



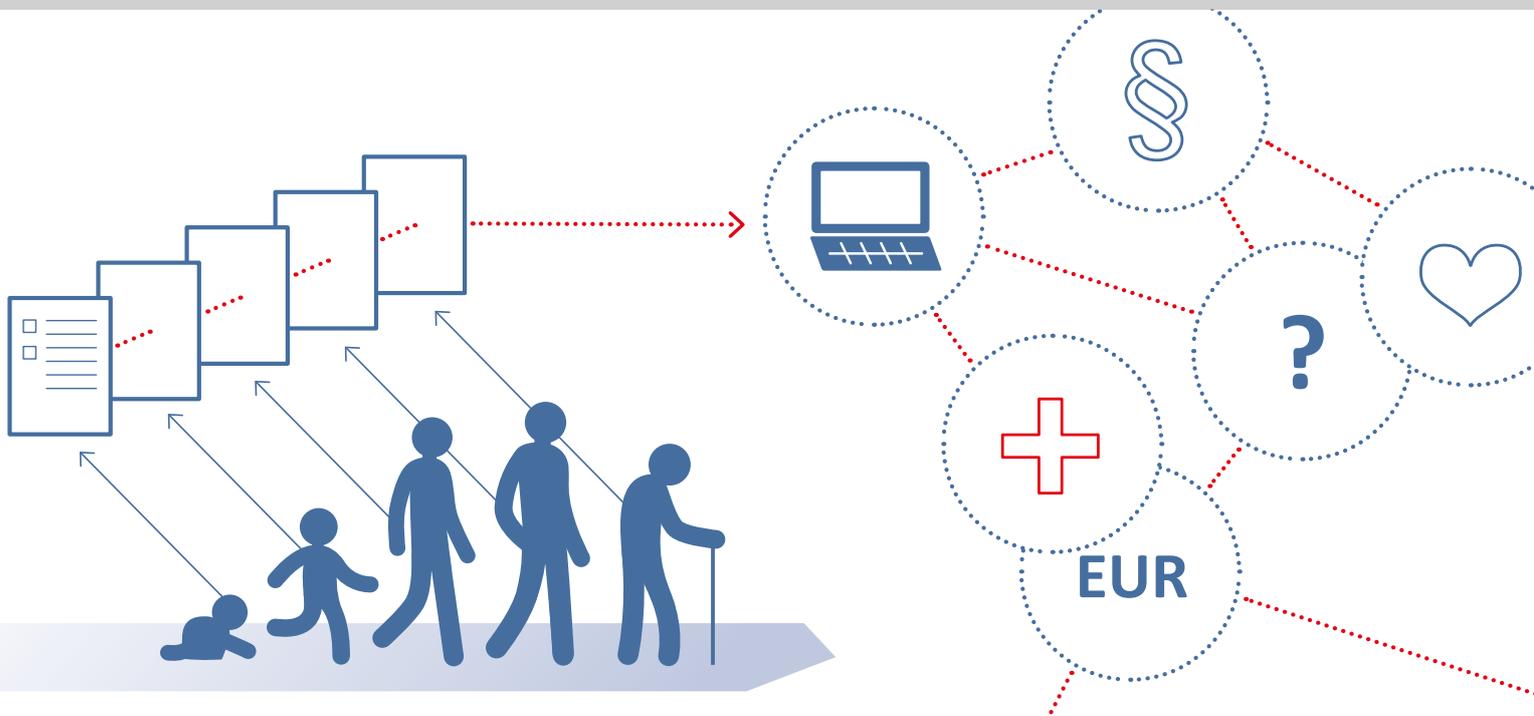
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The relevance of population-based longitudinal studies for science and social policies



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Preface

Political and social players require reliable data as a basis for decisions and to verify the effectiveness of activities and measures – for instance regarding the occurrence of common diseases or the development of individual educational biographies. By repeatedly observing the same group of people over a long period, population-based longitudinal studies can provide precisely such data.

In their jointly published statement “The relevance of population-based longitudinal studies for science and social policies”, the German National Academy of Sciences Leopoldina, the Union of the German Academies of Sciences and Humanities and acatech – National Academy of Science and Engineering wish to take stock of the current situation and provide recommendations for the future development of longitudinal studies and the infrastructure required for these purposes.

We would like to express our sincere thanks to the authors who prepared this paper in numerous sessions over the past two years as well as to the reviewers for their contributions and efforts. The Academies hope that this statement may provide political and social decision-makers as well as anybody concerned with a sound overview of the relevance of population-based longitudinal studies.

Halle (Saale) and Berlin, April 2016



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1 Executive Summary

Population-based longitudinal studies form the backbone of empirical research in the social, economic and behavioural sciences as well as in epidemiology and health research. As “large-scale instruments” in these fields of science, they serve to test theories and make new observations, while also constituting the basis for evidence-based policy advice.

Such large-scale instruments or indeed “research infrastructures” are extensive and complex research instruments with an at least national, if not international relevance for the respective fields of science. They are intended for long-term use (without striving to thwart scientific creativity), and are available to a large number of users, mainly for scientific purposes.

Germany has increasingly promoted population-based longitudinal studies in the past few years. Due to structural barriers in the research funding system and to the lack of harmonisation of data collection and analysis along with shortcomings in the necessary interdisciplinary education and training, Germany is nevertheless struggling to keep pace with global research excellence. Against this background and drawing on a stock-taking of the current situation as well as pioneering international expert knowledge, the present statement aims at providing recommendations for the structure of research funding and the harmonisation of future research efforts.

Population-based longitudinal studies are indispensable for the world of research and for society due to three major functions:

Firstly, human societies are subject to constant change. Longitudinal studies enable the documentation of both stable patterns and changes over time as well as the identification of new trends and the analysis of links between socioeconomic and biomedical mechanisms.

Secondly, population-based longitudinal studies that examine the same individuals repeatedly over time are, under clearly defined conditions, ideal to test hypotheses about cause-effect relationships. This is usually not possible with administrative and process-generated data (“big data”).

Thirdly, model-based forecasts of potential future developments can be derived from many of these analyses. This prognostic knowledge provides important guidance in social, economic and health policy decisions.

The relevance of population-based longitudinal studies with multi- or interdisciplinary survey programmes in the above-mentioned fields of science results from the fact that the experimental methodology prevailing in the natural and life sciences is of very limited use for the study of processes at population level. Hence, the social, economic and behavioural sciences as well as epidemiology and health research (in short: social and health sciences) exploit the great variety of biomedical, personality-related and socioeconomic factors within a population and their changes over time. They use theory-based statistical analyses to identify causal relationships and to make projections. Examples are: the assessment of

the care and nursing requirements of an ageing population; evidence on positive effects of educational investments on an individual's lifelong health; the quantification of the influence of social class on life expectancy. The pioneering insights of birth cohort studies testify to the success of this research strategy. They allow for the analysis of biomedical and socioeconomic processes over an individual's life course. These studies also show the importance of a long-term perspective, since the value of longitudinal data increases exponentially with the number of study waves.

On the one hand, the working group agrees that Germany as a research location is fortunate to have a diverse as well as intensely and widely used landscape of population-based longitudinal studies which also compares well internationally. This includes, for instance, the *Socio-Economic Panel* (SOEP), the *National Educational Panel Study* (NEPS), the *Panel Analysis of Intimate Relationships and Family Dynamics* (pairfam) as well as several epidemiological cohort studies along the lines of *Multinational Monitoring of Trends and Determinants in Cardiovascular Disease* (MONICA)/*Cooperative health research in the Augsburg region* (KORA) and, in particular, the recently initiated *National Cohort* (NAKO). Germany is also involved in a number of internationally comparative studies, such as the cross-sectionally replicative *European Social Survey* (ESS) and the longitudinal *Survey of Health, Ageing and Retirement in Europe* (SHARE). Finally, Germany has a considerable number of well-qualified graduates in the relevant fields of study as well as a large pool of academic staff.

On the other hand, the working group finds that this potential is currently not sufficiently exploited. Knowledge potentials remain untapped for three reasons: firstly, the existing financial and organisational infrastructures (e.g. funding instruments) suffer from contradictions

and shortcomings that hamper the sustainability of population-based longitudinal studies. This also holds, secondly, for the intellectual infrastructure (for example, education and training). Thirdly, social science and biomedical research approaches are insufficiently linked and coordinated at virtually all levels.

Therefore, the central aim of this statement is to provide key elements of a long-term and coordinated promotion strategy for population-based longitudinal studies. This should complement and improve the currently prevailing short-term planning and ad hoc management in a number of financially and organisationally inadequately equipped institutions. In addition, biomedical and socioeconomic contents should be combined better in research and education.

A need for action is indicated first of all with regard to the funding instruments and the career opportunities for senior employees. The working group considers such measures to be primarily the responsibility of the German Federal Ministry of Education and Research (BMBF) in cooperation with the non-university research institutions and the German Research Foundation (DFG). Similar to the large-scale facilities in the natural sciences, the research infrastructures in the social, behavioural and health sciences are dependent on long-term stable funding and supervision by senior staff members. However, in contrast to the natural sciences, this fact has hitherto been inadequately recognised in the social, behavioural and health sciences. Firstly, therefore, instruments should be created that will allow for long-term funding (e.g. scheduled funding extensions). Secondly, management staff of major research infrastructures should be able to acquire the relevant skills and to aspire to defined career paths (e.g. tenure track for senior study staff or jointly appointed S-Junior professorships, a German form of junior

professorship). Currently, both are not the case for many population-based longitudinal studies.

The working group is aware of the inherent tension between creativity and stability. The group therefore continues to advocate a decentralised approach which restricts neither the creativity of new initiatives nor scientific innovations within already successful infrastructures. However, every already established population-based longitudinal study requires a stable financial base complete with relevant funding instruments, allowing for its continuation and further development on the basis of repeated evaluations (as has, for instance, been successfully established with the Leibniz Association's seven-year evaluation rhythm).

Action is likewise indicated with regard to universities and non-university research institutions. The current education and training programmes are deficient in several aspects. For one thing, only few locations offer a targeted training of methodological skills in the core subjects of this field of research; this is true both for undergraduate and postgraduate programmes. Furthermore, there exist no training programmes for transdisciplinary research cooperation, in particular for young researchers from the biomedical and the socioeconomic sciences who can be indispensable for obtaining innovative insights. There is also an appalling lack of coordination between the curricula of biomedical and socioeconomic studies, so that frequently, no comparable data can be generated and instructive synergies consequently remain unrealised. Finally, training opportunities in survey management are scarce.

The working group specifically recommends the following (cf. chapter 6):

1. Launching a national funding initiative in order to strengthen interdisciplinary cooperation in the implementation of population-based longitudinal studies, in particular between the biomedical and socioeconomic sciences.
2. Creating such support instruments as will allow for an essentially unlimited continuation of longitudinal studies while ensuring their verifiable quality. This includes the classification of infrastructure and survey costs as construction costs and their appropriate categorisation in the national research budget.
3. Improving coordination between the European and the German roadmaps for research infrastructures.
4. Providing resources for the documentation, communication and linkage of longitudinal data.
5. Establishing career paths comparable to tenure-track professorships, offering senior staff permanent contracts with remuneration up to the level of W2 professorships.
6. Expanding the advanced training programmes in research and project management for senior study staff.
7. Developing the skills of junior researchers in the field of population-based longitudinal studies by establishing doctoral programmes and post-doctoral training.
8. Meeting the increasing need for qualifications by teaching relevant knowledge and skills in master and post-graduate programmes.

2 Background and objective of the statement

In Germany, substantial research policy investments are made in population-based longitudinal studies¹ such as the *Socio-Economic Panel* (SOEP), the *National Educational Panel Study* (NEPS), the *Family Panel* (Panel Analysis of Intimate Relationships and Family Dynamics – pairfam) as well as in several epidemiological cohort studies along the lines of *Multinational Monitoring of Trends on Determinants in Cardiovascular Disease* (MONICA)/*Cooperative health research in the region of Augsburg* (KORA) – in particular the recently initiated *National Cohort* (NAKO) (cf. the summary table in chapter 4 and the detailed table in appendix 1). Germany is also involved in internationally comparative longitudinal studies, such as the *Survey of Health, Ageing and Retirement in Europe* (SHARE). These population-based longitudinal studies are of great significance in the social sciences, economics, the behavioural sciences, demography as well as epidemiology and health research, since the experimental methodology prevailing in the life and natural sciences is of very limited use for the study of processes at the population level.

Population-based longitudinal studies fulfil three important functions: for one thing, human societies are subject to constant change, for instance due to changes in the population structure, technological and economic developments, as a result of institutional reforms, social movements or political conflicts. With longitudinal studies, these changes can be documented and analysed over time. Furthermore,

population-based longitudinal studies that examine the same individuals repeatedly over time can be used, under clearly defined conditions, to test hypotheses about cause-effect relationships. The information thus obtained is particularly significant with regard to a number of basic socio-political areas, e.g. early childhood development, personal development, educational and professional success, the distribution of income and wealth, the development of diseases, health preservation and ageing. It is therefore not surprising that these issues are the subjects of most longitudinal studies around the world. Thirdly, many of these analyses allow for prognoses as to possible future developments. This prognostic knowledge provides important guidance in social and economic policy-planning and decision-making.

Population-based longitudinal studies are ideal for obtaining these results because they reflect the wide range of biomedical, behavioural and personality-related as well as socioeconomic factors within a population and the interaction of these factors over the course of an individual's life. At the same time, they can provide “reference populations” for more specific studies that have particularly restricted samples (e.g. limited to a certain region, examining only twins or taking into focus only persons in need of assistance, such as children from educationally disadvantaged homes).

Process-generated data sets (“big data”) will not be able to replace population-based longitudinal studies – certainly not in the foreseeable future and probably never at all. Process-generated sets of data typically cover a very narrow-

¹ Technical terms are explained in the glossary.

ly defined set of features. Even the most basic socioeconomic or health characteristics, such as the level of education, are inadequately covered or missing altogether. Furthermore, the household context is usually not included. This is due to the commercial origin and primary use of the data or, in the case of administrative data, to the legal provisions concerning its storage. In addition, “big data” is not governed by science’s hypotheses-based regulations. Finally, process-generated data sets vary strongly in terms of quality and standardisation requirements. They are often highly selective with respect to the population groups they include (e.g. customers of Amazon or members of the public health insurance scheme). Hence, as a rule, conclusions from such data cannot simply be generalised for the entire population or its relevant subgroups – even less so since switching between various sub-groups (e.g. customers vs. non-customers, members of the public insurance vs. privately insured individuals) is one of the most relevant subjects of analysis.

The official statistics can likewise not be a substitute for scientifically designed and conducted population-based longitudinal studies. To be sure, official statistics has not only provided the scientific community with a considerable amount of process-generated longitudinal data bases, but has also conducted its own surveys; these are either designed as longitudinal studies, e.g. the *European Union Statistics on Income and Living Conditions* (EU-SILC) or include longitudinal components (e.g. the micro census). However, not only is science’s access to the data often difficult, but the design and selection of variables frequently does not reflect the current scientific issues and requirements. This is not least due to the questionable decoupling of the official statistics from empirical social and health sciences, as became apparent during the implementation of EU-SILC.

Since population-based longitudinal studies are not limited to subpopulations and snapshots of a specific point in time, their implementation is a time-consuming undertaking tying up substantial resources. International experience has shown the chances of success for such a project to depend on a number of key conditions. These include a high level of scientific qualification amongst the study’s academic management and the continuous training and motivation of the employees involved, an effective distribution of work including reliable cooperative relations with partners, as well as reliable and secure long-term funding. The latter is particularly important with regard to the fact that the value of longitudinal data increases exponentially with the number of study waves and the length and quality of the follow-up.

Neither in Germany nor abroad do these conditions exist as a matter of course. There is a considerable discrepancy between the socio-politically significant potential insight gained from such studies and the available scientific, organisational and financial infrastructure which is needed to conduct these studies in a sustainable way, to repeatedly prepare and analyse their complex data structures in the face of newly emerging questions, and, finally, to publish the results in internationally high-ranking journals and communicate them in a meaningful way to decision-making bodies. Specifications regarding longer-term funding are frequently the result of ad hoc decisions and do not provide the necessary orientation and security. Furthermore, there are virtually no training courses in Germany for the management of large research infrastructures. Finally, in many subject fields there is either no communication at all of the required methodological expertise to students and young scientists or it is not given the necessary priority and lacks in quality.

In its *Recommendations on research infrastructures in the humanities and social sciences* in January 2011 and its *Recommendations on career goals and paths at universities* in July 2014, the German Council of Science and Humanities has addressed similar topics. In addition, the German Research Foundation (DFG) organised two relevant workshops: *Large Scale Studies in the German Social Sciences: Status and Prospects* (Kämper & Brüggemann, 2009) in March 2009 and *The promotion of social science surveys in the DFG's long-term programme – an interim report* in October 2014. Due to the above-discussed specificities, these observations and recommendations are particularly relevant to population-based longitudinal studies: they are more than commonly affected and threatened by the structural problems in the areas of funding, career paths and capacity expansion as identified by the German Council of Science and Humanities and the DFG workshops.

This statement therefore has a threefold aim: a) To outline the scientific, social and economic relevance of population-based longitudinal studies, b) to describe their current situation in Germany, and c) to recommend options on how, against this background, the development, conduct and analysis of population-based longitudinal studies in Germany can be ensured both qualitatively and quantitatively.

Specific goals are:

1. A more efficient and sustainable institutional framework should be established for longitudinal studies and their complex infrastructural, organisational and financial structures. In particular, Germany is lacking in stable long-term funding for many existing and indeed almost all newly-launched population-based longitudinal studies. The working group has drafted specific

recommendations for sustainable funding schemes.

2. Advanced training programmes for the management of large research infrastructures should be particularly promoted. Above all, Germany lacks “mid-career” training units for organisational and communication skills for the governance, management and financing of population-based research infrastructures. To this end, the working group has summarised the required work profiles, skills and relevant curricula (cf. appendix 2).
3. The methodological expertise in university education and training and the qualification of young scientists should be strengthened. This aims more particularly at a synthesis of previously disciplinary approaches in the social, behavioural, economic and health sciences/medicine in a common framework (e.g. multi-level models, longitudinal analyses, cross-country analyses, the combination of biomedical, geographical, economic, psychological and sociological variables, the analysis of gene×environment interactions). To this end, a curriculum showing relevant teaching content has been drafted along the lines of international models (cf. appendix 3).

Some members of the working group have initiated or are managing large population-based longitudinal studies. The experiences gained during the development of these studies (examples of which are outlined in section 4.4) form an important basis for the working group's recommendations.

Since such a statement cannot be written without the input from experts in the field, conflicts of interest are inevitable. Therefore, great emphasis has been placed on the involvement of international experts. Furthermore, the contributing Academies specifically pointed to the potential for conflicts of interest during the external reviewing process, asking for

a critical appraisal. This assessment was then duly taken into account by the working group.

Based on hearings with international experts as well as its own research, the working group has received a number of fundamental suggestions which are of interest to the organisation of the future development in Germany. These will be illustrated with specific examples.

This statement is structured as follows: Chapter 3 differentiates population-based longitudinal studies from other methods and shows their significance and practical use for science and society.

Chapter 4 presents the development of population-based longitudinal studies in Germany, giving a tabular overview of the most important current longitudinal studies including organisational and funding structures. In the process, the above-mentioned structural challenges become evident, which everybody at German universities and non-university institutions has to face who is currently conducting population-based longitudinal studies, is contributing to them and is using them for research purposes.

These structural challenges are presented in detail in chapter 5, structured according to the three areas mentioned above: firstly, challenges regarding the funding and organisation of population-based longitudinal studies; secondly, challenges regarding the further qualification of the employees in longitudinal studies, which implies improving, in particular, their methodological and management skills as well as their career paths; thirdly, challenges in the field of student education and the skills and capacity development of young scientists.

The evidence compiled and evaluated suggests that structural changes are necessary to address the challenges

outlined. Chapter 6 condenses these challenges into eight specific re-recommendations, addressed to the stakeholders from the scientific community and science policy arena.

Technical terms and abbreviations cannot always be avoided; they are explained in a glossary and a list of abbreviations. An overview of the ongoing population-based longitudinal studies in Germany as well as the key points of each curriculum for methodological and organisational training can be found in the tables in the appendix. A list of all researchers involved in the development of the present statement is likewise provided in the appendix.

The working group wishes to thank the participants of its three expert panels for their valuable suggestions regarding the issues of funding models, student training and advanced training in research infrastructures and for summarising their experiences in other countries.

We would also like to thank the Executive Committee of the German National Academy of Sciences Leopoldina, the members of its Standing Committee “Demographic Change” and the academic staff at the office who supported the working group. Dr Alexandra Schulz, in particular, was of valuable assistance in matters of editing and drawing up the glossary and the various tables. Further thanks are due to the staff of the Max Planck Institute (MPI) for Social Law and Social Policy, especially to Dr Thorsten Kneip, who supported the working group and supervised the chapters on career paths and professional training, and to Judith Kronschnabl and Dominik Steinbeißer for their research assistance and the supervision of the bibliography.

We would finally wish to thank the reviewers of this statement for their detailed comments and suggestions.

