaningful (longitudinal) analyses can be conducted. For example, in household panel studies, the effects of divorce as an event that occurs between two interviews can be studied by comparing the outcome measure (e.g. income) before and after the event, comparing those who experience a divorce with those who don't.

In both academic research and research for informing policy, longitudinal data become more valuable when more measurements are taken. For example, the effects of a divorce may have a different effect on income in the short term than in the long-term. An initial decline in income after a divorce may be temporary, or permanent. Collecting three (or more) waves allows policy makers and academic researchers to estimate the nature of change. This implies that the value of longitudinal studies increases with time. Cohort studies especially may take many years to become valuable for policy makers.

Missing data is potentially a large problem in longitudinal studies. When either of two measurements is missing, it becomes impossible to estimate rates of change. Therefore, maximizing participation rates remains of paramount importance for longitudinal surveys. Although Web-based interviewing can generate high response rates in mature panels (e.g. Understanding Society), it is still unclear whether self-administered interviews can generate high response rates in the recruitment or during the first waves of a longitudinal survey. More research is needed here.

**Analytical strategies**

A large difference between cohort and panel studies is the spacing of waves, that has to do with the difference in substantive focus between the two panel studies. Whereas cohort studies aim to explain the effect of age on the life course, panel studies have more generic aims to monitor both change and take a cross-sectional snapshot of the entire population. In fact, a panel study can be thought of as a combination of a series of cohort studies. The Millennium Cohort Study contains a cohort of approximately 14,000 people who are all about 20 years old. The panel study Understanding Society consists of about 90 cohorts (there are few people over age 90 in the panel), with each cohort consisting of about 450 people on average. Aside from the differences in the spacing of waves, the data structure of cohort studies and panel studies is similar when data are collected longitudinally. Table 1 shows a hypothetical design for both a cohort or panel study of children in their transition to adulthood. For illustrative purposes, let's assume that we can sample 10,000 students, and that we interview them annually, and that we would use the same questionnaire in the cohort and panel study.

A traditional cohort study would start by recruiting 10,000 students at the start of secondary school. This is cohort 1 in table 1. The 10,000 students are followed for 6 years, spanning ages 12-17. A panel study of secondary school students would split the total sample size by year of school, reflecting the total size of the population in each age group in the population. Imagine for example, that the panel study includes 2,000 students each for ages 12-15 at lower secondary school and 1,000 students doing their A-levels (ages 16 and 17). There are now 6 cohorts (defined by the year of secondary school), that are each followed for 6 years as well. The panel study is more challenging to conduct operationally. After the first wave, some students will move from secondary school to another school or work, making it harder and more expensive to conduct fieldwork successfully. The cohort study

that follows the 12-year olds faces fewer problems while the children all attend secondary education. After this, tracking of children becomes an important and time-consuming task, as in panel studies.

In year 1 of the study, the cohort study will have collected 10,000 interviews with 12-year olds, allowing differences within the cohort of 12-year olds to be studied. For example, we can study how differences in gender, the relationship with parents, and socio-economic backgrounds affect school grades in year 1 of school. In the panel design, we will only have collected 2,000 interviews among the 12 year olds. The smaller sample size will make it harder to obtain precise estimates in the panel study for year 1 of school. An advantage of a panel study is however that after year 1 of data collection, we already have information about school grades at different ages. We can now study differences in school grades across ages.

*Table 1: hypothetical structure of a cohort/panel study, depicting average age at interview*

| Year | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 |
|------|--------|--------|--------|--------|--------|--------|
| Cohort 1 | Age 12 | 13 | 14 | 15 | 16 | 17 |
| Cohort 2 | Age 13 | 14 | 15 | 16 | 17 | 18 |
| Cohort 3 | Age 14 | 15 | 16 | 17 | 18 | 19 |
| Cohort 4 | Age 15 | 16 | 17 | 18 | 19 | 20 |
| Cohort 5 | Age 16 | 17 | 18 | 19 | 20 | 21 |
| Cohort6 | Age 17 | 18 | 19 | 20 | 21 | 22 |
| | | | | | | |
| Panel: new entries | | x | x | x | x | x |

After 6 years of data collection, these stark initial differences between what panel and cohort study data allow us to study diminish. After 6 years, the cohort study will allow a detailed study of change at the individual level of 10,000 students between the (average) ages of 12-17. The advantage of this design is that the effect of age, and moderators of the age effect can be studied for the entire group of 10,000 students. A disadvantage is the fact that the cohort can only study change among a relatively small age range, and that it cannot study any differences between cohorts.