3 The relevance of population-based longitudinal studies for science and social policies

The object of this statement are population-based longitudinal studies of individuals and/or households. Their principal characteristics are (a) that the survey is conducted on the basis of a representative sample of the population, and (b) that these individuals or households are observed over an extended period of time. In order to ensure representativeness, samples are drawn in accordance with the requirements of the probability theory. This approach attempts to adequately capture the great heterogeneity of biomedical-socioeconomic interactions and their social embedding in a population.

In terms of content, population-based studies can cover the social environment, i.e. the totality of human relationships in a population that is limited in space and time. Social environments are characterised by the development of independent structural features and principles, the analysis of which is the subject of various scientific disciplines, in particular demography, sociology, psychology and economics.

Hence, *population-based* studies differ from case studies of selective groups of the population (e.g. patients with specific diseases, individuals purchasing certain goods or services) whereby the results of biomedical or socioeconomic processes determine the inclusion in a study. By using representative samples of the total population, chosen on the principles of the probability theory, these selection effects can be avoided.

From a methodological point of view, population-based *longitudinal studies* also differ from cross-sectional studies,

which record the data of a group of individuals at *one* specific point in time only, excluding reliable statements as to changes or possible cause-effect relationships. Nor do longitudinal studies correspond to repeated cross-sectional studies (replication studies). This survey method is, indeed, used for many official surveys (e.g. micro census) and social science surveys (e.g. the *German General Social Survey* – ALLBUS, or the *European Social Survey* – ESS). While it allows for facts to be documented in the same way over a period of time, it differs from the longitudinal approach in that the group of individuals is not identical.

Longitudinal studies in the strict sense involve the repeated questioning, examination and monitoring of a representative group of individuals from the population over an extended period of time, ideally spanning the respective persons' entire lifetime. The established term in demography and sociology is "cohort", designating an age group (i.e. those of a population born in the same year) which is the subject of prospective or retrospective examination, either from the time of birth or beginning at a later date. In addition to birth cohorts, research also resorts to marriage cohorts, education cohorts or labour market entry cohorts. In epidemiology, a cohort comprises those amongst a population recruited for the purpose of a new prospective study.

This statement focuses on prospective population-based longitudinal studies, i.e. studies in which surveys are conducted at regular intervals ("waves") over of an extended period, focusing on

the respective points in time (e.g. SOEP, pairfam). Retrospective studies were also partly taken into account, e.g. featuring interviews conducted within a birth cohort on living conditions in the past (for instance the *German Life History Study* – GLHS, the *Generations and Gender Survey* – GGS, or SHARE).

Prospective and retrospective longitudinal studies have complementary advantages and disadvantages. Retrospective longitudinal studies have to deal with the problem that at the time of the survey, mortality and migration will have taken their toll on the defined section of the population. The surveys may also be contaminated with memory errors (Kroh et al., 2015). Prospective studies, on the other hand, face the problem of a selective loss of participants as well as the occurrence of so-called panel effects, i.e. the influence of repeated data collection on the respondents' behaviour (e.g. learning effects). Some panel studies therefore resort to complementing their sampling during extended studies by newly recruited respondents ("refreshment sample") in order to secure statistical validity.

Population-based longitudinal studies have the decisive advantage of increasing our understanding of life processes, allowing for extensive advances in knowledge and applications, particularly at the level of each individual. The development of personalised or individualised medicine currently evolving in the field of health care is a case in point: it aims at individually customised prevention, diagnosis and treatment methods (Leopoldina, 2014a). In education, population-based longitudinal studies have traced the foundation for successes or failures in adulthood back to very early stages of childhood and adolescence. At the same time, they have revealed how decisively the natural and social environment can influence individual characteristics. It is hence recommended to extend the corresponding

research programme to the analysis of the connections between individual life courses and environmental conditions.

Population-based longitudinal studies offer a further important advantage by allowing for the analysis of the connection between certain causes and subsequently observed effects. From this, practical conclusions may be drawn. In order to prove such a causal relationship, certain scientific criteria were defined – above all, in the fields of econometrics and epidemiology – which must be fulfilled if a statistical connection between two consecutive features is to be interpreted as a cause-effect relationship. These criteria are comprehensively discussed in the statement *Public Health in Germany* published by the Leopoldina in 2015. In order to identify causal relationships, one exogenous dimension in particular should be considered: time, i.e. the temporal sequence of causal actions (exposure) and their results (effects); this adds to the epistemological significance of longitudinal studies.²

The impact of the two central attributes of population-based longitudinal studies – viz. the ability to appreciate phenomena as the result of the cumulative interactions between biological, behavioural and sociocultural influences and to identify causal relationships in these interactive processes – may vary according to the application area. Hence, the following sections show the relevance of population-based longitudinal studies in selected application areas.

² First attempts have been made to complement population-based studies with proper behavioural experiments (cf. e.g. Fehr, 2009; Dohmen et al., 2011; Vischer et al., 2013, and for an overview Keuschnigg & Wolbring 2015).

3.1 Relevance for early childhood development and its long-term consequences

Birth cohort studies are a particularly conclusive form of population-based longitudinal studies. First initiated some decades ago in the Scandinavian countries, the UK and the United States, such studies have yielded numerous new insights into the close interaction of genetic predispositions and development processes conditioned by environmental settings and experiences. Here, the epigenetic research methods recently introduced in the life sciences play an important role. Such studies are typically launched by recruiting a sample of infants who are representative of the population and were born in a specified period of time. This cohort is then examined in periodical waves over several years or, indeed, decades, using biomedical and/or behavioural and social science methods. In addition to established evidence on major risk factors for chronic diseases (Ezzati & Riboli, 2012; Ezzati et al., 2015), these studies have yielded fundamental results relating to the long-term effects of adverse conditions during pregnancy and early childhood on the physical, psychological and social development in childhood, adolescence and adulthood (so-called life course epidemiology) (Power & Kuh, 2006). According to the *latency model*, damages acquired early on (e.g. as a result of maternal malnutrition or drug consumption during pregnancy) will not manifest themselves until decades later in the form of diseases connected with early dysregulation (such as type-2 diabetes) (Barker, 1998). The *model of vulnerability* or of critical periods postulates that events occurring in a limited period of time during sensitive developmental stages have pathogenic, i.e. harmful or, as the case may be, protective effects on an individual's functional ability in later life. Pathogenic effects become apparent, for instance, in the correlation between early childhood trauma, the lack of

self-regulation skills and subsequent adjustment disorder (Caspi et al., 2005; Moffitt et al., 2011), whereas the psychological resilience of young people as a result of early childhood deprivation exemplifies the possible protective effects (Masten, 2013). Similarly, psychological life course studies (Baltes et al., 1995; Mühlhig-Versen et al., 2012; Voelcker-Rehage et al., 2011) have yielded ground-breaking results regarding the plasticity of cognitive and personality-related skills in old age. These findings have an immense bearing on our conception of the consequences of demographic change.

According to the *cumulative effects model*, certain behavioural disorders and diseases are a consequence of recurring stress situations which increasingly undermine an individual's coping mechanisms and resources (Graham, 2002; Viner et al., 2012). In the statement *Early Childhood Socialisation* recently published by the Leopoldina, the complex correlations of disposition, early developments and later cognitive, affective and motivational abilities, recorded by means of the models outlined, were comprehensively discussed (Leopoldina et al., 2014b). German studies have provided further findings in this field (Blossfeld, 2013).

Here, as in health research, the existing evidence as to cause-effect relationships is corroborated by intervention studies – in the medical field particularly by randomised controlled trials (RCTs), in the social sciences by field experiments. Preschool and school education initiatives for socially disadvantaged children, for instance, have yielded extensive results that are also relevant in terms of education and social policies (Heckman, 2006; Heckman et al., 2010; cf. also sections 3.3, 3.4 and 3.6).

3.2 Relevance for health and health policy

Despite ground-breaking research progress, the causes of widespread diseases are still not sufficiently clarified. This is particularly true for complex, multifactorial chronic degenerative diseases, which account for the bulk of the disease burden in modern societies. These include cardiovascular and metabolic diseases, almost all types of cancer, neurodegenerative diseases and mental disorders.³ In addition to basic biomedical research and clinical research, a third line of research is here required, viz. an epidemiological approach. *Epidemiology* analyses the correlations between the frequency and intensity with which certain characteristics assumed to be causes or risk factors of a certain disease are distributed among a section of the population, and the number of outbreaks of this disease in the subsequent observation period. These features can be genotypic or phenotypic characteristics of individuals as well as environmental conditions to which people are exposed over an extended period (so-called exposition).⁴ Usually, it is the combination of internal and external factors that will trigger an outbreak.

Population-based longitudinal studies are consequently of particular significance for epidemiological research. Based on these quality criteria, several longitudinal epidemiological studies have been conducted. The basic discoveries they yielded regarding causes as well as risk and protective factors of widespread diseases are recognised both in medical research and in health policy. This is true for the discovery of *genetic causes* of certain diseases (Bickeböller & Fischer, 2007) as well as for the proof that *unhealthy behaviour* has a significant bearing on the development of chronic degenerative diseases.

The *Framingham* study, for instance, conducted in the United States in the early post-war years, provides evidence that the classical risk factors hypertension, (cigarette) smoking and hypercholesterolemia increase the risk of heart attacks (Dawber, 1980; Kannel, 1988). The subsequent *Seven Countries Study*, while duly taking the classical risk factors into consideration, added proof of the negative impacts of dietary behaviour and other lifestyle factors (e.g. lack of physical activity) (Kromhout et al., 2002). These findings formed the basis for the development of important prevention strategies (Rose, 2008).

In terms of scientific progress and health policy developments, the essential findings regarding social determinants of chronic diseases and functional limitations are of particular relevance (Marmot & Wilkinson, 2006; Berkman & Kawachi, 2014; cf. section 4.3). Social inequality is a particularly convincing example. Following the lead set by the influential *Whitehall Studies* in England (Marmot et al, 1978; Marmot et al, 1991), a systematic correlation between social class (determined by the level of education, income and/or professional status) and the incidence of chronic diseases and premature death has by now been proven for the majority of European countries: the lower the social position, the higher the risk (Mackenbach et al, 2008; Gallo et al, 2012). Evidence of this social gradient of morbidity and mortality has been found in the German population, too. An extensive body of research results exists to explain this phenomenon. The bulk of these findings comes from population-based longitudinal studies, since they show causality working in both directions (Smith, 1999). The influence of critical socioeconomic and psychosocial conditions during pregnancy and in early childhood on health in later life is particularly well documented (Kuh & Ben-Shlomo, 2004). Extensive results have also been obtained with a view to the pathogenic effects that psychosocially

³ For an estimate of the corresponding disease burden in a global perspective cf. Mathers & Loncar (2006).

⁴ See Bonita et al. (2008) and Gordis (2008) as examples for textbooks of epidemiology available in German.

stressful working conditions and the lack of social integration can have on an individual's health in middle and advanced age (Siegrist & Marmot, 2006; Berkman & Krishna, 2014). Section 4.3 references recent results on these moderating psychobiological mechanisms.

Some of the above-mentioned risk factors bearing upon prevalent diseases will only lead to an actual outbreak of a disease if they occur in combination with genetic predispositions. Basic research is therefore particularly interested in gene×environment studies. Since the statistical associations between gene variants, which cause or encourage a disease, and the incidence of the corresponding disease, are usually very weak, large numbers of subjects are required to obtain reliable new results. The increased probability with which certain genetic variants (“alleles”) occur compared to their standard occurrence rarely exceeds a range of 5–30 per cent (Collins, 2004). The same applies to the correlations between certain gene variants and associated traits (“phenotype”). Two strategies are worth considering if statistical validity is to be ensured against the odds of the weak effects and the complexity of the correlations in question: merging comparable data from different studies in the framework of research consortia (Hindorff et al., 2009) and performing one or more mega studies with a very large number of participants (in the range of five or six digits). Current examples of such mega studies are the *European Prospective Investigation into Cancer and Nutrition* (EPIC) (Riboli et al., 2002), *The Million Women Study* (The Million Women Study Collaborative Group, 1999), the Norwegian CONOR consortium (Næss et al., 2008) or the CONSTANCES study in France (Zins et al., 2010; cf. section 4.5). The NAKO currently being established in Germany is the most recent study in this series (cf. section 4.4). An account of the opportunities and problems inherent in this research development is given further down.

The scientific and health-policy significance of existing results from population-based longitudinal studies on determinants of health and disease is illustrated by the strong influence of these longitudinal studies on the design of successful intervention studies. Intervention studies attempt to eliminate or at least mitigate one or more of the factors bearing upon the development of the disease in order to reduce the incidence rate in the subsequent observation period. Municipal prevention studies aimed at reducing cardiovascular risks and particularly the *North Karelia Study* are examples of successful intervention studies in this context (Puska, 2010), which also applies to intervention studies to reduce HIV risks (Rhodes, 2014).

After all, one strategic aim of health policy is the promotion of preventive approaches. This particularly includes fostering the promotion of workplace health in the professional world and strengthening the role of primary and secondary prevention in health care, particularly for elderly patients. According to the applicable approval and refund rules for new interventions under the German Federal Code of Social Law (SGB V), new intervention instruments must be evidence-based. For many measures, however, such evidence is currently not available. Providing the necessary reliable data is a main objective of the NAKO, whose survey programme is focused on the quantitative, standardised survey of risk factors for chronic diseases and their early subclinical manifestations and changes. Repeated surveys over a long observation period allow for an assessment of the influence that individual risk factors and specific combinations of risk factors have on the emergence of major widespread diseases. This enables a systematic consideration of both the development over time and the influence of pre-existing subclinical or already clinically relevant changes. Based on this

data, appropriate intervention measures for primary and/or secondary prevention are to be developed and implemented. Using the NAKO database, it should further be possible to identify the respective segment of the population particularly suited for a specific intervention and to characterise this group with regard to the expected benefits.

This exemplary evidence from epidemiological observational and intervention studies vividly illustrates the relevance of longitudinal studies with a view to the scientific and public health efforts to improve the health of entire populations.

3.3 Relevance for families and migration

In family research, longitudinal data has become indispensable since it enables the above-described analysis of life courses, including the causal effects of events/changes. The older findings, based on cross-sectional data, increasingly reveal massive distortions. Cross-sectional data does, for instance, not allow for any distinction as to whether differences between unmarried and married individuals are due to marriage (causal effect) or did indeed exist prior to the marital/non-marital status (selection effect). Cross-sectional data suggests, for instance, that married people are (supposedly) happier than unmarried people. It does not, however, provide any information as to whether this is because happier people more often marry or whether marriage brings happiness. With longitudinal data, these effects can be distinguished: while finding proof for both factors, relevant studies also differentiate their respective impact (Stutzer & Frey, 2005). In addition, it emerges that the causal effect of marriage is much smaller than the cross-sectional studies suggest and that it disappears altogether within a few years.

Similar problems occur in the field of social mobility: here, too, longitudinal data is required to distinguish selection effects and causal effects. Kratz and Brüderl (2013), for instance, show that cross-sectional analyses underestimate the income gains from interregional labour mobility, because such mobility is found more amongst low-paid workers. On the other hand, owing to a positive health selection in migration, i.e. that to migrate tends to be the choice of the healthy, cross-sectional studies overestimate the health of migrants (Razum et al., 1998; Norman et al, 2005).

These are only a few highlights from amongst the many new insights obtained from longitudinal data in the fields of family and social mobility research. By providing the necessary longitudinal data base, SOEP, in particular, has enabled us to expand our knowledge with a number of findings. To name but a few: only longitudinal data allows for the assessment of the causality between economic uncertainty and fertility behaviour (Kreyenfeld, 2005; Kreyenfeld, 2010), or women's employment and fertility (Kreyenfeld, 2004), or else between the level of women's income and the decision to have a second child (Andersson et al., 2014). In migration research, the oversampling of individuals with an immigrant background allows for separate analyses of migration and integration (Milewski & Doblhammer, 2015). For instance, Milewski (2010) reveals that second-generation immigrant women have more or less adapted their fertility behaviour to that of German women. Owing to SOEP and its "oversampling" of immigrants, it has also become possible to prove that mobility is frequently a circular process and that, under certain conditions, immigrants will eventually return to their home countries (Dustmann et al., 2015). SOEP also plays an important role in the analysis of care dependency, morbidity and mortality (Doblhammer & Hoffmann, 2009).

Pairfam data have in recent years become increasingly relevant for this field of research as well.⁵ In coming years further important results can be expected regarding the integration of immigrants from the new panel *Children of Immigrants Longitudinal Surveys in Four European Countries* (CILS4EU) and the SOEP migration samples of the German Federal Employment Agency's Institute for Employment Research (IAB) (Brücker et al., 2014).

3.4 Relevance for education and skills development

Longitudinal studies in the education sector mainly focus on the conditions and interdependencies of success at school. Success at school is regarded as a determining factor for many aspects of an individual's later life, such as the choice of profession, career success and lifetime earning potential, but also for their later health-related behaviour. The studies examine e.g. how beneficial or adverse conditions in the family of origin and during childhood affect educational success, or look into the mechanisms behind the selection processes at the different levels of a highly structured educational system (Solga & Becker, 2012). The question whether, independent of an individual's performance at school, the family background has any influence on his or her subsequent educational path, is a further major point of interest in this field (Uhlig et al., 2009). This is closely connected with the question as to which interventions at what points in pre-school, school and post-school education are particularly effective and cost-efficient (Heckman, 2006). Recent research has used educational trajectories to analyse skills independently of school grades (Lohmann et al, 2009; Blossfeld et al., 2011), extending the examination over a prolonged period right up to adulthood (Rammstedt, 2013).

Population-based longitudinal studies are all the more relevant in educational research as institutional conditions tend to vary strongly between different regions (e.g. in Germany between the individual federal states (Länder)) and because changes in educational policies with interesting effects are often introduced at rather short notice. Hence, longitudinal studies with short examination intervals are needed to examine what bearing the educational efforts and corresponding choices made by a family within the existing institutional framework will have on their children's success in school. Such studies can also identify factors influencing education inequalities of children from disadvantaged families (Solga, 2001; Blossfeld et al, 2015; Diewald et al, 2015). They complement and expand the results from the OECD's PISA study which revealed extensive – and for the most part preventable – social inequalities in terms of access to secondary education and successful graduation (Baumert et al, 2006; Becker & Hadjar, 2013).

3.5 Relevance for careers, the labour market and social inequality

Longitudinal studies addressing aspects of the professional world are of considerable importance for a variety of socio-political issues. The questions arising include: How effective are qualification processes before and during employment in terms of workforce allocation and professional success? How do workers adapt to structural change, particularly in terms of professional mobility? What patterns evolve in typical adaptation processes like changing the job or the employer (Mayer et al, 2010; Stawarz, 2013; Manzoni et al, 2014)? How far-reaching are the consequences of career breaks due to unemployment or family leave (Aisenbrey et al., 2009)? How open are our societies, what structures are characteristic of the

⁵ Cf. e.g. the overview of important findings from pairfam provided in Keller & Nauck (2013).

inequality of opportunities and how do they change over time (Müller & Pollack, 2004; Hillmert, 2015)? In addition to process-generated data, i.e. the data obtained in administrative processes such as the social security system, it is vital to complement scientifically-based and defined longitudinal studies in particular when it comes to identifying causative mechanisms and direct and indirect effects.

The availability and quality of professional opportunities influence several spheres of life such as the decision to start a family, parenting behaviour (Kohn, 1969; Bertram & Deuffhard, 2014) or leisure time activities including active citizenship and political commitment (Karasek & Theorell, 1990). It also affects the extent to which an individual preserves his or her working capacity and health – which, in turn, reflects on the respective income opportunities (Siegrist, 2015). Recent research findings also suggest that fundamental influences from the social – particularly the professional – milieu can, in effect, change personality traits previously considered stable and time-invariant (Diewald et al, 1996; Anger 2012). Although international studies have already convincingly established how socially unequal opportunities in life are perpetuated in the course of career paths, further research is still required. In all these cases, results from longitudinal studies can provide insights that are not only scientifically innovative but also of practical relevance.

3.6 Relevance for economic and social policy

Economic and social policy, broadly understood as including education and labour market policies, fundamentally shapes our living conditions over the entire course of our lives. It bears upon the educational status, the quality of employment, the level and distribution of income, the standard of living, social inclusion and, indirectly,

upon health, since an individual's income level and social status strongly correlate with his or her state of health. With a view to these powerful effects, it is essential that the direct short- and long-term effects as well as the frequent unintended side effects of economic and social policy interventions are identified both qualitatively and quantitatively. This is necessary in order to understand the respective institutional mechanisms at work. In this context, population-based longitudinal studies are an indispensable feature of any analysis of economic and social policy interventions claiming significance and validity. This is due to three scientific characteristics of the research subject: the virtual impracticability of randomised experiments, its overlapping two-way cause-effect relationships and its embedding in a constantly changing political setting.

For one thing, whereas the usual procedure in natural sciences, i.e. implementing well-defined and controlled *randomised experiments* ex ante, is frequently possible in medical sciences (where it has, indeed, come to be the methodological standard), it is rarely feasible in economic and social policy. The reasons for this state of affairs include ethical and legal reservations against the resulting unequal treatment and the difficulty of consistently controlling the experimental conditions of socioeconomic policy interventions (the consequences of which, whether direct or indirect, tend to emerge in the long term only). In addition, the many interactions between the subjects and their economic and social environment usually forestall any isolating experimental design.⁶ Hence, the great “social

⁶ In economics, laboratory experiments did nevertheless play an important role in the development of the discipline (Falk & Heckman, 2009). In some situations, field experiments may also be successful. However, it often takes decades for the results of such field experiments to become observable, which, in turn, makes subsequent socioeconomic and/or longitudinal epidemiological surveys necessary. The field experiments in (pre)school education and their impact on an individual's later career in the labour market and his or her health development are cases in point (e.g. Heckman et al., 2010).

experiments” of the 1980s and 1990s⁷ have likewise had to rely on accompanying longitudinal studies for an undistorted assessment of cause-effect relationships.

A second peculiarity of an economic and social policy analysis is the difficulty to isolate *unequivocal cause-effect relationships* from the results of an ex post observation of economic and social policy interventions. Generally, such relationships are the result of complex impact chains manifesting themselves differently in different individuals. Consequently, selection effects will occur over time, superimposing the actual causal effects. For instance, welfare recipients differ from non-recipients of social welfare not only by receiving this benefit, but also with respect to measurable characteristics (e.g. education) as well as a range of features that are difficult or impossible to measure (e.g. openness, the willingness to take risks, or motivation). Moreover, the longer these causal chains operate, the more likely is the emergence of other factors unconnected with the original economic and social policy intervention, such as the financial, economic and debt crisis since 2008. Incidentally, economic and social development processes typically trigger counter-movements, avoidance reactions and adjustment processes, giving rise to the “chicken and egg” problem of reverse causality. Thus, for example, generously designed unemployment insurance can lead to higher unemployment, which, in turn, can cause psychological problems for recipients of unemployment benefits. On the other hand, it is equally possible for an individual to have become unemployed as a consequence of his or her rather poor psychological state. A continuous and comprehensive long-term monitoring of people affected by economic and social policy interventions is therefore essential for economic and social policy analysis.

This is exactly what population-based longitudinal studies can achieve.

In this respect, the development of population-based longitudinal studies in economics and social sciences went hand in hand with the development of statistical and econometric methods allowing for the identification of causal dynamics. This is established by Adams et al. (2003), Stowasser et al. (2012), and Stowasser et al. (2014), all of whom follow the concept of the Granger causality (Granger, 1969). Granger causality identifies causality on the basis of the chronological order of events (i.e. the principle of “post hoc, ergo propter hoc”), which is why it cannot be implemented without longitudinal data. In terms of science history, the significance that this interaction between instrument (population-based longitudinal studies) and method (statistical theory of causal identification) has for the economic and social sciences can hardly be overestimated. A key concept is the concept of the “instrument”: it refers to a variable that, together with the actual cause, influences the impact to be identified. It does so without being itself affected by the effect of the cause. Modern statistical theory has proven that causal interpretations of interactions would be impossible without such instruments. The evidence of a reciprocal effect between entering unemployment and the level of subjective well-being – first established in a Germany-based panel-econometric modelling by Winkelmann and Winkelmann in 1998 – has meanwhile been widely replicated. The resulting essay has become one of the most frequently cited amongst SOEP-based publications, inspiring psychologists around the world to corresponding replications and further developments of the Set-Point Theory. Typical instruments of economic and social science analysis are almost always triggers of institutional change. The short school years during the 1960s in Germany are a case in point: the parents of the generation of young

⁷ On negative income tax: Pechman & Timpane (1975); on housing allowances: Rose (1985); on health insurance: Newhouse et al. (1993).

adults and children affected by the short-school-year arrangement did not conceive their offspring several years earlier with the view of enabling them to save time at school. It follows that by comparing the lives of children who went through similar stages of life around the time of the introduction of this “instrument”, the effects of less education on a number of later developments can be empirically assessed. However, such changes in time structures are found in population-based longitudinal studies only, making this type of studies indispensable for modern economic and social policy analyses.

Economic and social policy analyses have a third peculiarity which highlights the importance of population-based longitudinal studies. This is the fact that economic and social policy is inevitably embedded in a *historical and political context* and consequently is constantly confronted with unpredictable incidents and decisions. Continuous population-based longitudinal studies can then document the consequences of these unforeseen events and decisions and allow for their subsequent analysis. The financial, economic and debt crisis since 2008 serves as a good example: owing to existing population-based longitudinal studies, such as SOEP and SHARE, the economic, social and health-related consequences of the crisis can be analysed by comparing them with the situation before the triple crisis. This documentation and analysis function also applies to foreseeable and highly relevant events of historic socioeconomic relevance, such as the predictably immense burdens on the social security systems which the looming retirement of the entire baby-boom generation will entail. In this respect, the role of population-based longitudinal studies is comparable to that of a telescope (Butz & Boyle Torrey, 2006), which must be positioned early on so as to capture predictable as well as unpredictable astronomical events.

3.7 Relevance for successful ageing

Hitherto, a large number of population-based longitudinal studies focused on childhood and early adulthood. Recent years, however, have seen the launch of more and more studies starting their analysis in a later phase of people’s lives. Along with adolescence (Viner et al., 2012), middle age is focussed upon as the initial phase of prospective studies. Consequently, such studies typically include people over the age of 40 (cf. section 3.2). Analysing the *conditions of successful ageing* has thus become a main research focus. With a view to demographic ageing in economically developed and rapidly evolving societies, the issue of healthy ageing has found wide public interest⁸ and prompted the initiation of extensive longitudinal studies on older sections of the population in research and science policy.

Since ageing processes and their effects vary widely intra- as well as inter-individually, robust results from such studies are not only of interest in the respective scientific disciplines, but also for all the policy areas facing the challenges of a rapidly ageing society. Because differential ageing and its consequences affect many areas of life, studies on ageing will typically cover a wide range of aspects in an interdisciplinary approach. The development of life expectancy and the explanation of the existing differences along the lines of gender, social status and ethnicity receive special attention (Vaupel, 2010), as does the development of diseases in old age (Christensen et al., 2009). A substantial part of the studies is devoted to the examination of age-related changes in cognitive abilities (Lindenberger, 2014) and to the active structuring and organisation of the “Third Age” (Morrow-Howell et al., 2001). This phase typically spans the period between the beginning of retirement

⁸ In German e.g. Schröder & Pohlmann (2012); information on recent US studies can be found at <http://www.nia.nih.gov/> (accessed: 01/03/2016).

and a state of limited functional capacity and incipient care dependency. Since a considerable part of the population in this age range is relatively healthy and energetic, new vistas of social productivity and individual freedom are opened up (Laslett, 1989). Studies on ageing with a socio-economic outlook revolve around issues of income maintenance and financial circumstances, inter-generational transfers, and living conditions and care situation in old age, including medical and nursing care⁹.

The pioneering work carried out in these fields in the 20th century has not only radically changed our conception of ageing, but is also the basis of numerous practical improvements. Meanwhile, a new generation of studies has been devoted to these issues. They are characterised by the fact that their study designs and methods are closely coordinated, allowing for a transnational comparison of results. The first of these new-generation studies, the *English Longitudinal Study of Ageing* (ELSA) (Banks et al., 2006) closely follows the model of the US *Health and Retirement Study* (HRS) launched a few years previously. This example was taken up by a German initiative within the Europe-wide SHARE (Börsch-Supan et al., 2011), which, in turn, served as a model for similar studies in Japan, China, South Korea and other emerging and developing countries. Typically, these studies establish a close international cooperation network in order to ensure the necessary harmonisation of the methods and evaluation strategies and to connect biomedical with psycho-sociological and socioeconomic survey areas. This cross-disciplinary approach is a result of realising that successful ageing can only be understood as a lifelong process, starting in early childhood and featuring a complex set of interacting biomedical and socioeconomic mechanisms.

3.8 Conclusion

In summary, it can be said that around the world, population-based longitudinal studies constitute an indispensable element of all research activities attempting to identify the conditions of a successful and healthy development over the course of a human life. Research programmes enabling the initiation and implementation of multidisciplinary scientific collaborations have been – and continue to be – developed at the intersection of biomedicine, demography, epidemiology, genetics, geography, psychology, economics, sociology, and statistics. The results have decisively contributed to the launching of a number of preventive measures and programmes aimed at improving life chances and quality of life in the respective population groups. The vast majority of ground-breaking studies in this field were conducted in North America, the UK, the Scandinavian countries and the Netherlands.

In Germany, population-based longitudinal studies have likewise undergone an impressive evolution (chapter 4), albeit somewhat delayed and with varying levels of development in the various disciplines. Further structural measures are required to reach and permanently maintain the standards of international top-level research. The following chapter is devoted to a brief description of this development and an overview of important current longitudinal studies. The identified development needs are discussed in chapter 5, which is followed by the working group's recommendations (chapter 6).

⁹ These questions are currently examined in large international studies on ageing, including: Juster & Suzman (1995), Marmot et al. (2003) and Börsch-Supan et al. (2013).

4 Development of population-based longitudinal studies in Germany

For some decades, Germany has had a leading role in Europe regarding the survey, method development and analysis of longitudinal studies in the economic and social sciences. The *Supplementary Micro-census* which the German Federal Statistical Office implemented in 1971 (aimed mainly at examining the educational and professional careers of refugees and displaced people) provided Germany with a representative retrospective longitudinal data base early on. At the time, the survey was carried out with official statistics and subsequently placed at the disposal of the scientific community. This data enabled the fairly accurate representation, section-wise longitudinal description and analysis of careers in post-war Germany. In the UK, prospective longitudinal studies were established during this period, e.g. the *National Child Development Study* (NCDS) (1958) or the *British Cohort Study* (BCS70). The latter included individuals born in the same week in England, Scotland and Wales who were repeatedly interviewed (at long intervals) over the course of their lives. Valuable longitudinal information was thus generated.

In the 1980s, Germany increasingly became a worldwide protagonist in the survey and analysis of retrospective and prospective longitudinal studies. This expertise was based on the GLHS conducted by the MPI for Human Development in Berlin (Director: Karl Ulrich Mayer) and the SOEP launched by the Collaborative Research Centre (CRC) 3 at the universities of Frankfurt and Mannheim (Director: Hans-Jürgen Krupp), a subproject of the German Institute for Economic Research (DIW) in Berlin. This has led to a

unique upswing in sociological life course research, as well as in micro-econometric labour market analysis and the development of micro-simulation models, including the German studies on economic inequality (in which e.g. poverty and income were considered as dynamic phenomena in the life course). At the same time, the methodological development of event and panel analysis was significantly advanced. In the meantime, SOEP plays a global role in the field of developmental and personality psychology. Since 2012, a special longitudinal innovation sample (*SOEP Innovations Study* – SOEP-IS) serves to expand this development and perpetuate it for new issues, processes and methods. To be sure, other European countries also conducted longitudinal studies, for instance the UK with the *British Household Panel Survey* (BHPS) and its follow-up survey, the *Understanding Society* study (both located at the ESRC UK Longitudinal Studies Centre at the Institute for Social Economic research (ISER) at the University of Essex). However, not only were these studies usually launched a few years later than comparable studies in Germany, but in the UK they continue to be less stable as funding remains conditional and the respective research programmes are under constant threat of discontinuation. It was only later that specialised longitudinal studies such as ELSA, the study *Growing Up in Scotland*, the *Longitudinal Study of Young People in England* and the *Millennium Cohort Study* were launched in the UK. They all followed on from the birth cohort studies started in the 1960s and increasingly allowed for multi-cohort analyses of life courses and social change.

Owing to its leading position in longitudinal research, Germany was able to contribute, in some cases significantly, to the international comparative retrospective longitudinal studies conducted at the European level. These include the *Fertility and Family Survey* (FFS) in 1992, the GGS in 2005 (both on behalf of the Federal Institute for Population Research in Wiesbaden) and since 2004, SHARE (first at the University of Mannheim, later at the MPI for Social Law and Social Policy in Munich, cf. section 4.4).

These various longitudinal studies in Germany eventually formed the precondition for the development of the NEPS in 2009, which has won Germany the international leadership in longitudinal educational research. The same is true for pairfam, launched in 2008 at the Universities of Mannheim, Bremen, Chemnitz and Munich and for the genetically sensitive twin study *TwinLife* (at the Universities of Bielefeld and the Saarland in close cooperation with the DIW Berlin). In view of this development, the frequent assertion that the UK is Europe's leading country in the field of longitudinal research should be reconsidered. Since the 1980s, if not before, Germany has been keeping up with and contributing extensively to data collection and methodology development in longitudinal research, even surpassing the UK in recent years.

It is hardly possible to identify a consistent pattern in the development which, as outlined above, research structures in Germany underwent in the disciplines working with longitudinal studies. The scientific traditions of these disciplines differ too widely, as do their chances of research funding. In the following, developments will therefore be described for each discipline individually. It becomes evident that in the fields of economics, sociology and demography, population-based longitudinal studies caught up with the international leading trends

somewhat earlier than in epidemiological and public health research.

4.1 Epidemiology and Public Health

Various memoranda from the 1970s and 1980s stated that Germany lagged behind in terms of population-wide health research. This was attributed to several factors (Labisch & Woelk, 2012), the most important of which was the disruption and destruction during the Third Reich of the highly successful research development in the German Empire and the Weimar Republic. From a science-historical perspective, the effects of this were drastic. In post-war Germany there was but very limited room for the development of epidemiology and prevention strategies: to the fact that research in the field of public health had been largely discredited were added the lack of scientific expertise and a research funding system focussed on basic biomedical and clinical research. These conditions gradually changed during the last two decades of the 20th century.

A major pioneering funding initiative with funds from the programmatic research funds from what was at the time the Federal Ministry for Research and Technology, for instance, was established in the field of public health and created five regional research networks which were funded for a maximum period of ten years. By combining the funding of research projects with the support for continuing education programmes at university level broad support for young scientists in the respective disciplines was to be effected. Prior to this, the required academic qualification had only been secured to a limited extent in the form of scholarships for Master's and/or PhD programmes at foreign universities by the German Academic Exchange Service (DAAD) (DAAD Special Programme Epidemiology). The 140 scholarship students received a research-orientated international training.

Several among them advanced to become leading epidemiological scientists; several are professors in the fields of epidemiology, biometry and care research or are on the management boards of corresponding professional societies. However, owing to the fact that this was not followed up with adequate research funding programmes which would have ensured the necessary structural development and allowed for the establishment of a coordinated research system, these funding initiatives were only moderately successful.

Other initiatives emerged from epidemiological research projects at medical schools or in close cooperation with medical research centres. With a view to their paramount importance in health policy systems, cardiovascular diseases and their key risks were the focus of the first major studies. These include the MONICA/KORA study (Keil, 2005) in Augsburg/Munich, together with the European SCORE project (Conroy et al., 2003; Keil et al., 2005) and the Münster-based PROCAM study (Schulte et al., 1999). To these were added the *Study of Health in Pomerania* (SHIP) in Greifswald (Völzke, 2012), the *Heinz Nixdorf Recall Study* (Recall) in Essen (Schmermund et al., 2002) and the *Gutenberg-Gesundheitsstudie* (GHS) in Mainz¹⁰, whereby the latter studies covered an extended range of the targeted diseases. The last decades of the past century saw the development of further relevant epidemiological contributions. Prominent examples of these rather extensive research activities are the Cancer Epidemiology Department at the German Cancer Research Center in Heidelberg, the Psychiatric Epidemiology Department at the Central Institute of Mental Health in Mannheim, the Diabetes Epidemiology Departments in Düsseldorf and Munich, or the Departments for Nutritional Epidemiology in Potsdam and Heidelberg. The

EPIC study (Gallo et al., 2012) can be cited as an example of a study with strong international links. The *German Rubber Industry Cohort Study* (*Kohortenstudie in der deutschen Kautschukindustrie*) exemplifies the occupational healthcare perspective in cancer epidemiology (Birk et al., 1995). Provided they are still being continued, the most relevant of these studies are listed and described in the following sections. One point, however, can already be made beyond doubt: in recent years, epidemiological research in Germany in terms of both methodological expertise and the underlying organisational processes has been substantially consolidated. A critical mass has thus been established which does now enable the launch of an extensive study whose scope greatly surpasses that of all previous projects: the *National Cohort* (NAKO, cf. section 4.4). For more details of the German research achievements in the public health sector, see the recently published statement on public health by the German National Academy of Sciences Leopoldina (Leopoldina, 2015).

4.2 Sociological longitudinal studies

a) Demography

Traditionally, demographic research resorts to the official population statistics to examine issues pertaining to the three demographic processes of mortality, fertility and migration. In Germany, the statistics used to yield mainly cross-sectional data without longitudinal references, for instance from the census, the birth and mortality statistics or the relocation statistics (arrivals and departures). This eventually changed about two decades ago, when the provision of longitudinal secondary data, mainly by the *Research Data Centres of the Federal and Regional Governments*, resulted in a substantial improvement in data availability. A major objective of demographic studies being the estimation of demographic indicators such as cohort-

¹⁰ Cf. <http://www.gutenberg-gesundheitsstudie.de> (accessed: 03/01/2016).

and period-specific fertility and mortality rates at population level, longitudinal register data is of great importance. It yields the relevant data on the numerator (e.g. births and deaths) and the denominator (population) required for the calculation of the respective rates.

Demographic research has thoroughly analysed the advantages and disadvantages of different data bases, for instance in the fields of fertility research (Kreyenfeld et al., 2012), migration research (Carnein et al., 2015) and morbidity research (Schulz & Doblhammer, 2011). In the following, a selection of relevant longitudinal data from registers and panel surveys is presented.

The first instance that merits mentioning in the context of *longitudinal studies based on register data* is the German statutory pension insurance scheme. The register data it provides serves to examine different issues, e.g. careers and retirement (Hansen et al., 2011), social differences in life expectancy (Himmelreicher et al., 2008), or fertility (Kreyenfeld & Mika, 2008). Although the pension insurance data contains no information as to an individual's possible migration background, it does differentiate between German and foreign citizenship. With a view to the large number of cases the data covers, this allows for detailed citizenship-based analyses (Mika, 2006).

Another important source of data based on longitudinal surveys is the statutory health insurance system, which was, however, not accessible for this purpose until 2012. In a decree regulating the implementation of data transparency provisions¹¹, the German Institute for Medical Documentation and Information (DIMDI) was then commissioned to pseudonymise the data of the so-called Morbiditäts-

orientierter Risikostrukturausgleich (in short: Morbi-RSA – a risk structure compensation between health insurances based on their members' morbidity rate) and make it available for research. In cooperation with these institutions, questions in the fields of the prevalence, incidence, medication and cost of diseases are addressed (Doblhammer et al., 2015) along with issues arising in the context of an individual entering the statutory care insurance, including the questions of nursing homes and mortality (Fink, 2015).

Among the *longitudinal studies based on panel data*, SOEP is of particular relevance in demographic research. Conducted since 1984, it is one of the longest panel studies worldwide (cf. section 4.4a). In fertility research, it is employed to analyse the fertility behaviour of men and women (subsample SOEP *Families in Germany* – SOEP FiD) (Kreyenfeld et al., 2012). In migration research, the oversampling of individuals with an immigrant background allows for separate analyses of migration and integration (Milewski & Doblhammer, 2015). SOEP is also important for the analysis of long-term care, morbidity and mortality (Doblhammer & Hoffmann, 2009).

In addition to these multi-purpose panels there are a number of family panels. In the first wave of the GGS in 2005, about 10 000 people between 18 and 79 years of age were questioned. The second wave, surveyed in 2008, contained only one third of the individuals from the first wave. A critical validation of the data for fertility research revealed a “family bias” with the effect that childless people are underrepresented. In addition, the fertility of younger cohorts is overestimated while that of the older cohorts is underestimated (Kreyenfeld et al., 2013). The authors point out that this bias appears to be much more marked in surveys with a family-specific focus than is the case in multipurpose surveys.

¹¹ Cf. <http://www.gesetze-im-internet.de/bundesrecht/datrav/gesamt.pdf> (accessed: 03/17/2016).

The most recent family panel is pairfam, the first wave of which was conducted in 2008/2009, surveying more than 12 000 people (Huinink et al., 2011). The supplement sample *Demographic Differences in Life Course Dynamics in Eastern and Western Germany* (DemoDiff) contains an additional 1 400 people from Eastern Germany. Pairfam currently appears to be the largest family-related panel in Europe. It is conducted on an annual basis and is designed for a term of 14 years. Further details are presented in section 4.4.

The fields of morbidity research and research on ageing will be discussed in the following sections, with a focus on the German section of SHARE, the *Berlin Age Study* (BASE I and II) and the *German Ageing Survey* (DEAS).

With the existing register data and surveys, Germany's data base for demographic longitudinal studies is generally regarded as satisfactory. The limitations in the data quality due to survey bias and to certain subpopulations not represented in the register data should nevertheless be mentioned. An important step for future development will be the combination of survey and register data. This harbours great research potential, which, unlike in the Scandinavian countries or the Netherlands, so far remains unexploited in Germany.

Mortality research, too, is subject to limitations, particularly regarding the causes of death: unlike the United States, where a National Death Register provides the relevant information, Germany has no central, scientifically accessible mortality register. Indeed, research as to causes of death is hampered by a German law, the Federal Statistics Act, which prohibits the analysis of the relevant sections of death certificates.