In the panel design, the data will span a larger age range. After 6 years of data collection, data will be available for ages 12-22. The initial disadvantage of having a smaller sample size at every age is at least partially fixed: there are now 10,000 measurements taken at ages 17 and 18. At age 12 the sample size is however still only 2,000, and for age 22 we only have 1,000 interviews. The panel study does allow the study of age effects as well as cohort effects, although the statistical analysis methods that are required to do this are more complex than for a cohort study design (Miyazaki & Raudenbusch, 2000). There are also longitudinal designs that would allow the separation of period and age effects (the so-called time-sequential design), but this design is less focused on measuring change, and so is not discussed. For an introduction to such designs, see Adam (1978).

Until now, we have contrasted panel designs and cohort designs as the two principal ways to design a longitudinal study. We have briefly discussed rotating panel designs as a specific type of panel study that is time-limited in nature. There are however cohort designs that have borrowed some design features from panel studies: the accelerated cohort design.

**The accelerated cohort design**

An accelerated cohort design is a cohort study where multiple cohorts are followed simultaneously. This design was originally labelled a "convergence design" (Bell, 1953, 1954) and is also known as a cohort-sequential design (Nesselroade & Baltes, 1979). Using Table 1 again as an example, a possible accelerated cohort design could not only follow Cohort 1, but also choose to follow Cohort 4. A combination of these cohorts will generate a broader age-range within the resulting data, and allows for the study of cohort effects, as long as the two cohorts overlap. In the example above, the two cohorts followed in the accelerated cohort design overlap in that they both at some stage interview adolescents at ages 15-17. Differences between the cohorts at those ages may indicate a cohort (or period) effect.

An important issue in accelerated cohort designs is how many cohorts to start with, and how much overlap there should be between the cohorts over the course of the study. The more cohorts one follows, the more closely the design will resemble a panel study. If all 6 cohorts are followed, one often speaks of an unstructured cohort design (Galbraith, Bowden & Marden, 2017). Such a design still differs from a typical panel study, as panel studies would allow new entrants into the study (e.g. immigrant children). The more cohorts are followed, the greater the overlap in age ranges across cohorts, and the easier it is to study cohort effects. The disadvantage is again that the statistical power per cohort decreases (see also work package 6).

An important criterion in choosing whether an accelerated design is useful, and if so, how the study should be designed, is the proposed duration of the longitudinal study. In cohort studies, the length of the study is limited by the fact that everyone in the sample ages. For example, the average age of members of the 1948 NSHD is currently 71. In about 30 years, the sample size will be close to 0 because of mortality. Panel studies in theory can run endlessly. For example, the 1968 PSID now interviews a lot of the children and grandchildren of original sample members annually, as well as the original sample members themselves (Hill, 1992).

In practice, the duration of longitudinal studies is guided mostly by the availability of funding. (Birth) cohort studies are typically financed on a wave-by-wave basis. If funding is not available at a particular point in time, waves of data collection are simply postponed until funding is available. Panel studies rely more on regular, annual interviewing, and so are often funded for multiple waves at a time. A problem for accelerated cohort designs is that they can only be efficiently designed if one knows that the study will run for a particular number of years. In the example, an accelerated cohort design following cohort 1 and 4 will work well when 6 waves of data are collected, each 1 year apart. If the same study ran for only 3 years instead of 6, there would be no overlap between the different cohorts, and it would be impossible to estimate either age- or cohort effects.

Possibly for this reason, only a minority of cohort studies use an accelerated design. A famous example of an accelerated cohort design is a study of alcohol use among 9, 11 and 13 year olds across 4 years in the United States (Duncan, Duncan & Stricker, 2006). There are many accelerated cohort designs studying small cohorts (e.g. schools (Cole et al, 2003; Terry-McElrath & O'Malley 2011)) or geographical areas (e.g. The Denver Youth Study (Huizinga et al, 1994)). More recent examples in larger population include for example the German ageing survey (Klaus et al 2017) or the Dutch Youth cohort study (Utrecht University, 2019). The United Kingdom has so far used an accelerated design in the Growing up in Scotland Study.

**Implications for the UK longitudinal data infrastructure**

The UK is well served by its existing infrastructure of longitudinal data, partly because some studies have been running for a long time. The current longitudinal studies landscape has resulted from a series of decisions, and while these have included elements of system design, at least including an assessment of the needs for continuing and new investment and how these fit with the existing surveys, they have also been subject to the vagaries of the availability of funding and operational considerations (for example the operational challenges and low recruitment which resulted in the early termination of the Life Study (Dezateux et al. 2016)). Some thoughts on the design of the whole system of longitudinal studies are included in WP0 (Smith 2019). Here we focus more specifically on the specific choices around the use of cohort and panel surveys.