A future approach should therefore focus on addressing data protection issues and interconnecting the various data providers.

b) Economics and social sciences

In the 1980s and early 1990s, sociological life course research was dominated by (retrospective) life course studies. Between 1979 and 2005, the GLHS was carried out at the CRC 3 at the University of Mannheim and the MPI for Human Development in Berlin. The GLHS comprises eight retrospective birth cohort studies for West Germany and five retrospective birth cohort studies for East Germany (Mayer, 1990). In order to examine the consequences of the German reunification, the studies for the East German cohorts and the 1971 West German cohort were supplemented by a further panel wave (Mayer et al, 2006; Mayer & Solga, 2010). Initially, the GLHS was to identify the conditions and mechanisms of social inequality in the birth family, education and training and the professional career. This research programme was accordingly supplemented by studies on family education, migration, and further questions such as the relationship between social policy and life courses (Mayer, 2015).

The large panel studies used by economic research are virtually all science-driven or based on official statistics regulations. They only indirectly serve as science-based policy advice.¹² The two existing panel studies conducted for the satisfaction of commercial interests (GfK Consumer Panel and Nielsen Household Panel), will not be further discussed in this paper (cf. Council for Social and Economic Data 2011).

Social scientists and economists are taking the lead in several multidisciplinary long-term studies in Germany and Europe. Amongst these, SOEP is the largest and longest running study. A full description

¹² This shows plainly that an accurate income assessment (based on the full calendar year preceding the respective year of the survey or interviews) plus the careful preparation of the data prolong the process so much that economically determined panel findings on income issues notoriously become available too late to describe current developments.

is given in section 4.4a. Currently, SOEP covers around 50 000 participants in about 25 000 households (*SOEP Core* and *SOEP-IS*). SOEP data include information about pregnancy, childhood, personality development, education, income, employment, health, and life satisfaction (Schupp, 2012). SOEP serves as “reference sample” for a number of specialised studies (such as *BASE II*, *TwinLife*). With its innovation sample *SOEP-IS*, SOEP provides German and international users with a tool for innovative approaches, e.g. a special survey on stress conducted by means of epigenetic markers. Since the beginning of *SOEP-IS*, more than 40 research proposals a year were handed in, nearly one-third of which could be realised.

The 1990s saw a shift towards prospective panel studies, which was essentially triggered by the success of SOEP (Schupp, 2009). The subsequent studies being not so much a replication of SOEP as a more detailed analysis of specific issues, they set certain focal points. The DEAS, a survey programme running since 1996, examines the social, economic and health situation of the population in the second half of life (Motel-Klingebiel et al., 2010). The DEAS is funded by the Federal Ministry for Family Affairs (BMFSFJ) and conducted by the German Centre of Gerontology (DZA) as a departmental research project. The participants, aged over 40, are repeatedly and comprehensively asked about their objective and subjective circumstances. This is complemented by test procedures allowing for the survey of cognitive performances and aspects of physical health.

The DEAS combines recurring, nationally representative cross-sectional surveys with individual longitudinal panel surveys. The data currently available covers the survey waves 1996 ($n = 4\,838$), 2002 ($n = 5\,194$), 2008 ($n = 8\,198$) and 2011 ($n = 4\,855$). They allow for the cross-sectional analysis of the

situations and interactions during the life course, for the study of social change and the analysis of individual development in the process of ageing. In 2014, the fifth wave was conducted: from April to October 2014, a fresh sample of 6 000 people was interviewed as to their situation in life and more than 4 000 previously interviewed people repeated the survey process.

At the European level, SHARE, the first wave of which was conducted in 2004, was the first major specialised panel with a sociological and economic focus. SHARE is wholly science-driven and was funded first by the EU Commission and then by the Federal Ministry of Education and Research (BMBF) (a detailed description is given in section 4.4e). The fifth wave conducted in Germany (2013) consisted of a sample of 4 556 persons aged at least 50.

From 2010 to 2013, the large household panel *Families in Germany* (FiD), which includes as many as 4 337 households with children under the age of 18, was jointly funded by the BMFSFJ and the Federal Ministry of Finance. In 2014, the FiD households were incorporated into SOEP and, in order to increase user-friendliness, in 2015 the FiD data from 2010–2013 were used to update the SOEP dataset retroactively.

At the European level, the *European Community Household Panel* (ECHP) was provided with the reformatted SOEP data for the assessment of the situation in Germany. This panel was succeeded by the EU-SILC, conducted in the EU member states under the authority of the respective statistical offices. Designed as a “rotating panel”, the EU-SILC is a European survey of the population in private households. It aims at collecting chronologically and internationally comparable multidimensional as well as comparative panel data on several issues. This involves sur-

veying monetary as well as non-monetary aspects from both an objective and a subjective point of view. The German share includes about 14 000 households with approximately 28 000 people questioned every year. A quarter of the sample drops out every year and a quarter has to be recruited from scratch.¹³ The EU-SILC being neither science-driven nor consistently harmonised, comparable sociological and epidemiological analyses tend to be difficult (cf. Jagger et al., 2008).

In 2006, the panel *Labour Market and Social Security (PASS)* was launched as part of the research conducted to evaluate the German unemployment benefit known as “Hartz IV”. It is organised under the aegis of the IAB. PASS collects data every other year¹⁴; its survey data has now been linked to the IAB’s administrative data (cf. Antoni & Bethmann, 2014). The linked process and survey data consist of information gleaned from interviews with participants of the IAB survey PASS and these participants’ personal data from the German Federal Employment Agency’s (BA) administrative data – provided the individuals in question have consented to the linking of the data and could be identified. The PASS data includes detailed information on the dynamics of the receipt of unemployment benefits (Arbeitslosengeld II/Hartz IV) and the supply situation and social participation levels of households. For all respondents data was collected on points such as labour market integration, employment-related attitudes and behaviour, physical and mental health or social networking. Wave 5 contains information on 15 607 people in 10 235 households. As in SOEP, external scientists can make suggestions for the design of the survey.

The largest specialised panel is the NEPS, likewise described in the overview

table in section 4.4. In this context, the *Programme for the International Assessment of Adult Competencies (PIAAC)* is worth mentioning. In Germany, the first wave of this OECD-initiated survey was conducted in 2011 and 2012, based on a representative population sample.¹⁵ A computerised interview was succeeded by the assessment of competencies, usually computer-based. In Germany, PIAAC was transferred to a panel (PIAAC-L) in which respondents were repeatedly questioned over at least three years and – analogous to SOEP – where information was also gathered on all adults in the household. Besides which, some national supplements provide further potential for analysis: *The Competencies in Later Life (CiLL)* which examined the PIAAC data for the age group 66 to 80 years, and the *Study on the connection between the competencies of low-skilled workers in Germany and their labour market prospects (Studie zum Zusammenhang von Kompetenzen und Arbeitsmarktchancen von gering Qualifizierten in Deutschland)*. For the latter, additional data was surveyed for the age group 26 to 55 years.

Under the aegis of a research consortium from four universities and funded by the long-term programme of the German Research Foundation (DFG), pairfam was launched in 2008 as a panel specialised in the field of genealogy (cf. the detailed description in section 4.4d).

With the first wave of the CILS4EU in 2010, migration research entered the panel scene. Initially funded by the DFG as part of the *New Opportunities for Research Funding Agency Co-operation in Europe (NORFACE)*, the German sample has meanwhile been incorporated into the DFG’s long-term programme. In 2014, the first wave of the twin panel *TwinLife* was eventually launched, likewise funded by

13 Cf. https://www.destatis.de/DE/Meta/AbisZ/EU_Silc.html (accessed 3/16/2016).

14 Cf. <http://www.iab.de/de/befragungen/iab-haushaltspanel-pass.aspx> (accessed 3/16/2016).

15 Cf. <http://www.ratswd.de/forschungsdaten/fdz-piaac> (accessed 3/16/2016).

the DFG long-term programme. 2014 also saw the launching of the GESIS panel, an online panel placing its survey time at the research community's disposal free of charge (a project financed by the *German Society of Social Science Infrastructure Institutes* (GESIS) with funds from the BMBF).

An even more specific approach was chosen in the panel study *Savings and Pensions in Germany* (SAVE): in ten waves conducted between 2001 and 2013, data was surveyed with regard to the economic and socio-psychological conditions behind long-term financial planning, the dynamics of savings and to public, operational and especially private pension schemes. The initial funding by the CRC 504 in Mannheim was first replaced by various third-party funds before being finally secured with funds from the MPI for Social Law and Social Policy. As part of an international comparative project of the European Central Bank, the German Central Bank launched a similar *Panel on Household Finances* (PHF), which so far, however, is suffering from very low response rates.

With SOEP, NEPS and the numerous other specialised panel studies, Germany's infrastructure of sociological and economic panel data is currently extremely well developed even by international standards.

4.3 Latest developments: combining biomedical and social sciences

A new research field, which is of particular significance for the present statement, has evolved from the realisation that an individual's health and social and economic situation in adult life are determined according to the genetic predisposition as well as the parental milieu and early childhood setting, and are shaped in a

lifelong interaction process of biomedical, social and economic factors. The lifelong correlation includes aspects like the "socioeconomic gradient" and the gene×environment interactions that were briefly discussed in section 3.2. For instance, an individual's health affects his or her economic status because healthier people tend to have greater learning capacities when they are younger and can bear greater strain in old age. Income disparities, in turn, enhance the risk of health inequalities. Generally, wealthier individuals will find it easier to bear high additional medical expenses; how great a difference this makes depends, however, on the structure of the respective healthcare system (Deaton, 2002; Marmot, 2002; Willett, 2002; Smith, 2003). Health behaviours, lifestyles, environmental and working conditions likewise influence this correlation between health and economic status and at the same time reveal a connection with the social environment (cf. section 3.1). Thus, there is ample evidence that being in a functioning family is beneficial to the health of the family members (Fagundes et al., 2011). A key finding of recent research is that these correlations manifest themselves from a very young age, generating both positive and negative feedback cycles over the course of an individual's life (Blane et al, 2006; Swedish National Institute of Public Health, 2006; Heckman & Conti, 2013) until they finally determine the general state of health and the economic and social situation in old age. Figure 1 shows a diagram of these correlations: numerous research projects, particularly from the English-speaking world, evolve around the effects of social, economic and public health interventions. They prove that the trajectories of health and social and economic situations illustrated in figure 1 can indeed be modified by policy measures in different fields, from the public health, education and social welfare sectors to economy and labour market policies (Ben-Shlomo and Kuh, 2002; Oxley, 2009). Some interventions

in welfare states have a direct bearing upon their populations' health and the structure of their working world. For instance, health is clearly directly influenced by medical interventions, the prevalence and intensity of which, however, varies according to the healthcare system (Sirven & Or, 2011). Similarly, early retirement is the direct outcome of pension schemes including disability pensions and special provisions for the unemployed (Gruber & Wise, 2004; Börsch-Supan, 2007). Much less is known, at least quantitatively, about the long-term effects of welfare state conditions, such as education levels, poverty prevention and health and safety regulations. The lifelong, complex and often indirect influence that these very broad and

rather non-specific welfare state interventions can have on health and employment is an important topic of socio-political research. Here again, the spheres overlap. A preventive health care system, for instance, is supposed to do more than improve health: it is also aimed at enabling older workers to remain in employment longer. High professional standards, in turn, not only promote the continued employment of the elderly by reducing early retirement schemes, but also improve physical and mental health (Jusot et al, 2012; Reinhardt et al 2013). Recent studies show that in countries with a higher retirement age, negative age-related cognitive developments occur later (Rohwedder & Willis, 2010; Börsch-Supan, 2013).

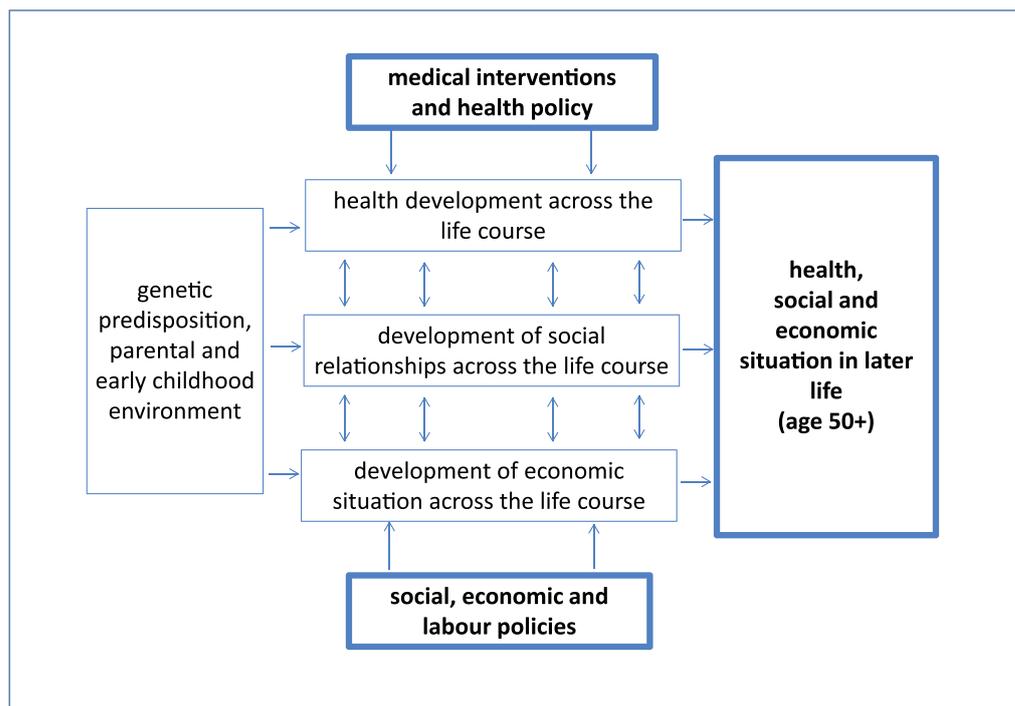


Figure 1: Conceptual basis for longitudinal studies combining findings from biomedicine and social sciences.

Certain socioeconomic factors have a great quantitative effect. For example, the difference in life expectancy is frequently more marked between individuals of low and high socioeconomic status than between men and women (Marmot, 2002; Olshansky et al, 2012). The connection between social and economic factors and health on the one hand, and between

health factors and the social and economic situation on the other, is therefore a research object of paramount socio-political importance.

From a scientific point of view, the greatest challenge is to identify the correlations illustrated in figure 1 as the result of a causal effect and to quantify them. It

is known, for instance, that amongst the reasons for the decline of cardiovascular diseases changes in the conventional risk factors such as smoking, hypertension and obesity play an important role (Ezzati & Riboli, 2002; Harper et al., 2011; Ezzati et al., 2015). The interesting point is how these conventional risk factors can, for their part, be attributed to the development of socioeconomic factors over the course of an individual's life (e.g. education, income and social status) (Mackenbach et al., 2008; Mackenbach et al. 2013).

As can be seen in section 3.2, work is already in progress on a number of specific approaches. For instance, the immune system has been proven to respond to acute psychosocial stress; such stress, in turn, occurs as a consequence of an unfavourable socioeconomic background, poor working conditions and social isolation (Steptoe et al., 2007). Many studies have found evidence of changes in the number and proportions of circulating T and B cells as well as in the number of natural killer cells and their cytotoxicity; likewise, functional reactions such as the mitogen-induced cell proliferation were found to be impaired (Zorrilla et al., 2001; Segerstrom & Miller, 2004). There is also evidence of a connection between stress in social relationships and inflammations: for instance, longitudinal surveys show that stress due to nursing care accelerates the age-related increase of cytokine IL-6 (Kiecolt-Glaser et al., 2003).

These insights have expedited the development of population-based longitudinal studies covering both biomedical and socioeconomic variables. On the biomedical side, technical improvements in the measurement methods have allowed for the analysis of numerous important markers (e.g. C-reactive protein, vitamins, cytokines) even in very large sections of the population. This includes methods such as the use of dried blood drops

(Dried Blood Spot – DBS), employed, for instance, in the sixth wave of SHARE. Meanwhile, it has not only become possible to extract genetic information from DBS; even a complete DBS-based genome analysis is currently being developed. On the socioeconomic side, technological progress in software development has led to the creation of computerised graphical user interfaces enabling the intuitive and comprehensive assessment of the entire life course. This could, for instance, be of use in the *National Cohort*. By combining innovations from biomedicine and the social sciences in population-based longitudinal studies, “biosocial surveys” have been established (Weinstein et al., 2007). Their distinguishing feature, viz. the close cooperation between the biomedical and social sciences has led to major advances. For instance, a close link was recently established between lifelong socioeconomic disadvantages and the extent of the DNA methylation of a gene that plays a decisive role in the regulation of the body's inflammatory processes (Stringhini et al., 2015).

Collecting such data is a complex process, since it implies ascertaining the socioeconomic situation as well as various biomedical indicators. However, once surveyed, the data allows for the identification of the basic mechanisms indicated above. It is thus easier to understand how psychosocial factors – not least formed by reactions to the economic environment – affect the risk of diseases and their prognosis or, vice versa, how biomedical developments at the beginning of an individual's life influence his or her future socioeconomic situation. No clinical study can adequately capture the heterogeneity of socioeconomic circumstances; this requires a population-based dataset. The longitudinal dimension, in turn, is necessary to capture the dynamics and interactions of the factors indicated in figure 1.

4.4 Selected studies: research subjects, research organisation and funding schemes

Germany is currently conducting twelve population-based longitudinal studies surveying both biomedical and socioeconomic features. Five of them are carried out at the national level; the others, though regionally limited, are chosen so as to be representative of the respective regionally

defined segment of the population within the selected age range (cf. table 1). To this substantial number of studies, which is only exceeded by the US, there must be added a large number of further German longitudinal studies surveying either biomedical or socioeconomic characteristics. They are listed in appendix 1, which provides further information on all population-based longitudinal studies currently conducted in Germany.

Table 1: Overview of longitudinal studies that cover biomedical and socioeconomic characteristics

| Name | Number of observations | Launch | Regional coverage | Age groups | Focus | Link |
|---|--|--------|--|---|---|---|
| BASE-II <i>Berlin Age Study II</i> | 2 200 | 2009 | Berlin | 20–35, 60–80 | health, social conditions | https://www.base2.mpg.de/de |
| DEAS <i>German Ageing Survey</i> | 4 000 + 6 000 (extended in 2014) | 1996 | Germany | over 40 | demography, labour, health, values and norms | http://www.dza.de/forschung/deas.html |
| DEGS <i>German Health Interview and Examination Survey for Adults</i> | 8 152 | 1997 | Germany | over 18 | health, living conditions, health care system | http://www.degs-studie.de/deutsch/studie.html |
| GHS <i>Gutenberg Health Study</i> | 15 000 | 2007 | Rhine-Main region | 35–74 | health and mental health | http://www.gutenberg-gesundheitsstudie.de/ |
| KORA <i>Cooperative Health Research in the Augsburg Region</i> | 20 000 | 1984 | Augsburg | 25–74 | health | http://www.helmholtz-muenchen.de/kora/ueber-kora/index.html |
| NAKO <i>National Cohort</i> | 200 000 (scheduled) | 2014 | Germany | 20–69 | widespread diseases, lifestyles | http://www.nako.de |
| Recall <i>Heinz Nixdorf Recall Study</i> | 4 814 | 2000 | Bochum, Essen and Mülheim/Ruhr | 45–75 | cardiovascular diseases | https://www.uni-due.de/recall-studie/ |
| Rhineland Study | 30 000 | 2015 | Rhineland | over 30 | well-being, way of life, brain | http://www.dzne.de/wissenschaft-gesellschaft/rheinland-studie.html |
| SHARE <i>Survey of Health, Ageing and Retirement in Europe</i> | 3 000 (w1), 900 (w2), 4 500 (w5) | 2004 | Germany | over 50 | demography and health | http://www.share-project.org/ |
| SHIP <i>Study of Health in Pomerania</i> | 4 308 | 1997 | Stralsund, Greifswald, Anklam (incl. the respective districts) | 20–79 | health | http://www.medizin.uni-greifswald.de/cm/fv/ship.html |
| SHIP-TREND <i>Study of Health in Pomerania</i> | 4 420 | 2008 | Stralsund, Greifswald, Anklam (incl. the respective districts) | 20–79 | health, mental health, lifestyle, demography | http://www.medizin.uni-greifswald.de/cm/fv/ship.html |
| SOEP <i>Socio-Economic Panel (SOEP Core and SOEP-IS)</i> | 12 200 (w1), 13 972 (w7), 51 028 (w30) | 1984 | Germany | from birth (since 2002; before: after school enrolment) | personality, income, occupation, education and health, preferences and satisfaction | http://www.diw.de/de/soep |

Along with the regional panel study KORA, which is limited to the city of Augsburg and the counties of Augsburg and Aichach-Friedberg, the Germany-wide SOEP is by far the longest-running longitudinal study. Many of the studies are based on comparatively small samples (less than 10 000 participants); with an intended 200 000 participants, the NAKO will, in terms of sample size, take a leading position. Small samples can compromise the quality of a study, particularly if subpopulations (e.g. migrants or very old people) or rare events (particularly rare diseases) are to be examined.

For the following section, five studies – SOEP, NAKO, NEPS, pairfam and SHARE – were selected to illustrate how population-based longitudinal studies started and evolved in Germany, what challenges had to be overcome in the process and what difficulties are currently threatening their success. From this common patterns should be deductible, suggesting specific structural problems. Each study will be presented briefly in a box before tracing its development.

a) The Socio-Economic Panel (SOEP)

SOEP, the *Socio-Economic Panel*¹⁶, is a representative longitudinal survey among private households frequently used all over the world. Its aim is to document the consequences of demographic and economic change – individually and for society as a whole. This, in turn, allows for a better understanding of these changes and provides a sound scientific basis for the frameworks and reforms of labour, health and social policy conditions (Schupp, 2009 and 2014). To this purpose, about 25 000 households with more than 15 000 children and adolescents (starting with new-borns) and about 35 000 adults of all ages have been surveyed annually since 1984. Comprehensive information is thus obtained regarding the household composition, subjective attitudes and individual characteristics, working careers and family biography, labour market participation and occupational mobility, income trajectories and financial circumstances as well as life satisfaction and health. As early as June 1990, even before the monetary, economic and social union of the two previously separated German states had been realised, SOEP was extended to the territory of the former GDR, taking advantage of the historically unique chance to obtain longitudinal data on how the transformation of a society affects certain areas of life (Schupp & Wagner, 1991).

SOEP explicitly included topics inherently pertaining to the fields of the social sciences and health. In consequence, SOEP was able to leave the path established by its model, the *Panel Study of Income Dynamics* (PSID), and implement innovative new approaches in terms of topic selection, survey methods and conceptual development (Schupp & Wagner, 2010).

In 2015, the 32nd wave of the SOEP core sample was surveyed. The same year, the fourth edition of the SOEP Innovation Survey was conducted, based not on the main sample but on a separate one that – based on a proposal contest – introduced innovative questionnaire items (Richter & Schupp, 2012). The “SOEP-Related Studies”, in particular the BASE-II (see Mayer & Baltes, 1996; Bertram et al. 2014) as well as *TwinLife* and the *Bonn Intervention Study* (BIP) (cf. Hahn et al., 2015; Schildberg-Hörisch et al., 2015) provide additional data in close cooperation with SOEP.

Contractually registered researchers from Germany and abroad can access SOEP data free of charge (Bowen et al., 2008).

Budget: 9.5 million euros (total annual budget)

Third-party funding: 10 percent

Duration: since 1984

Employees: 90

Interviewers: 500

In the early 1980s, SOEP was set up as a multidisciplinary subproject in the DFG’s CRC 3 *Microanalytical foundations of social policy* (Krupp, 2008). From 1983 on, the longitudinal study SOEP was funded by the DFG as a subproject of CRC 3 and located at the DIW, the head of SOEP hav-

ing left the Goethe University Frankfurt to take over the DIW presidency. At the time, the connection with the DIW was established for a pragmatic reason: as an institution from the so-called “blue list” of non-university institutions, the DIW could offer their academic staff permanent contracts for long-term tasks – something then virtually impossible at universities.

16 Cf. <http://www.leibniz-soep.de> (accessed 3/17/2016).

After the scheduled expiry of the CRC 3 in 1989, the German Federal and State Governments, following the standard procedure, took over the funding of SOEP as a series of individual DFG projects from 1990 to 2002. Since 2000, the BMBF provides supplementary funding (project funds). It was not until 2003 that, following a decision of the former German Federal and States Commission for Educational Planning and Research Promotion (BLK), SOEP was granted the status of an infrastructure facility of the Leibniz Association (Scientific Association Gottfried Wilhelm Leibniz – WGL) at the DIW. This made it eligible for inclusion in the institutional funding programmes of both the federal and individual states' governments; the federal government (more specifically: the BMBF) provides two-thirds of the funding. The long-term study has since been included in the Roadmap published by the BMBF in 2013.

The history of SOEP shows that a successful development of SOEP from its early CRC 3 days to an established panel could by no means be taken for granted. In the context of this statement's objectives, SOEP's successes shouldn't cloud the fact that mistakes were made in the early years (such as the frequent changes in the questionnaire, or the unfortunate survey on financial status in 1988). These were the result of a prolonged struggle to establish the structures for a professional development in Germany. An earlier professionalization of SOEP outside the structures of pure research funding could probably have prevented some of these mistakes.

b) The National Cohort (NAKO)

The NAKO is currently Germany's largest epidemiological health study (German National Cohort Consortium, 2014). In the next 10 years, 200 000 individuals aged between 20 and 69 will be submitted to a comprehensive medical examination and be questioned as to their living conditions. The study is a joint interdisciplinary project of numerous scientists from the Helmholtz Association (HGF), several universities and the WGL in Germany.

The NAKO is planning the detailed exploration of widespread diseases, in particular cardiovascular diseases, cancer, diabetes, psychiatric and neurodegenerative diseases, infectious diseases, respiratory diseases and diseases of the musculoskeletal system. The aim is to throw light upon the causes of these chronic diseases and on their correlation with certain lifestyles, environmental conditions and genetic and sociodemographic factors. New disease risk factors are to be identified and the impact of geographic and socioeconomic inequalities on the risk of disease in Germany is to be examined. Ultimately, evidence-based prevention strategies are to be developed. An important focus of the NAKO will be to analyse the influence of social and psychosocial factors on the health of the population (cf. section 4.3).

From the biological samples obtained in the process, biochemical and genetic markers are to be evaluated as effective tools for the early detection of chronic diseases. In the course of the study, a total of approximately 28 million biological samples are to be collected and stored and will be made available for scientific research. The data from the current main study is to be released in sections, having been submitted to the necessary quality assurance procedures. It will then be available (on application) for scientific evaluation. Since June 1, 2015, the application process for the data and biological samples and their transfer are being organised and implemented by a NAKO transfer office, which is currently under construction following funding release. In order to address the challenge of an estimated rate of up to 1 000 transfers of biological samples a year, complex IT solutions are being developed to achieve an optimum automation of the processes.

Budget: 210 million euros (for the first 10 years)

Third-party funding: 67 percent

Duration: since 2013, initial grant until 2018

Employees: 257 FTEs, including 220 FTEs in the study centres

Interviewers: currently 110 certified interviewers; reinforcements planned, partly with additional assignments

The preliminaries for the NAKO have been underway since 2009. Initially, the participating Helmholtz Centres were financed from internal funds (premiums budget), while the universities and Leibniz Institutes had to tap their own budgets. The first BMBF grant was awarded at the start of the pre-test in September 2010. Financial problems nevertheless kept occurring until 2013 and had to be compensated for by extensive use of own resources, particularly for the design of the study.

Following a positive evaluation of the NAKO's scientific concept by an international panel in February 2011, the German Federal and States' Governments' Joint Science Conference (GWK) resolved the launch of the NAKO on June 29, 2012.

On May 1, 2013 the grant for the main study was issued. It is limited to April 30, 2018. However, a continuation until April 2023 has been notified. At present, however, no commitment has

been made for further funding. Altogether 25 research institutions from all over Germany are involved. The funding for the first ten years, amounting to 210 million euros, will be covered by public resources via the BMBF, the individual federal states and the Helmholtz Association. The participating institutions additionally contribute to the financing with about 30 percent from their own funds. These contributions are listed in the allocation decision and require verification.

The study is conducted by the project management organisation National Cohort e. V., which was founded in September 2013. The association's office is based in Heidelberg.

Due to the expiry of the current funding in April 2018, the employees in the study centres and central institutions of the NAKO are under fixed-term contracts. With a view to the successful implementation of the NAKO and its importance for epidemiological research in Germany, it is expected that funding will be continued beyond the current expiry date for a further fixed period.

Some of the study centres were fortunate enough to take over well-qualified and experienced staff from previous or ongoing studies. Those study centres that had only recently launched into epidemiological cohort research had to build up the necessary infrastructures, and it was sometimes difficult to recruit suitable staff. The qualification and training of these new employees was realised primarily within the NAKO by means of formal and informal measures for the transfer of knowledge, know-how and experience.

The data protection concept for the study was developed in close coordination with the Federal Commissioner for Data Protection and Freedom of Information. It is based on the experiences made in participating study centres and takes rel-

evant recommendations into account (the standards elaborated by the Telematic platform for medical research networks (TMF e.V.), the German Ethics Council's recommendations on biomaterials). All documents relating to data protection and ethics are available on the homepage of the association.¹⁷ The NAKO is monitored by an external ethics committee.

¹⁷ Cf. <http://www.nako.de> (accessed 3/16/2016).

c) The National Educational Panel Study (NEPS)

The *National Educational Panel Study* (NEPS) is one of the major interdisciplinary networks in the German human and social sciences sector. It is devoted to the longitudinal examination of educational processes and skills development from early childhood to old age, focusing on such questions as: How do cognitive and social skills develop over the course of a life? How are the relevant decisions made at the different stages of education? What influence does the social background have on the decision-making processes, directly or as secondary effects? How important are different learning environments for the acquisition of skills and for the individual education-related decisions at different stages of an individual's life? What interactions can be observed over time between educational institutions and non-formal/informal learning environments (such as the family, peers, the media)? How does the situation of migrants change over the course of their lives and across generations? What role does the first and second language play in this development? How does education pay off in different phases of an individual's life? How does education affect careers and incomes and such features as health, satisfaction and social commitment in the course of a life?

Budget: 85 million euros for 5.5 years

Third-party funding: 0 percent (as of 2014; previously 100 percent)

Duration: since 2006

Employees: 200

Interviewers: 1 100

Clearly, the issues examined by NEPS cannot be answered by one discipline alone, but require the joint expertise from different subject areas and research institutes. Against this background, a network of research groups from ten universities and non-university research institutions was established between 2006 and 2008, assembling leading experts from different disciplines in Germany to examine “The role of education in the life course” (Blossfeld et al., 2011).

In this development phase, the NEPS project plan was submitted to two international review processes by the DFG, in 2006 and 2008. Positive evaluation paved the way for funding by the BMBF from mid-2008 to the end of 2013. The DFG provided further support for the NEPS project in form of the accompanying priority programme 1646 *Education as a lifelong process*, in which scientists from different disciplines methodically process, edit and evaluate the NEPS data.

A further evaluation by the German Council of Science and Humanities in 2013 was followed by the institutionalisation of the NEPS consortium in a new Leibniz Institute for Educational Trajectories (LIfBi) at the University of Bamberg in January 2014. By adjusting the survey design, the consortium was able to compensate for the 10 percent budget cut which the transfer into the Leibniz funding system entailed.

d) The German Family Panel (pairfam)

As a sociological infrastructure, the *German Family Panel* (pairfam) provides data for the analysis of individual decision-making processes and long-term developments in the areas of couple relationships and family. The pairfam data allows for longitudinal analyses regarding e.g. the choice of a partner and the development of relationships as well as decision-making processes with respect to parenting and the arrangements for care and education in different family constellations and intergenerational relationships. Owing to its thematic focus, pairfam is essentially interdisciplinary in its scientific approach and in its staff composition, the main disciplines being sociology, psychology, education and demography.

During Wave 1 (2008/09), a total of 12 402 individuals from three birth cohorts were interviewed (anchor persons). They consisted of around 4 000 individuals respectively from the cohorts 1971-73, 1981-83 and 1991-93. The sample was randomly drawn from 343 registry offices throughout Germany. These anchor persons have since been surveyed annually by means of a computerised one-hour interview, carried out by TNS Infratest in Munich. Meanwhile (June 2015), seven waves have been conducted, six of which are available to the scientific community as Scientific Use File (SUF) (Brüderl et al., 2015a). The SUF is accessible via the GESIS data archive; the metadata is provided via a portal developed by SOEP at the DIW Berlin.¹⁸ Since the second pairfam wave, the MPI in Rostock surveyed an East German refreshment sample of about 1 400 anchor persons (DemoDiff), which has since been fully integrated into pairfam. This means that altogether 5 900 anchor persons participated in Wave 7.

Besides the anchor persons, their partners, (step)parents and children (between 8 and 15 years of age) are likewise interviewed. Pairfam thus attempts to depict the different perspectives on family relationships (Multi-Actor-Design). For a detailed description of the design of pairfam and the response rates cf. Brüderl et al. (2015b).

Budget: 2.5 million euros p.a.

Third-party funding: 100 percent

Duration: since 2004, until approximately 2022

Employees: 23

Interviewers: about 300

Pairfam was launched in 2004 as DFG priority programme 1161 *Relationships and Family Dynamics* for a duration of six years.¹⁹ This priority programme was initiated by five family researchers who wished to provide a solid data-base for international genealogy. The first four years of the priority programme served to prepare the main survey. In a pilot study (“Mini Panel”), more than a dozen research projects tested various instru-

ments to record familial processes. During the last two years of the priority programme, the first two waves of the main survey were conducted. In 2010, pairfam was transformed into a DFG long-term project with an expected duration of 12 years, viz. until 2022.

The regular preparation and documentation of data is a complex and time-consuming task and therefore constitutes an immense challenge for pairfam (as for panel studies in general). Particularly in the first waves, extensive data preparation and documentation routines

¹⁸ Cf. <http://www.paneldata.org> (accessed 3/16/2016).

¹⁹ On the substantive conception of pairfam cf. Huinink et al. (2011).

need to be developed. Unlike other studies, pairfam applied for, and was granted, a comparatively large staff (10 FTE). However, owing to the deficiencies in the training system and career paths illustrated in section 5.2, the attempts to recruit appropriate personnel at the post-doc level failed. The bulk of the data preparation was consequently carried out by PhD students – by rights an unacceptable state of affairs since they are thus left with hardly any time to pursue their own qualification objectives. Eventually, an increase of staff (to approximately 12 FTE) and the routine established in the course of several waves improved the situation. It is therefore important that care should be taken that new panel studies have adequately qualified and experienced staff at post-doc level from the start (cf. recommendations 5-7).

A further problem arises with regard to long-term funding (cf. section 5.1b). The combination of priority and long-term programmes secured pairfam a relatively long funding period of 18 years. Together with the well-established, scientifically adequate routines of the DFG, this amounts to an adequate funding. However, the DFG has made it very clear that funding will have to expire after the (maximum) twelve years in its long-term programme. Therefore, pairfam will probably cease to survey data after the year 2022.

e) The Survey of Health, Ageing and Retirement in Europe (SHARE)

SHARE, the *Survey of Health, Ageing and Retirement in Europe*, is a comparative pan-European survey with the aim of documenting and better appreciating the individual and social consequences of demographic change and also providing a sound scientific basis for the accompanying health and social policy measures. In a two-year sequence, SHARE collects data on health, economic status and the social inclusion of people over 50 years of age in 20 European countries, following an internationally rigorously harmonised survey structure and focussing on the interdependencies between the surveyed features.

The core concept of SHARE consists of three pillars: (a) a broad thematic and interdisciplinary approach, gauging the socioeconomic status and health as objectively as possible; this includes blood sampling and test batteries testing physical and cognitive faculties, (b) a longitudinal perspective, and (c) harmonising the survey instruments and methodology in all participating countries *ex ante*, thus enabling an internationally comparative analysis of the causes and effects of social, economic and health changes over the course of demographic change. Currently, the sixth wave of SHARE is being conducted, with 82 000 respondents giving computerised personal interviews of about 75 minutes length.

Budget: 12.5 million euros p.a.

Third-party funding: 94 percent

Duration: since 2004, until approximately 2024

Employees: 23 in the coordination centre in Germany, about 80 in the participating countries

Interviewers: about 2 000

For about two years, a large group of international researchers carried out the necessary preparations and successfully applied for funding within the then 5th Framework Programme of the European Commission. In 2002, SHARE started out as a fully EU-funded individual project (Börsch-Supan et al., 2013). Until 2007, SHARE was financed essentially by central funding from five other EU projects within the 6th Framework Programme as well as by two grants from the US National Institute on Aging (NIA). As the applications were reviewed as separate individual projects, they each had to revolve around a different thematic priority. The preparation of these applications – each about 100 pages long and requesting funds to the respective amount of about 3 million euros – tied up a significant part of the available manpower. The above-mentioned EU and NIA projects also financed the surveys in Germany. In addition, the DFG contributed to the funding of a methodological

experiment and of the SHARE Research Data Centre.

In 2008, SHARE was included as a priority project in the European roadmap of the European Strategy Forum for Research Infrastructures (ESFRI). It was thus subjected to a decision of the European Council specifying that the survey costs should be borne by the member states. In Germany, the BMBF provided the necessary funding as of January 2010 in form of a grant to the University of Mannheim. The European Commission remained responsible for the international coordination; to this end, three further applications were filed, once again with varying focuses.

In 2011, SHARE was constituted as a legal entity in the form of a European Research Infrastructure Consortium (ERIC). The BMBF, representing Germany, signed the corresponding treaty specifying the financial obligations for the member states.

It limits the duration of SHARE to ten waves in the first instance, i.e. until 2024.

When in 2011 the director of SHARE left the University of Mannheim and joined the Max Planck Society (MPG), the coordination office was likewise moved from the University of Mannheim to the MPI for Social Law and Social Policy. This led to uncertainty as to which institution was to take over the contractual obligations of the Federal Republic of Germany. According to an internal BMBF agreement (not applicable to universities), the construction of research infrastructures for the ESFRI Roadmap is to be financed by the BMBF, whereas the operating costs are to be borne by the respective non-university institutions. However, according to the current cost definition, longitudinal studies such as SHARE incur operating costs only. This point, unknown when the move from Mannheim to Munich was negotiated, was unacceptable for the MPG. A plan intending to share the burden between BMBF, MPG and DFG as of January 2015 likewise met with difficulties: not only is any preliminary agreement incompatible with the independence of the DFG review process, but the German SHARE initially failed to be granted the status of a DFG long-term project. In consequence, the costs for the German SHARE survey had to be jointly covered by BMBF and MPG project funds.

At the end of 2015, the German SHARE survey was included in the DFG long-term programme. The expenditures arising in Munich for the international coordination are jointly paid by the BMBF and the MPG; the remaining coordination costs are borne by the EU Commission. In total, SHARE is funded by no less than 64 different grants (situation in May 2015, only grants over 10 000 euros in the different countries).

There are 21 academic employees and two administrative employees currently working at the central coordination office

in Munich. Amongst the academic staff in Munich, five hold a PhD and seven work on a specific PhD project. In the non-economic subjects, the supervision of PhD students lies mainly with professors outside of Munich, which makes supervision more difficult. PhD students in economics are essentially managed by the academic director of the study and are integrated into the Munich Graduate School. One of the greatest challenges in terms of HR management is to ensure that employees involved in research are given enough time to pursue their scientific goals in addition to their coordination tasks. Another issue that gives rise to considerable friction is the loss of experience and knowledge due to staff turn-over amongst the senior executives. The MPG has no means of retaining highly qualified academic staff that have been offered a position at another research institution or a university. To be sure, this experience is but the negative side of scientific success: so far, three senior SHARE employees have succeeded in obtaining a W3 professorship (i.e. the highest salary level for professors in the German university system).

4.5 Development of organisational structures at home and abroad

The setting-up, implementation and sustainable data management of population-based longitudinal studies is a challenging task: for one thing, it requires the long-term availability of extensive research funds and considerable investments in building and infrastructure (such as study and research centres, test person management, data management including data security and IT). Moreover, success depends essentially on the commitment of a consortium of highly qualified scientists from relevant disciplines, responsibly organising and implementing the research work with competent, experienced and motivated staff. The scientific development was accompanied by the evolution of organisational structures, particularly in

the UK, that complied with these requirements and accelerated the scientific and organisational professionalization of population-based longitudinal studies. The following selected examples cannot claim to be representative of the international research community. However, they should serve to show adequately the opportunities and limits inherent to the organisational structures in this field of research. They will be clustered under the four categories “centres of excellence”, “study centres”, “collaborative research” and “networking projects”. For historical reasons, this type of research is still at an earlier stage of development in Germany; it is therefore very helpful to take a look at the international research community. Such best-practice collections must obviously consider certain specificities in the respective national conditions that will complicate both their applicability and their evaluation. Therefore, the following classifications and assessments of international examples are to be seen with regard to the recommendations for the situation in Germany only.

a) Centres of Excellence

Centres of excellence are a suitable form of organisation to meet the specific needs of population-based longitudinal studies. Typically, a centre of excellence is characterised by eminent researchers in a certain field of research adding to the distinction of their university’s research profile by successfully working at that university for a certain period, thereby creating science and research beacons and a momentum for growth.

The University College London (UCL) perfectly exemplifies the opportunities and limits of such a national centre of excellence. So far, there is no comparable centre of excellence in Germany.

The example of the University College London (UCL)

UCL is home to the currently most extensive and probably most productive centre

of excellence for longitudinal studies in the UK. It has evolved over decades, based essentially on the two longstanding British birth cohort studies (*MRC National Survey of Health and Development* (NSHD): *1946 Birth Cohort Study* and the *National Child Development Study* (NCDS): *1958 Birth Cohort Study* – the latter under the auspices of the Institute of Child Health (Centre for Paediatric Epidemiology and Biostatistics)) (Ferri et al., 2003; Power & Kuh, 2006).