There are three types of analysis that are afforded by longitudinal designs – the effects of age (examined by considering how respondents within cohorts change as they get older), the effects of cohort (examined by comparing different cohorts at the same ages) and the effects of period (examined through changes in multiple cohorts at the same time). Inasmuch as a panel survey can be treated as a series of small cohorts (see above), it supports all of these types of analysis. Typically, however, the cohorts within a panel study provide only a small sample size, even for the whole population, and this means that the characteristics and relationships in small populations will not be well estimated. One option is to turn to statistical methods to make the most of the available data.

**Suggestion**: Ferrante & Pacei (2004) provide approaches to small area estimation in a rotating panel survey, but further extension to borrow strength in different ways to improve estimates for (for example) individual cohorts could provide a framework for getting the best out of datasets having restricted coverage of target populations.

But small area estimation only offers so much in compensating for small amounts of data, and in order to have a strong evidence base it is preferable to have a greater quantity of directly relevant data for the subpopulations of interest. Therefore a collection strategy is needed. Panel surveys provide information about the population in general, and therefore provide a solid foundation for analysing the effects of age and period (the latter particularly because of the relatively frequent data collections). However, they provide small information on (tightly defined) cohorts, and particularly so when these are subsetted by other characteristics of policy interest (for example ethnicity, worklessness).

Cohort studies are designed to provide this detailed information. In essence they sample a particular cohort (from the range of cohorts implicitly present in a panel survey), and then use the full resources of the study on this cohort. This allows a sufficiently large sample to ensure adequate representation of small populations. The other advantage of cohort studies is the ability to concentrate on relevant life events and to ask a more detailed set of questions. The major disadvantage of such designs is the length of time required for them to produce the required analytical data. As described above, accelerated cohort designs provide an intermediate position with the best points of both approaches, but it is important in realising their potential that they do achieve the continuity with which they are designed – particularly continuity of funding for long enough to realise the planned overlaps is essential.

One of the challenges of cohort studies is the additional prospects for detail that they offer. This leads to a risk that many topics are proposed, particularly near the beginning of the study when there is a desire to collect as much baseline data as possible so that analyses of later developments can be related to conditions at the beginning of the study. Life Study (Dezateux et al. 2016) included several

innovative data collections of this type. However, this is also the critical recruitment phase where the most important objective is to get sufficient numbers of people recruited, so the burden of participating in the survey needs to be managed. If there is a real need for data collection to provide detailed baselines during pregnancy and birth, then consideration should be given to splitting the data collection over participants. This may argue for a larger overall sample size so that each of these data collections separately provides an adequate sample size for analysis. This type of approach could similarly be implemented over a number of cohort studies if they are scheduled at regular intervals as part of a comprehensive longitudinal data infrastructure.

Therefore a cohort study provides data to support detailed analyses which would not be available from the more general approach of a panel study. Cohort studies should be part of the UK longitudinal data landscape, and a regular pattern of cohort studies would improve the possibilities for spreading topics across successive studies (to manage respondent burden, particularly in recruitment). It would also simplify cohort analyses if cohorts were introduced at regular intervals. This approach relies on continuity of funding; an agreed programme might provide some additional assurance of the continuity of fiunding, but it is clear from history that changes in government finance can have significant impacts on such large investments.

**Conclusion and Recommendations**

The UK has a rich history of longitudinal studies. Although the studies are all unique, many studies share design aspects. Birth cohort studies have been important data sources for research about determinants of the life course among cohorts born in the 1940s, 1950s, and cohorts born around 1970, 1990 and 2000. Since 1991, a large panel study of the general population has operated with the twin goals of tracking households over time, and informing policies at any particular moment in time. Finally there are a number of issues that in our view require further study, or an explicit decision before a future longitudinal study can be designed. These are:

1. What is the population under study? This decision is relevant both in terms of the age-range to be covered by the new study, and the geography. If the study is to be UK wide, it becomes harder to use some of the local circumstances (e.g. administrative data of the devolved governments). Related to this choice is whether the study should be nationally representative, or whether it can consist for example of multiple local cohort studies.
2. What are the topics under study? What should the focus of the study be? Should it be a study primarily focusing on the life course? On generational differences in health and lifestyles? On something else?
3. How long will the study run for? Accelerated cohort designs can potentially combine the best of both panel and cohort studies. They come at the price of having a more complicated data structure, making it harder for researchers to analyse these data. And more importantly, they only work once considerable overlap in terms of the age range covered is established between the cohorts. Whether an accelerated cohort design is feasible therefore depends mostly on whether a commitment can be made to fund a study for at least the period of time to achieve this overlap.

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