In 1985, the so-called *Whitehall II* study was added, a longitudinal study with more than 10 000 men and women aged 35-55 years and employed as government officials in London. The study was initiated by Michael Marmot, director of the Department of Epidemiology and Public Health at UCL and longstanding manager of the study (Marmot et al., 1991). The *Whitehall II* study is the source of continuous publications noticeable both for their scientific quality and innovative approach (the most recent example is Zalli et al., 2014).

In 1999, a further study was established in that same department: the *Health, Alcohol and Psychosocial Factors in Eastern Europe* (HAPIEE) Study, devoted to the prospective study of urban populations in the age group 45-64 in three Eastern European countries (Pikhart et al., 2001).

In 2002, ELSA was launched with an initial sample recruited from previous survey waves of the *Health Study of England* (HSE) (12 100 men and women over 50). This multi-centre, interdisciplinary study was – and still is – conducted by the Universities of Oxford, Cambridge and Nottingham, along with the National Centre for Social Research, the Institute for Fiscal Studies and, finally, the Department of Epidemiology and Public Health at UCL, which is also responsible for the overall management (Banks et al., 2006).

The recent incorporation of the renowned London-based “Institute of Education” into UCL meant a further concentration of longitudinal studies under the umbrella of UCL: the Institute’s Centre for Longitudinal Studies has been and still is conducting various cohort studies, for instance the well-known *Millennium Cohort Study*²⁰.

Such a concentration of resources, organisational coordination and ongoing data collection and analyses combined with the presence of so large a number of acknowledged scientific experts appears to form the ideal conditions for the development of synergies. Incidentally, this cursory description of a research centre that is, after all, the result of a long development under specific conditions, is not to be understood as a general evaluation of the advantages and disadvantages of promoting centres of excellence.

b) Study centres

Basically, the purpose of a study centre is more modest than that of a centre of excellence: its task is to manage and coordinate a single scientific study. This study is, however, comprehensive and involves several institutions or locations. A study centre may of course evolve into a centre of excellence but this must not inevitably be the case.

Nevertheless, a study centre is indispensable for the development of research networks for longitudinal studies. By way of example, we refer to the French *CONSTANCES* study. The nearest German equivalent to such a study centre is probably the sophisticated infrastructure of SOEP at the DIW in Berlin (including training and guest programmes).

The example of the *CONSTANCES* Study in France

CONSTANCES is a representative epidemiological study of the adult population in France between the age of 18 and 69 years. Its objective is to gain new insights into the development of common diseases with complex genetic and environmental causes. The data is further to be used for health monitoring and epidemiological surveillance purposes (Zins et al., 2010). Currently, the first data collection is being conducted. By means of health check-ups offered in 17 regional health centres, 200 000 people with both a health insurance and pension schemes are to be recruited from amongst the population. The examinations follow a standardised study protocol and include a medical screening, the obtaining of laboratory data, a standardised survey (interview, questionnaire) and various functional tests (e.g. examination of an individual’s cognitive performance).

CONSTANCES has a particular structure insofar as the project is the result of an alliance between a scientific management committee from the university research group INSERM UMS011, the two national health and pensions insurance companies and the Ministry of Social Affairs and Health. This circumstance has far-reaching consequences for the intended linking of primary data with administrative data as well as for the long-term chances to secure funding for corresponding research projects.

Basically, *CONSTANCES* is a study platform, the organisation, operation and data management (including the establishment of a biobank) of which is in the hands of the scientific management committee at the University of Versailles. Quality control is secured by an external institution. As a platform, however, the study can be used by national and international scientific communities for integrated research projects where specific

²⁰ Cf. <http://www.birthcohorts.net> (accessed: 03/17/2016).

analyses of the centrally available data are required. The corresponding applications have to pass a three-stage evaluation by the so-called steering committee (consisting of the project management committee plus representatives from the project funding organisation), an international scientific advisory board, and finally the ethics committee of the national research organisation INSERM.

A first tender was limited to those research groups that were involved in the project development of CONSTANCES. Approximately 40 project applications were approved. It must particularly be noted that not only individual projects were selected, but also explicitly interdisciplinary thematic project proposals handed in by research consortia. Meanwhile, a second tender was launched for research projects centred on the analysis of data from the CONSTANCES study. Since this is addressed to international research groups, it opens up new vistas of transnational scientific cooperation.

c) Supra-regional research networks

The third form of organisation is frequently found also in Germany: the DFG's priority programmes and transregional collaborative research centres or the BMBF-funded programme research in the form of supra-regional research networks are cases in point. The organisational structures of NAKO, NEPS and SHARE are based on this well-established pattern. The new British public health funding initiative is an instructive example from abroad.

The UK Clinical Research Collaboration as example of a Public Health research association

The UK Clinical Research Collaboration aims at obtaining funds for research groups working on novel approaches for the prevention of widespread chronic diseases. It is a national tender upheld by eight different funding organisations as-

sembled under the umbrella of the Medical Research Council (MRC). Five groups were selected for funding: their eligibility was either due to a long-standing tradition in such fields as exercise and diet or drug consumption or to the fact that they submitted innovative programmes of behaviour modification and media influence. The bulk of the funds, amounting to 36 million British pounds over two five-year terms until 2018, was devoted to financing projects at the five selected locations. A modest part was reserved for coordinated activities between the five centres (methods exchange, education and training initiatives).²¹

That funds on such a scale could flow into the field of public health is due to the fact that in 2006, the MRC was commissioned to document the previous funding for the different fields of health research and to make the findings available to the public. The results were as follows: more than two thirds of all funds were used for basic research in the fields of life sciences and medicine, almost 20 percent for clinical research (including evaluation research), 5 percent for both research on the early detection of diseases and healthcare research and only 3 percent in the field of prevention research. In consequence, stakeholders from research policy called for an increase of funding for prevention research.

d) Networking projects

A distinctive feature of the funding of networking projects is that these projects are based on existing funding structures established by research networks and provide incentives for the specific development of synergies between the selected project partners. It is, in a way, project funding at a meta-level, launched in order to achieve optimal benefits from a decentralised research funding. This, in turn,

²¹ This and the following paragraph: Janet Valentine, personal statement at the hearing organised by the working group, Munich, July 3, 2014.

strengthens the national research position in the global competition. The British project *Cohort and Longitudinal Studies Enhancement Resources* (CLOSER) is an informative example showing that this form of organisation is based on a far more targeted approach than e.g. a DFG priority programme in Germany.

criteria, 34 long-term studies were selected for inclusion in the report. It was found that, in total, more than two million participants are involved in these studies and that more than half of the studies have already been conducted for more than 20 years (MRC, 2014).

CLOSER as an example for a networking project

The CLOSER programme²² is jointly realised by nine study teams and includes studies such as *Understanding Society* and the *Millennium Cohort Study*. Networking activities are organised in four working groups on “data harmonisation”, three working groups on “data linking” and a common educational and training programme for capacity building. In addition, the management team works on strategic planning issues for further research in the field. The British Library has the mandate to document the publication impact in this research field. This initiative is not least remarkable for its joint funding by the MRC and the Economic and Social Research Council (ESRC). It is to contribute to an optimal use of the results of complex and expensive longitudinal studies and enhance the value and impact of the collected data by fostering cooperation. In addition, the existing research resources are to yield useful results with regard to innovative issues relevant in various different studies. Long-term studies invariably exceed the usual funding periods. The strategic planning and the continuous exchange between researchers, sponsors and decision-makers in relevant policy fields is therefore a permanent challenge. CLOSER is a contribution towards meeting this challenge.²³ A recent survey by the MRC has revealed the extensive scientific potential of interdisciplinary cohort studies in the UK. In accordance with strict

²² Cf. <http://www.closer.ac.uk> (accessed: 03/17/2016).

²³ Heather Joshi, personal statement at the hearing organised by the working group, Munich, July 3, 2014.

5 Current challenges in Germany

5.1 Funding and organisational structures

a) Establishing new population-based longitudinal studies

Section 4.2 has shown that a very rich landscape of population-based longitudinal studies has evolved in Germany, even in international comparison (e.g. SOEP, NEPS, pairfam, NAKO, further epidemiological cohorts such as KORA). Germany also participates in international comparative studies (e.g. SHARE, household panels), with German institutions (MPG, DIW) playing a leading role.

This suggests that the institutional framework in Germany has allowed for the creation of numerous initiatives for new population-based longitudinal studies without requiring organisation through a centralised funding policy. The working group considers this approach of “Darwinian selection” helpful: while not hindering the emergence of new initiatives, those that are not very promising are quickly ended. The recent example of NEPS suggests that the launching of a new study – whether suggested by the scientific community or by political instances – should ideally begin with a peer-review-process within the DFG. This guarantees an excellent quality control and helps the respective team to successfully collaborate.

The diversity of the German studies and their very different institutional ties are, to begin with, of great advantage: they allow for competing scientific approaches and prevent the same mistakes from being made in different studies. This is all

the more important as opinions diverge as to the best scientific measurement approaches.

However, the study descriptions in section 4.4 have shown that the current financial, organisational (especially in terms of funding instruments) and to some extent intellectual infrastructure in Germany (especially in education and training) needs to evolve in order to allow for a sustainable implementation of population-based longitudinal studies at a high international level. Financial issues or problems with the organisational structure tend to occur at the “maturity stage” of such studies rather than at their “birth”, unless, of course, their realisation requires a large financial and organisational effort from the start.

The historical development of the existing longitudinal studies in the medical field has often been marked by great uncertainties, occasionally even by random coincidences. Not one of the longer-term cohorts is currently receiving significant funds from one of the established and quality-controlled research funding instruments (DFG, EU research funding). Rather, funding is frequently “split up”: as a rule, selected aspects will prevail in competitive application processes; the majority of the ensuing contracts will, however, exclude the logistics required for the study, such as examination centres, recruitment structures, respondent management, data management, data transfer and quality assurance. The result is a precarious potpourri making both medium-term planning and an appropriate human resources development impossible.

In order to compensate for the omnipresent financial bottlenecks, it is necessary to resort to cross-financing, own resources and “self-exploitation” of employees (and frequently even that of academic directors) of the studies. Instead of consistently pursuing medium- and long-term research goals, study teams are forced to act upon tactical considerations, always in the hope of obtaining the next grant. Structurally, the universities in Germany are in a far worse position than the government-funded non-university research institutions, since they depend to a far greater degree on external research funds while having to manage with a less developed infrastructure.

The NAKO constitutes a certain exception, the selected funding structure being, indeed, unique. During the planning phase of more than two years, funding was only granted to those participating institutions belonging to the HGF. The respective funds were taken from a separate in-house HGF budget. The participating universities and Leibniz Institutes, on the other hand, financed their work entirely from their own resources. In the pretest and pilot stages, project funding was granted by the BMBF. In the current main stage of the study (since 2014), the bulk of the funds is supplied by the BMBF, with most of the individual states co-funding on the basis of an agreement between the Federal Government and the individual states. Further federal funds are administered indirectly via the HGF. The participating institutions, mostly universities, must contribute own contributions of at least 30 percent.

In summary, it can be stated that there has been a substantial development of research in the field of population-based longitudinal studies in Germany which has received international attention. In order to continue successfully, certain changes in organisational, financial and science policy matters are required (cf. recommendations).

b) Continuing existing population-based longitudinal studies

As yet, Germany’s institutional landscape lacks a clearly defined process for establishing who will decide on the continuation of a population-based longitudinal study and when and how such a decision is to be made.

Two examples may serve to illustrate this. It has taken SOEP about 20 years to secure stable funding at the Leibniz Association. In terms of quality assurance, it was doubtlessly wise that SOEP did not receive a commitment for permanent funding from the outset, but was peer-reviewed and financed by the DFG (with an increasing share of special funds allotted to the DFG by the Federal and States’ governments). However, ten years lay between the German Council of Science and Humanities’ first recommendation for long-term funding of SOEP in 1992 and the panel’s incorporation into the infrastructure of the Leibniz Association.

Initially, SHARE was funded almost entirely by the European Commission. After three waves, funding was transferred from the Commission to the member states on the grounds of a decision made by the European Council. The result was that in the 6th wave, SHARE had to deal with 64 different funding bodies. Germany signed the statutes which constitute the legal basis of SHARE, but at that time failed to specify a funding source. Only later, this was fixed. It currently lies with four funding institutions.

In both examples, many funding decisions were taken without a long-term view and mostly on an ad hoc basis. The upshot was that the necessary longer-term orientation could only be established very late in the case of SOEP (in reference to the German Council of Science and Humanities’ first recommendation) and, so far, not at all in the case of SHARE.

NEPS constitutes an exception to this funding pattern: after only a few years, the Leibniz Institute for Educational Trajectories (LIfBi) was already founded in 2014 for the express purpose of endowing NEPS with full funding by the Federal Government.

Funding rules (e.g. of the DFG) give rise to some particular problems: long-term projects cannot be handed in as continuing projects, but must be applied for in the guise of new projects all over again. This is the case even if they do, in fact, continue a longitudinal study, which, true to the defining properties and structural and quality features of such studies, will invariably revolve around the same main issues. Examples include not only the above-described early stage of SOEP, but also the beginnings of the ALLBUS, a study significant for sociological research and the political sciences that was eventually institutionalised at GESIS. A current case is BASE, presently in the application process for its third stage. In all these cases, the further collection of data could not be named as the explicit objective of an application aimed at continuing an existing funding by the BMBF: until recently, the latter was not authorised to provide long-term funding. This requirement leads not only to a waste of time and resources spent on applications, but also to artificial alterations to the respective scientific content. This may complicate a successful application and result in opportunistic switches to other focus areas that do not necessarily have scientific priority.

A second funding provision, which hampers particularly, but not only, population-based longitudinal studies, is the limitation of DFG long-term projects to a period of twelve years. A prominent victim of this limitation is the cross-sectional replicative ESS, the further financing of which had to be improvised in Germany after its funding as a DFG long-term

project expired. An application for the funding of phase 8 (2016/17) has been submitted to the BMBF. Subsequently, a request for “a major strategic exception” will be submitted to the Joint Science Conference (GWK) by the Ministry of Science, Research and Art of Baden-Wuerttemberg.

Once its fourteenth wave will have been completed (i.e. in 2022), pairfam will be facing a similar situation. In this case, however, the financial uncertainties have far greater effects because unlike the ESS, pairfam is a genuine longitudinal study that depends on consistently interviewing the same people. The funding should therefore only be discontinued if an independent expert committee confirms a drop in or an absence of scientific results from the respective research infrastructure. In this sense, the limitation of the DFG long-term projects to twelve years is not appropriate if there is a continuing scientific interest in the study and neither the academic directors nor external experts consider that a termination is indicated.

In several cases, longitudinal studies evolved from one of the DFG's CRC's (for example SOEP and the GLHS from CRC 3 and SAVE from CRC 504). In this context, another funding provision impeding the establishment of long-term projects is the limitation of Collaborative Research Centres to a twelve-year term. To be sure, by combining the CRC funding instrument with the standard funding, a relatively long funding period can be achieved (especially if the DFG is provided with special funds for this purpose by the Federal and States' governments, as in the case of SOEP). However, this approach implies the aforementioned necessity to regularly “invent” a new project with new research content: under the standard procedure, a project may not be identical with the original CRC projects, even if it is, in fact, the same longitudinal study.

A clearly defined process for the continuation of population-based longitudinal studies should generally be based on criteria recognised by the stakeholders involved. Currently, however, various ad hoc appointed expert panels are developing criteria independently from one another. Consistent criteria for assessing the quality of the data, the previous results and the topicality of a population-based longitudinal study are missing.

A clearly defined process towards a stable long-term funding is also important because the value of longitudinal data increases exponentially with the number of study waves and the length and quality of the track kept on the participants. This is particularly true for causal analysis potentials. A further valuable asset of population-based longitudinal studies is that they survey the effects of historical and personal events that were not foreseeable when the study was started. This means that they will have collected data from the period prior to the event in question – which is essential for the causal analysis (cf. section 3.7, particularly the examples referring to the financial/economic/debt crisis and their impacts on income, social status and health).

Long-term financing structures are not least indispensable, because only they allow for an efficient HR development. This includes the longer-term extension of employment contracts or permanent employment as well as career opportunities for staff (e.g. remuneration above the pay scale for senior employees, continuing part-time qualifications and internationally recognised specialist careers, tenure tracks for senior academic staff or jointly appointed S-junior professorships, cf. section 5.2.).

c) Coordination problems between funding parties

A further obstacle to the scientific development of population-based longitudinal studies is the fact that the coordina-

tion of different funding parties tends to be fraught with difficulties. SHARE is a typical example where the attempt to coordinate BMBF, MPG and DFG initially foundered on the independence of the relevant bodies, not least of the peer review committees (cf. section 4.4). In this particular case, several inherent contradictions come to bear upon the process: the MPG's reticence to fund infrastructures, the independence of the DFG's reviewers process and the principle of the BMBF that non-university institutions should finance the operating costs of research infrastructure from their own funds (in the case of longitudinal studies, however, the collection of the data is included in the operating costs without any appropriate justification, cf. description below). Each of these three elements has an inner logic; in combination with the other elements, however, they can bring the financing of any project eligible for multi-party funding to a dead end.²⁴

The lack of coordination between the federal and state levels may likewise lead to contradictions, as the example of SHIP/SHIP-TREND goes to show. Here, the Federal Government suggests funding by the individual state, which is, however, partly offset against the allocations the University Medicine Greifswald receives from the government of the Land in question, i.e. Mecklenburg-Western Pomerania. In the case of SHARE, funds acquired from third parties are likewise offset against government funding, which makes third-party fundraising unattractive.

The lack of coordination between the different funding bodies is inconsistent with the fact that population-based longitudinal studies are national research infrastructures which constitute an indispensable basis both for socioeconomic

²⁴ We expressly point out that a leading member of the working group is coordinator of SHARE.

and biomedical research projects and for decisions in the fields of economic, social, labour, health and family policy. Their financial and organisational promotion should therefore be a national responsibility.

As far as physical infrastructure (buildings with large-scale appliances, research centres, etc.) is concerned, this is, indeed, recognised, since the Federal Government bears the respective construction costs. In the case of population-based longitudinal studies, however, the situation is far more complicated. This is a consequence of the inappropriate decision to classify all costs for the preparation of population-based longitudinal data as operational rather than construction costs. Although at first sight, this appears to be a mere accounting technicality, it does, in fact, constitute a heavy burden for population-based longitudinal studies. The upshot is that the bulk of the expenditures of such studies have to be borne either by the relevant ministerial departments or by the academic directors' parent institutions (often universities). With the exception of the HGF and the Leibniz Association, these parent institutions are, however, not endowed with investment funds for costly long-term projects, but are expected to fund ongoing research.

Classifying the development of population-based longitudinal studies and the necessary waves of data collection as operating costs is not appropriate: with a view to the purpose, i.e. the creation of a permanent research infrastructure, the process is comparable to the construction of large facilities in the natural sciences. Only after the data has been collected and a database has been created (with the corresponding construction costs) can the data be made available as a service to the scientific community (at the corresponding operational costs). Like large-scale facilities in the natural sciences, longitudinal studies begin with a construction

phase. During this period, the possibilities for cross-sectional analyses are rather limited, since the time intervals between the data sets are not yet sufficiently long. In large-scale facilities in the natural sciences, on the other hand, the regular extensions are, in accordance with the applicable rules, classified as construction costs. In the digital age, an equal treatment of population-based longitudinal studies cannot be declined on the grounds that they create not a physical but a predominantly electronic infrastructure. Ongoing operating costs, which include expenditures for data survey, harmonisation and standardisation, quality assurance, certification for surveyors, the construction of data management and data security, are therefore frequently a mixture of operating and construction costs. The development of population-based longitudinal studies creates jobs just as well as the construction of large-scale facilities in the natural sciences does.

d) Coordination problems between the national and European levels

The European and the German roadmap for research infrastructures likewise require better coordination. As the example of SHARE shows, German consent to a research infrastructure at European level does not automatically lead to the creation of a funding mechanism guaranteeing that this research infrastructure can indeed be established or further developed in Germany.

The fact that population-based longitudinal studies are national research infrastructures implies the necessity of centralised funds. The same is true with a view to research infrastructures that Germany has consented to within the European Roadmap. So far, however, there are no such centralised funds for transnational longitudinal studies. Instead, the necessary costs must currently be borne by the relevant departments in the BMBF. This naturally competes with the funds

for the ongoing analytical research. This situation calls for the establishment of a centralised national budget for European research infrastructures.

Finally, there is room for improvement from a scientific point of view as well when it comes to the coordination between the European and German levels. The purely national focus of the existing national longitudinal studies (such as SOEP and NAKO) is a case in point: a stronger network and harmonisation between prospective cohort studies could add scientific value while facilitating the data transfer across borders. A positive example here is the transfer office of the Community Medicine research association at the University of Greifswald.

e) Impediments to the interdisciplinarity of longitudinal studies

Interdisciplinary projects find it particularly difficult to obtain long-term funding: since research in practically all scientific institutions is divided up between the various disciplines, the protagonists of the individual disciplines are in a good position to assert their interests. This particularly affects projects in the context of population-based longitudinal studies, which are, for the greater part, based on an interdisciplinary approach. The assessment of such initiatives and research infrastructures within the DFG is still strongly “siloeed”. Assigning a project proposal to two disciplines of equal ranking for assessment is impossible in the DFG. Rather, the applicant is obliged to settle for either one discipline (e.g. biomedicine) or the other (e.g. economy). It is then up to the relevant scientific staff to assemble an interdisciplinary expert group, also including reviewers of the respective other discipline. This, however, does not always succeed.

In addition, the disciplinary width of the next higher level in the DFG review process is also rather limited: for historic

reasons, the DFG’s cross-section expert committee for long-term projects has a strong focus on Academies’ projects in the humanities. While this is well-founded if the research infrastructure in question is a long-term project in literary studies, it is not appropriate when it comes to population-based longitudinal studies. Even at that level, they would require the consultation of epidemiologists as well as of social scientists and economists. In the case of population-based longitudinal studies, however, there is currently no question of the disciplines involved in the respective research infrastructures being proportionally represented.

Greater cooperation between biomedical and socioeconomic research is also hampered by the fact that, unlike the situation in the USA (with the NIA) or the UK (with the close cooperation between MRC and ESRC) (cf. section 4.5), there are no specific tenders for biomedical-socioeconomic research cooperation in Germany.

f) Research versus service – conflicting priorities

Sociological longitudinal studies invariably require very costly infrastructures in order to develop the survey instruments, implement the surveys and prepare, document and circulate the data. Moreover, longitudinal data should and must be available to external data users as early as possible. In this sense, there is a strong service aspect to them. It would therefore make sense to interpret and develop the function and institutional context of such data along the lines of a scientific service facility.

This has sometimes induced the funding institutions to set up informal standards or conditions, on the one hand restricting the prompt use of the data by those responsible for its generation and/or their cooperation partners, and on the other hand reducing their expectations

regarding the number of substantive research contributions by the studies' employees.

On the basis of expert hearings, the working group considers both conditions dysfunctional – for two reasons: for one thing, longitudinal studies can only develop and maintain their avant-garde role in the world of research if those directly involved are more than mere data procurers and take over an active part in international research exchange. Their research contributions are of particular significance from a methodological point of view – which does not imply that they should be limited to that field. Additionally, external top researchers will only consider cooperation with such centres an attractive option if the employees of the centres are themselves internationally acclaimed researchers. There is a close link between the quality of population-based longitudinal studies and the scientific quality of their employees.

g) Data quality and documentation

As a rule, the monitoring and documentation of the quality and reliability of the data, including the sample quality, is realised by the external (commercial) survey institutes (in social science panel studies), the participating study centres (in the case of biomedical panels) and/or by the institutions implementing the panels. On the other hand, there is a growing tendency amongst the users of secondary data to disregard issues of data quality – which testifies to a somewhat naive approach. However, since these users are, without exception, “interested parties” who are generally rather reluctant to make the less positive aspects of the data collection public, analyses of the data quality should be carried out by external researchers with the appropriate funding.²⁵

In the recent past, the principle followed in most longitudinal studies, i.e. imposing the responsibility for the documentation and transfer of the data locally on the respective institutions of the “data procurers”, has, on the whole, proven effective. From the users' point of view, however, this decentralisation does not help towards finding ongoing and finalised longitudinal studies and examining their features. Incidentally, there are likewise deficiencies in some of the publicly available data documentations of ongoing studies (e.g. NAKO, where there is currently no list of variables online). If an adequate documentation cannot be realised within the respective study, an institution such as GESIS should take over the task of properly documenting finalised and ongoing longitudinal studies and should provide information about the conditions for accessing this data.

Cooperation with the existing data archives in Germany could likewise be improved in order to make data archiving and data access (including meta- and para-data) more efficient in the long run.

h) Unused potential of data linkage

In some cases, the potential of longitudinal studies can be considerably increased by combining them with each other and with other data sources. The combination of the GLHS's cohort studies and NEPS is a good example (Blossfeld et al., 2015). Since there is little sense in every user having to make these linkages individually, such infrastructure services should be eligible for particular funding, for example by the DFG. There are already internationally successful models for such a funding system, e.g. the Swedish Linnaeus database.

At present, the coordination of scientifically engineered longitudinal studies with process data from the public authorities is likewise effected ad hoc. Individual initiatives have either conducted a stochastic matching (e.g. SOEP, where similar households were linked on the basis of household

²⁵ Cf. the methodical studies by Solga (2001) and by Manzoni et al. (2011) on SOEP and the GLHS, as well as Reimer's paper (2005) on the reliability of retrospective data compared to administrative register data.

characteristics) or a record linkage (realised first for GLHS and SHARE, and later for SOEP; here, identical households are linked by means of the social security number) with data from the social security institutions. There is a lack of informational, legal and technical infrastructures here with which the potential of such linkages in other longitudinal studies such as the NAKO would become easier to realise.

i) Funding models abroad

Based on hearings with international experts as well as its own research, the working group has received a number of fundamental suggestions which are of interest to the organisation of the future development in Germany. In funding matters, however, experience with the current systems in other countries revealed a similar potential for improvement as in Germany.

In the Netherlands, the funding of social science and interdisciplinary biomedical-sociological longitudinal studies was discontinued despite an outstanding infrastructure for epidemiological research. This caused the collapse of the Dutch equivalent of the German SOEP as well as of the Dutch branch of SHARE. Their high initial investments in the first waves are therefore lost.

Denmark and Sweden have likewise experienced the difficulties of establishing interdisciplinary research infrastructures within disciplinarily orientated Research Councils (cf. section 5.1e). In Sweden, it took several years to establish an association along the lines of the cooperation between MRC and ESRC in the case of CLOSER (cf. section 4.5). Eventually, however, this association was able to finance SHARE in Sweden. In Denmark, on the other hand, the funding of SHARE via one or several Research Councils failed.

The US predecessor for SOEP, the *PSID* (cf. section 4.4), is obliged to procure

its funds by regular applications to the US National Science Foundation, following the “regular procedure”. The financing of the new *Understanding Society* panel in the UK is likewise subject to periodic new applications. It is not least due to the difficult financial situation and the resulting postponements of innovations that the scientific potential of the *PSID* has lately been lagging considerably behind *Understanding Society* and SOEP.

The US counterpart to SHARE, the HRS, is, on the other hand, a positive example. The bulk of the HRS funds are borne by the NIA, a member of the National Institutes of Health (NIH), in respective funding periods of six years.²⁶ This includes three waves every other year. There are several remarkable points regarding the HRS: for one thing, the NIA has extended the usual funding cycle from 5 years to 6 years especially for the HRS; for another, the continuation of an existing study does not have to be “disguised” as a new project; and finally, the financial volume of each six-year-period is substantial (currently about 90 million US dollars).

5.2 Employee training and career paths

a) Employee training

Germany has a large potential of highly qualified academic staff. However, the requirement profile for experienced senior staff in population-based longitudinal studies is so demanding and specific that a shortage results (cf. the experiences at pairfam and NAKO, section 4.4).²⁷

²⁶ Referred to as “Ro1” in US official language.

²⁷ The new occupation profile “market and social research assistant” was recently established (cf. <http://www.gofams.de/>, accessed: 17/03/2016), offering a specific vocational training for non-academic professionals. Research institutions can design these training units so as to ensure that scientific quality standards can be met. Since experience shows that at the end of the training, some of the graduates decide to take up a relevant study course, it can be expected that well-qualified undergraduate assistants will continue to be available for a certain time.

This situation is aggravated by the fact that there are few appropriate advanced training opportunities for employees in longitudinal studies, both with regard to scientific and methodological aspects and in terms of management skills. Certainly, there is a wide range of additional postgraduate qualifications, including national and international training courses; however, these cannot replace a scientific qualification enabling the respective employees to address the specific scientific and methodological requirements arising in population-based longitudinal studies. This problem becomes particularly apparent when social science aspects are to be connected with biomedical aspects. On a similar line, there are numerous training programmes for general research and project management, but nothing that could be applied to such complex, extensive and long-term projects as population-based longitudinal studies.

Typically, project staff are not only employed as scientists. This is particularly true for those whose responsibilities include the extensive management tasks usually arising in the context of population-based longitudinal studies. As often as not, these individuals are indeed experts from the very discipline (or related disciplines) in which the respective project is based – in other words, they will either have a social science *or* a biomedical background. They will, however, not have the necessary know-how in business or administration matters, let alone the training and experience of a professional manager. This state of affairs leads to the direct conclusion that the (senior) employees of longitudinal studies require further training programmes on several dimensions, including the fields of project and science management, interdisciplinary working methods and the profound methodological skills required for longitudinal studies. Only if “learning by doing” and “training on the job” are supplemented by such training programmes

can a professional management of longitudinal studies be ensured.

The existing options for project or science management training are suitable to only a limited extent for the specific skills required for employees in longitudinal studies. These options include, for example, the part-time study programmes Higher Education and Research Management (MBA) at Osnabrück University²⁸, Education and Science Management (MBA) at the University of Oldenburg²⁹, Innovation and Science Management (M.Sc.) at Ulm University³⁰ and the study programme Science Management (MPA) at the German University of Administrative Sciences Speyer³¹. The latter includes a basic module *Empirical Methods in Science Management*, which does, indeed, explicitly address the central interface between content and management aspects in empirical research projects. Nevertheless, such training programmes still require these senior academic employees in longitudinal studies to have a certain level of previous knowledge regarding the relevant scientific aspects of their respective tasks. In principle, the programmes are therefore suitable for the further qualification of those members of the academic staff entrusted with management tasks, without being customised to a specific field of expertise. Moreover, it is by no means clear that a truly part-time training programme along these lines is possible or indeed meaningful. It would, after all, require a significant part of the respective employee’s attention and resources for 3-6 semesters. This is contrary to two central points that were raised at the third expert hearing: for one thing, any formal

28 Cf. <https://www.hs-osnabrueck.de/de/studium/studienangebot/berufsbegleitend-studieren/> (accessed: 07/09/2015).

29 Cf. <http://www.mba.uni-oldenburg.de> (accessed: 07/09/2015).

30 Cf. <https://www.uni-ulm.de/einrichtungen/saps/studiengaenge/innovations-und-wissenschaftsmanagement.html> (accessed: 07/09/2015).

31 Cf. <http://www.wissenschaftsmanagement-speyer.de/> (accessed: 07/09/2015).

training is often incompatible with the time available for immediately applying and deepening the newly acquired skills; and for another, formal training tends to remain too abstract, as there is often no sufficient connection between the programme and the employee's specific situation.³² In principle, this is equally true even for less extensive training courses, as offered, e.g. by universities³³ or private providers.

Advanced training in social science methods, including longitudinal data, is subject to a dynamic development. However, the more specific the procedures, the harder it is for researchers to find a suitable training course, since the options are limited. This is partly due to the fact that potential suppliers have only limited capacities and find it difficult to estimate the demand. Suitable lecturers are also neither easy to come by nor, indeed, automatically available for such a job. Very specific offers are therefore best developed in close proximity to the leading organisations in current research, such as the relevant expert associations, research institutions or infrastructure facilities. So far, there is no integrated database for social science training programmes – neither in Germany nor at international level.³⁴ A single provider such as GESIS cannot cover the wide thematic range of methods for which offers would be desirable. Better networking, strategic alliances and new teaching and learning formats are required here; the asynchronous provision of online teaching materials, could, for instance, be very helpful. The working group is not yet aware of such a format in Germany.

A project currently being established is *RITrain*, based in Austria (with the participation of SHARE) and funded

by the European Commission. It is aimed at developing specific competences for the professional management of research infrastructures. Initial priority will be placed on the training of existing staff, especially those from biomedical research infrastructures; the long-term plan provides for the expansion of capacities, including a “Master in Research Infrastructure Management” programme.³⁵

b) Career paths

The available pool of qualified employees cannot unfold its full potential due to contradictions and deficiencies in the available financial, organisational and to some extent scientific infrastructure. These make it difficult to sustainably conduct population-based longitudinal studies (cf. Wagner, 2010; Richter & Wagner, 2015). The pivotal point in this context is that a job as (senior) employee in a population-based longitudinal study is difficult to reconcile with further career planning. This was already criticised by the German Council of Science and Humanities (2014) with a view to universities in general. The successful implementation of longitudinal studies, is, however, still more affected than short-term research projects, since they greatly benefit from their employees' long-term commitment. From the career-planning perspective of qualified employees, a longer-term commitment to such an infrastructure seems not always advisable. Whereas the study directors usually occupy permanent positions as professors or institute directors, senior staff on the second hierarchy level have no prospects of a career path beyond the mostly temporary posts in the academic mid-tiers. In order to overcome this inconsistency, predictable career paths should be created along the lines of the tenure-track principle, paving the way towards permanent employment.

³² Cf. Minutes from the third expert hearing, 11/4/2014.

³³ E.g. at the Technical University of Munich, cf. <https://www.rm.wi.tum.de/de/wissenschaftsmanagement/aktuelles-kursangebot/> (accessed: 07/09/2015).

³⁴ For an example from the UK, however, cf. <http://www.ncrm.ac.uk/training> (accessed: 03/17/2016).

³⁵ Personal statement by Markus Pasterk, BBMRI ERIC, Graz (Austria).

Three different types of employees can be distinguished: a) employees aspiring to an academic career – which, under the present conditions, is tantamount to aspiring to a professorship (particularly post-docs); b) employees whose career ambitions are geared rather towards the field of project management, and who, while not attempting an academic career, are possibly interested in working in an academic environment; c) employees who cannot be clearly assigned to either category, or rather who oscillate between them or are in a different position altogether, for example because they have not yet decided on their future path. These three types of employees are each confronted with specific challenges with a view to their career planning. This, in turn, may have consequences for the success of the research infrastructure as a whole.

For the first type, the infrastructural work necessarily arising in a study may conflict with their own interest in acquiring further academic qualifications – especially, if far-reaching management tasks are involved. Typically, this type of employee will aspire to a professorship – in the present situation indeed the only practical way to obtain permanent and independent scientific employment. Currently, this mainly involves writing and publishing scientific papers and procuring third-party funding. Owing to the higher complexity, longer duration and marked collective nature of longitudinal studies, their infrastructural interests and requirements are more likely to clash with the employees' academic career ambitions than most shorter research projects would. Longitudinal studies strongly relying on employees of this type therefore risk the neglect of important infrastructural work in favour of the respective employee's own scientific ambitions. This can affect the entire project or simply encumber other employees who have to compensate for such deficiencies. This dilemma can only be solved if all levels involved, right up to

the appointment committees, accept that greater formal recognition of other factors than well-placed articles and external funding should prevail. Recent developments might show a trend in this direction, e.g. regarding the citability of data by means of DOIs. However, this presupposes that the range of quotable sources is not confined to publications of the respective study's academic directors, and also that citations from articles and from data are accorded the same validity. With a view to their intended career path, these employees typically remain on the project only for a relatively short period before taking up a professorship or a position bringing them closer to this goal. At the same time, a high degree of specialist expertise and methodological skills as well as corresponding motives and orientation is essential for longitudinal studies: such competences are vital for the cooperation with data users and to ensure a science-driven climate in the project team. Longitudinal projects should hence offer at least medium-term employment contracts along with the possibilities of adequate scientific qualification, for instance by cooperating with universities to establish part-time professorships.

Whereas working for a research infrastructure may clash with an academic career, the second type of employee, who "simply" aims at successfully managing a study, has no prospect of any career beyond the duration of the project. In practice, experienced senior employees, whose tasks are mainly or entirely in the management line, are usually employed as researchers in order to ensure an adequate remuneration for them. In some cases, however, the individuals in question have neither the ability for nor any interest in a scientific career targeted at a professorship. At the same time, the wealth of experience these employees have in the respective research infrastructure is indispensable and should be retained. It is important to create structures providing

long-term funding and career opportunities for employees in this category, because the implementation of population-based longitudinal studies is a time-consuming undertaking tying up extensive resources. As long as such structures cannot be ensured, the employees' lack of perspective, both regarding the overall time-frame and the further development of income opportunities, constitutes a risk to the sustainability of longitudinal studies. The obvious advantage of selecting this type of employee for management tasks is a higher professionalised project management. But here, too, employees will tend to quit before their time, if the non-academic job market offers permanent and better-paid positions and there is normally nothing on offer to retain them.

The overall situation therefore calls for the creation of career paths offering senior staff permanent employment as "laboratory directors". For university staff, the German Council of Science and Humanities has recommended the establishment of two career options: firstly, a career path using the *tenure track* to obtain a professorship and, secondly, the possibility of obtaining a permanent position as a researcher or lecturer for special tasks.³⁶ Similar to the tenure track for a professorship, permanent jobs with a remuneration of up to W2 (i.e. the mid-level salary for professors in the German university system) could be created for senior employees, who would thus have the assurance of continued employment even after the expiration of the project.

The third type of employee is in a – sometimes lengthy – phase of transition to one of the other two types, or out of the academic system altogether (although the systemic context often leads to the implicit assumption of an academic orientation). Employees of this type, especially if

they are strongly tied up in infrastructural work, run the risk of losing touch with scientific developments. Possibly, this is particularly true for external PhD students from non-university research institutions who are not integrated into any structured graduate programme or university teaching. The difficulty with this group is to fix on an employment term that keeps the balance between the different conflicting aspects, i.e. medium-term planning security for the staff, infrastructural work and incentives for further academic qualifications. One point to be taken into account either way is the strong probability of extended PhD research periods.

With regard to the second type of senior employee, it is up to the universities and research institutes hosting longitudinal studies institutionally to create permanent positions or career paths with the prospect of permanent jobs. Insofar as the project-related tasks these employees perform are not permanently required, the institutions hosting the respective longitudinal studies are confronted with the problem of finding other positions for employees with unlimited contracts once the project has expired. This is possibly less of a problem for research institutes than for universities, since they provide, at least partly, for suitable positions.³⁷

Switching to a corresponding infrastructure seems at first an obvious option. Not least with a view to encouraging such a result, better process harmonisation of, for instance, sample management, field management, data processing, and documentation is needed – including interdisciplinary or cross-disciplinary approaches. This would not only mitigate the threat

³⁶ Cf. German Council of Science and Humanities (2014): <http://www.wissenschaftsrat.de/download/archiv/4009-14.pdf> (accessed: 03/17/2016).

³⁷ Here, reference can be made to the different proportion of permanent employees in the total academic staff in non-university institutions (average: 46 percent) and in universities (average: 31 percent). However, the percentage also varies significantly between different research institutions, from an average of 30 percent at MPG institutions to an average of 55 percent in the case of HGF institutions (cf. German Council of Science and Humanities, 2014).

of unemployment for temporary employees once the project has ended. It would also reduce the risk for the institution of having to continue to employ a permanent member of staff without an appropriate field of activity.

A further option would be to integrate staff of this type into university teaching structures, particularly in the still underdeveloped field of training young researchers for longitudinal studies. Creating suitable programmes at universities and an early involvement of senior staff from associated longitudinal studies as lecturers would make it easier to set up permanent positions, since such jobs require a long-term commitment. In terms of models of good practice, reference can here be made to the Scientific Council's recommendations to expand long-term employment as well as to the "Anglo-Saxon model", boasting a much higher share of permanently employed scientists.³⁸

As long as a longitudinal study is not established at a research institute as a permanent project, but is financed from third-party funds, a majority of the staff will have to be employed on the basis of fixed-term contracts. These employees should at least have the possibility to enter into longer-term contracts or else to have successive fixed-term contracts. Here, the German Act of Parliament on Fixed-term Employment in Research (*Wissenschaftszeitvertragsgesetz*, § 2 para. 2 *WissZeitVG*) provides an applicable basis. If long-term funding is secured, longer-term contracts can be entered into. Similarly, the timely guarantee of a further funding period will enable the prolongation of existing contracts. Turning away from this possibility would considerably hamper the successful implementation

of longitudinal studies, because even projects with a long funding horizon or projects that were granted an extension of the funding period after successful evaluation would be unable to build up a stable workforce.

France is presently experiencing precisely such a situation: employees with a fixed-term contract are dismissed after three years at the latest unless they can be offered a permanent position.³⁹ As a consequence, the continuation of SHARE in France is currently in jeopardy. The first expert hearing identified the impossibility of employing permanent staff as the biggest structural problem for long-term studies. At the same time, the basic possibility of repeatedly concluding fixed-term contracts, if sound reasons should make such a solution eligible, was underlined as an important prerequisite for the successful implementation of longitudinal studies. Incidentally, appropriate rules are in force in both the UK and Germany.⁴⁰ The new legal structure of ERICs could indeed be useful, but only partly and only at the international level, since ERICs are detached from national labour laws.

5.3 Student training and capacity development

Population-based longitudinal studies revolving around central issues in the fields referred to in chapter 3, i.e. human development, health, education, training and labour market participation and success-

³⁸ According to the Higher Education Statistics Agency (HESA), in the academic year 2011/2012, at least one third of the academic staff at UK universities and a quarter of the full-time researchers had fixed-term contracts (cf. <https://www.hesa.ac.uk/news/17-01-2013/sfr185-staff>, accessed: 03/17/2016).

³⁹ The legal basis for this is intended as a measure for the protection of workers. According to the Directive 1999/70/EC of the European Council of June 28, 1999 on the implementation of the framework agreement on fixed-term work concluded by ETUC, UNICE and CEEP, member states are required to take one or more of the following steps to prevent abuse by successive fixed-term employment contracts or relationships: a) determine objective reasons justifying the renewal of such contracts or relationships; b) determine a maximum total duration of successive employment contracts or relationships; c) determine the permissible number of renewals of such contracts or relationships (§ 5 para. 1 of the framework agreement).

⁴⁰ Cf. Minutes from the first expert panel on 05/12/2014.

ful ageing, require specific methodological expertise. To this must be added the ability to merge knowledge from various disciplines in order to address innovative issues. The methodological competencies include skills like the development of study designs and of evaluation methods – particularly in the fields of social and behavioural sciences and economics (e.g. computerised data collection instruments). A further element are appropriate monitoring processes to ensure that the implementation of population-based surveys complies with the relevant quality standards. The following skills are of central importance: knowledge of the necessary statistical methods of data analysis (including the analysis of longitudinal data and multi-level analyses), knowledge of meta-analytical techniques and in the field of large-scale data processing, including the key elements of data security and data protection. Interdisciplinary work in this field of research requires above all the ability to connect knowledge and methods from the social and behavioural sciences with biomedical questions and processes. This is particularly evident in the fields of epidemiology and demography.

As a rule, neither the established university training programmes nor the graduate schools and postgraduate training programmes supporting young scientists take these requirements adequately into account. They are, however, an essential part of postgraduate programmes aimed at developing capacities in the field of population-based longitudinal studies.

a) University education programmes (Bachelor, Master, diploma, state examination):

Basically, a two-stage course of studies (undergraduate and advanced graduate studies) can be considered a reasonable system. However, undergraduate students will rarely be aware of interdisciplinary work or of the importance of establishing data sets. This is true both for medical and socioeconomic undergraduate training.

The most propitious course of studies with a view to analysing data is, indeed, statistical training in economics and the social sciences. Especially in economics, modern econometrics has prevailed. Here, however, stronger reference should be made to specific data sets to help students understand the practical application.

Medicine

As a consequence of nationally standardised examination rules, the educational content of medical studies is heavily regulated. Knowledge and skills in the fields of epidemiology, medical sociology, economics, biostatistics, etc. play but a marginal role. There are, however, exceptions in the form of pilot study programmes: the Mannheim curriculum is currently the most advanced attempt to integrate skills from the fields of health economics, business administration and public health into medical studies early on. As a general rule, however, young scientists in population research require an additional postgraduate qualification (cf. below).

Social Sciences and Economics

Data analysis training in sociology and economics is generally sound. Nevertheless, both fields of study share the same deficiencies with a view to longitudinal studies: neither are the necessary methodological skills taught in sufficient depth, nor are interdisciplinary work processes (for example, with clinical medicine) adequately taught and encouraged. In econometrics, there is often no reference to specific data and their difficulties; data collection and survey methodology are usually omitted altogether: data comes from the Ethernet. In sociology and demography, for instance, only a few locations (Bremen, Mannheim, Berlin's Humboldt University, Rostock, Bamberg, Duisburg-Essen) offer specialised courses in survey methodology or longitudinal data analysis. Mannheim is currently preparing a Master's programme in survey management in cooperation with GESIS.

Health sciences

In the context of the Bologna reforms, several countries have established bachelor and master's degree programmes in "Health Sciences", an interdisciplinary new study programme, which, however, lacks consistency in terms of content and methods. The nearest to this new curriculum is the formerly exclusively postgraduate "Master in Public Health". In Germany, these study programmes are, for the greater part, located at technical colleges; only the universities of Bielefeld, Charité Berlin and Bremen offer undergraduate studies in Public Health. However, the skills acquired in these studies usually do not offer sufficient qualification to start a career in the research fields discussed in this paper.

b) Post-graduate degrees (Master programmes Public Health, Epidemiology and related fields)

This field has seen a very dynamic development over the past two decades. At least seven universities offer accredited continuing education courses in Public Health (Charité Berlin, Bielefeld, Bremen, Technische Universität Dresden, Düsseldorf, Hannover Medical School, Ludwig-Maximilians-Universität München). A similar development can be observed in further education programmes in epidemiology. These are realised and in most cases coordinated by the universities of Bielefeld (in collaboration with Duisburg-Essen, Münster and Düsseldorf), Mainz and the LMU Munich. Munich further offers a Master in Clinical and Genetic Epidemiology, Heidelberg a Master in Biometry/Biostatistics, Leipzig a Master in Clinical Research and Translational Medicine as well as a Master in Health Informatics, Greifswald a Master in Community Medicine and Epidemiologic Research, and Halle (Saale) a Master in Health and Nursing. Assuming that each programme has an average of 20 places, there should be a sufficient number of young professionals available for the research requirements discussed.

It then remains to be assessed whether the graduates are sufficiently qualified to meet the specific requirements.

In addition, some of the above-mentioned universities offer summer or winter classes providing specialised knowledge in the fields of epidemiology and biostatistics. These programmes are partly coordinated by the relevant professional association.

In the social sciences, there is likewise a wide range of summer or winter classes and thematic workshops, developed and carried out nationwide by GESIS.

The predecessors of GESIS, in particular the Central Archive for Empirical Social Research (ZA) in Cologne and the Centre for Survey Research and Methodology (ZUMA) in Mannheim, have offered scientific methods training since the 1970s. Rather than merely continuing these classes, GESIS has substantially extended the programme in recent years, for instance by establishing the new GESIS Summer School in Survey Methodology (since 2012) and expanding the GESIS workshops. In 2014, the number of participants rose for the first time to more than 1 000, including over 50 percent doctoral students and 25 percent students from abroad. There are annually 50-60 classes revolving around social science methods that are addressed not only to social scientists, but to everyone wishing to learn and apply the respective methods. An interdisciplinary and international range of participants is explicitly desired. Owing to cooperations with universities, course attendance is increasingly rewarded with ECTS credits. Courses on the methods of longitudinal analyses, however, are so far only offered sporadically and are at best fragmentary. In particular, the systematic introduction to both algorithmic (e.g. sequence analysis) and probabilistic methods (event analysis, latent growth models) is omitted completely. It is

paramount that the existing range of classes should be extended rapidly with regard to the methods of collecting and analysing longitudinal data.

c) Doctoral schools

In the field of demography, an eleven-month training programme has been established over the last decade: the “European Doctoral School of Demography” (EDSD)⁴¹, addressing students with a Master’s degree in the first year of their PhD. At this doctoral school, students are provided with solid basic knowledge of the causes and consequences of demographic change, of population data, of statistical and mathematical demography as well as modelling, simulation and prognoses. The lectures are given by leading international experts in their respective field of expertise. The curriculum has a special focus on survey methodology and statistical methods for panel analyses.

In cooperation with the University of Rostock, the MPI for Demographic Research in Rostock hosts the training programme *International advanced studies in Demography*. Here, too, the focus is on the analysis of survey data.

SOEP offers a targeted further training course (SOEP@campus). The curriculum includes more than a dozen further training units per annum. A junior professor, jointly appointed with Bielefeld University, is exclusively employed for this purpose.

d) Support programmes for quality and continuity

Despite the fact that university teaching and research boast a number of appropriate models at international level, special support programmes (based on additional funding) are usually required to ensure their quality and continuity. Two examples from the UK will serve to illustrate this.

For one thing, the British ESRC has launched a multiannual programme to promote knowledge and skills at the interface between social and economic research and epidemiological methods. The coordination is ensured at the national level by the National Centre for Research Methods in Southampton, which has joined forces with the Universities of Essex, Manchester and Edinburgh in respective cooperation projects. The funding programme provides for three training levels: undergraduate and graduate studies; doctoral programmes; postgraduate programmes. In the context of this statement, the third funding level is of particular interest.⁴²

A second example is the above-mentioned project CLOSER (cf. section 4.5). The central activities of CLOSER include the development and implementation of training courses at three levels. The first level covers special introductory classes for young professionals. This includes elements like the introduction of necessary software programmes, and supervised exercises in data analysis with a data set specially established for that purpose. The second level addresses advanced students and offers in-depth courses on central methodological and substantive issues from the ongoing studies. So far, workshops have been organised on the following topics: progressive processes of data harmonisation; integration of biological and sociological data; linkage of primary and administrative data. The third level covers specialised knowledge regarding problems that arise during research. This includes experts presenting new statistical methods for the analysis of longitudinal data or discussing theoretical models of life course research. The procedures for comparative cross-study analyses are accorded particular priority.⁴³ Here, the ISER at the University of

41 Cf. www.eds-demography.org (accessed: 03/21/2016).

42 For details cf. <http://www.ncrm.ac.uk> (accessed: 03/17/2016).

43 Cf. <http://www.closer.ac.uk> (accessed: 03/17/2016).

Essex plays an important role, as it hosts the study centre of the longitudinal study *Understanding Society*. A separate chair for biological and social epidemiology was, for instance, established at the ISER, which is to merge the components from social science analyses with the respective components from biomedical examinations and explain the process to young scientists. In the fields of health research and survey methodology, ISER also offers PhD studies with a specific reference to ongoing cohort studies.⁴⁴ CLOSER will be funded until 2017. An extension of the programme to the international level is currently under consideration. This initiative is not least in Germany's interest (cf. chapter 6): it is significantly cheaper to invest in high-quality secondary data analyses, in the linking of primary data with administrative data and in cross-study data analyses by scientific networks than to initiate new studies. In this process of international cooperation, transnational expert panels and professional associations play an important role. Primarily, this relates to the Society for Longitudinal and Life Course Studies (SLLS), the European Society of Epidemiology, the European Society of Epidemiology, the European Public Health Association (EUPHA) and the European Society of Health and Medical Sociology (ESHMS).

44 Cf. <http://www.iser.essex.ac.uk> (accessed: 03/17/2016).

6 Recommendations

The working group makes the following recommendations to address the current challenges in Germany as identified in chapter 5:

Recommendation 1: National funding initiative for interdisciplinary longitudinal studies

- 1.1 Population-based longitudinal studies are national research infrastructures that constitute an essential basis for demographic, biomedical, socioeconomic and behavioural research projects (often conducted in an international context). Their financial and organisational support should therefore be a national responsibility.
- 1.2 The working group recommends a national funding initiative to strengthen interdisciplinary cooperation in the realisation of population-based longitudinal studies, in particular between the biomedical and socioeconomic sciences. It recommends that specific tenders are made for biomedical socioeconomic research cooperations, following the example of the US National Institute on Aging or that of the close cooperation between the Medical Research Council and the Economic and Social Research Council in the UK.

Recommendation 2: Long-term funding instruments

- 2.1 The working group recommends the expansion and creation of such support instruments as will provide for a funding of research infrastructures, the financing of which may be extended unlimitedly on the basis of periodic assessments and as long as the scientific relevance and quality

exist. To this end, the ongoing planning for new admissions to the Leibniz Association should provide for the expansion of Leibniz Institutes as infrastructure facilities for longitudinal studies. In this context, use should be made of the new possibilities which the amendment of Art. 91b para. 1 of the German basic law (GG) opens up with regard to the establishment of the Leibniz Institutes as Leibniz University Research Centres.

- 2.2 However, establishing and founding an institute (whether non-university or associated with a university) with Federal and States' funds, is not always the right solution. As an alternative form of temporary institutionalisation, the working group therefore also recommends abolishing the existing twelve-year limit for DFG long-term projects: with regard to the longitudinal studies in question, this period is deemed inappropriate. Furthermore, the review period of three years is too short and collides with the interview cycles of many longitudinal studies. The procedure should hence be extended to 5-6 years in accordance with the standards of the US National Institutes of Health.
- 2.3 Within the DFG, the evaluation of such initiatives and research infrastructures should be "unsiloed"; rather, the specific potential of the German scientific community's comprehensive network should be tapped. In long-term projects, the respective cross-sectional expert committees should be proportionally composed of scientists from the research fields responsible for the development and

operation of the respective research infrastructures, complemented by experts from existing infrastructures.

- 2.4 The currently applicable decision to classify all the costs for the preparation of population-based longitudinal studies as operating costs is likewise inappropriate. Both in substance and organisation, the establishment of such national research infrastructures is comparable to the creation of large-scale physical equipment. Expenditures for data survey, harmonisation and standardisation, quality assurance, certification for interviewers and setting up data management and data security should consequently be recognised both as operating and construction costs. This is particularly indicated since the development and operation of population-based longitudinal studies creates jobs just as well as, for example, the construction of large-scale physical equipment does. The working group therefore recommends the establishment of a budget item for biomedical socioeconomic research infrastructures in the Federal research budget, possibly by resorting to Art. 91b GG, which enables the extension of Federal funding to up to 90 percent.

Recommendation 3: Better coordination with the European level

- 3.1 The working group recommends a better coordination between the European and the German roadmaps for research infrastructures. This requires in particular that a German consent to a research infrastructure at the European level entails the creation of a funding mechanism to ensure that this research infrastructure can indeed be established or further developed. With a view to recommendation 2.4, this particularly includes a dedicated budget for research infrastructures in the context of the ESFRI roadmap.

- 3.2 Furthermore, the existing national longitudinal studies (e.g. the National Cohort in Germany and the CONSTANCES study in France; the HLS study in the UK, SOEP and several associated and cooperating prospective cohort studies) require better cross-border harmonisation. Likewise, international data transfer systems fulfilling the relevant data protection requirements should be simplified (e.g. transfer office of the research association “Community Medicine” at the University of Greifswald).

Recommendation 4: Resources for data harmonisation, documentation and linkage

- 4.1 In order to intensify the interdisciplinary use of longitudinal studies, possible harmonisations between the individual studies should be identified and extended to include the pooling of data.
- 4.2 To enhance user-friendliness, the information on the design and data content of surveys should be consistently processed and made centrally available. This should be realised in accordance with the standardised procedures for a user-friendly provision of longitudinal metadata.
- 4.3 Data access should be simplified by a cross-survey web-based portal.
- 4.4 Legal and technical possibilities for linking survey and administrative data should be extended (“data matching and linkage”); the same applies to the linkage of population-related data with geo-referenced environmental data. Data protection and ethical requirements regarding the interactions with respondents should also be ensured. All this requires additional resources that should be provided for in a study’s funding scheme.

Recommendation 5: Career paths for senior study employees

- 5.1 Whereas the academic directors of studies usually occupy permanent positions as (often jointly appointed) professors or directors of institutes, the senior employees at the second hierarchy level have no prospects of any career paths beyond the mostly temporary posts in the academic mid-tiers. So far, even in non-university institutes, where the conversion of a temporary contract into a permanent one is generally possible, no regular career paths have been developed for senior staff of longitudinal studies. However, these employees have an indispensable wealth of experience in the field of population-based longitudinal studies. The working group therefore recommends the creation of career paths analogous to tenure-track professorships, offering senior staff permanent employment as “laboratory directors” with remuneration up to the level of W2 professorships.
- 5.2 Relevant initial and advanced levels of qualification should be guaranteed in accordance with the following recommendations.

Recommendation 6: Advanced training programmes for senior study employees

- 6.1 Senior study employees should receive a structured advanced training in research and project management and this should be a precondition for advancing on the career paths proposed in recommendation 5. Although there are numerous training programmes for general research and project management, nothing appropriate exists for such complex, extensive and long-term projects as population-based longitudinal studies. Appropriate courses should be embedded in the structures proposed in recommendation 8.
- 6.2 The working group further recommends the establishment of an academic training scheme for senior study

employees, especially in non-university research institutions. This would mainly imply a better integration into the respective universities and graduate schools, prospectively enabling them to take over the supervision of doctoral students with empirical focus. This requires a study funding which takes the necessary extra time for training into account.

Recommendation 7: University curricula

- 7.1 The university curricula for the relevant core disciplines should include a targeted knowledge and skills development scheme in their basic training units. This is necessary to meet the increasing need for qualification and to raise the German research efforts in the field of population-based longitudinal studies to a high-quality level that will ensure long-term competitiveness.
- 7.2 In sociology and economics, data-analytical education is generally sound; there are, however, deficiencies in the field of data-generating training. This could be remedied by establishing Master’s programmes and specialised courses on survey methodology and data collection. This is likewise indicated in the fields of political sciences and psychology. In addition, appropriate Master’s programmes with a thematic and methodological focus in the field of health and medical sociology should be developed at individual universities.
- 7.3 In the field of medical studies, methodological skills of data collection and analysis should be included in the existing curricula for epidemiology and Public Health. It is also recommended to promote pilot study programmes offering medical students the option of obtaining an additional qualification in a subject area relevant for population-based health research.
- 7.4 Medical practitioners interested in further research after their graduation from medical school should have easier access to post-graduate part-time

training programmes (particularly Master of Science in Epidemiology, Master of Science in Public Health). The existing post-graduate degrees should be further developed so as to keep pace with leading international training programmes.

Recommendation 8: Capacity development through promotion of young scientists

- 8.1 The number of young scientists in the field of population-based longitudinal studies should be substantially increased and better supported by cross-regional doctoral programmes and post-doctoral training offers. A range of additional postgraduate qualifications and of national and international training courses does already exist but these do not provide a scientific qualification that will enable a researcher to address the specific scientific and methodological requirements arising in population-based longitudinal studies. This problem becomes especially apparent if social science aspects are to be connected with biomedical findings.
- 8.2 Suitable tailor-made qualification programmes should be developed for and within individual institutions as well as in cross-institutional cooperations. This could be realised either within the continuing education programmes of GESIS, or at the DFG-funded graduate schools or – in a joint approach with collaborating study centres – as a national funding initiative, modelled, for instance, analogous to the British CLOSER project.
- 8.3 In addition to supporting the development of scientific personnel, an appropriate national funding initiative should focus on strengthening interdisciplinary research cooperations.

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8 List of Abbreviations

| | |
|-------------------|---|
| ALLBUS | German General Social Survey (Allgemeine Bevölkerungsumfrage der Sozialwissenschaften) |
| BA | German Federal Employment Agency (Bundesanstalt für Arbeit) |
| BASE | Berlin Age Study (Berliner Altersstudie) |
| BBMRI-ERIC | Biobanking and BioMolecular Resources Research Infrastructure |
| BCS70 | British Cohort Study |
| BHPS | British Household Panel Survey |
| BIP | Bonn Intervention Study |
| BLK | Federal and States Commission for Educational Planning and Research Promotion (Bund-Länder-Kommission für Bildungsplanung und Forschungsförderung) |
| BMBF | Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung) |
| BMFSFJ | Federal Ministry of Family Affairs (Bundesministerium für Familie, Senioren, Frauen und Jugend) |
| CAPI | Computer Assisted Personal Interview |
| CEEP | European Centre of Employers and Enterprises providing Public Services |
| CILL | Competencies in Later Life |
| CILS4EU | Children of Immigrants Longitudinal Survey in Four European Countries |
| CLOSER | Cohort and Longitudinal Studies Enhancement Resources Project |
| CONOR | Cohort of Norway |
| CONSTANCES | Epidemiologic cohort study at the Centre de recherche en épidémiologie et santé des populations (CESP) |
| CRC | Collaborative Research Centres of the German DGF (Sonderforschungsbereiche) |
| DAAD | German Academic Exchange Service (Deutscher Akademischer Austauschdienst) |
| DBS | Dried Blood Spot |
| DEAS | German Ageing Survey (Deutscher Alterssurvey) |
| DEGS | German Health Interview and Examination Survey for Adults (Studie zur Gesundheit Erwachsener in Deutschland) |
| DemoDiff | Demographic Differences in Life Course Dynamics in Eastern and Western Germany |
| DFG | German Research Foundation (Deutsche Forschungsgemeinschaft) |
| DIMDI | German Institute for Medical Documentation and Information |
| DIW | German Institute for Economic Research (Deutsches Institut für Wirtschaftsforschung) |
| DOI | Digital Object Identifier |
| DZA | German Centre of Gerontology (Deutsches Zentrum für Altersfragen) |

| | |
|-----------------------|---|
| EATRIS | European Infrastructure for Translational Medicine |
| ECHP | European Community Household Panel |
| ECTS | European Credit Transfer and Accumulation System |
| EDSD | European Doctoral School of Demography |
| ELIXIR | European Life-sciences Infrastructure for Biological Information |
| ELSA | English Longitudinal Study of Ageing |
| EMBL-EBI | European Bioinformatics Institute at the European Molecular Biology Laboratory |
| EPIC | European Prospective Investigation into Cancer and Nutrition |
| ERIC | European Research Infrastructure Consortium |
| ESFRI | European Strategy Forum for Research Infrastructures |
| ESHMS | European Society of Health and Medical Sociology |
| ESRC | Economic and Social Research Council |
| ESS | European Social Survey |
| ETUC | European Trade Union Confederation |
| EUPHA | European Public Health Association |
| EU-SILC | European Union Statistics on Income and Living Conditions |
| FFS | Fertility and Family Survey |
| FiD | Families in Germany (Familien in Deutschland) |
| FTE | Full-time equivalent |
| GESIS | German Social Science Infrastructure Services (Gesellschaft Sozialwissenschaftlicher Infrastruktureinrichtungen), today Leibniz Institute for the Social Sciences (Leibniz-Institut für Sozialwissenschaften) |
| GG | German Basic Law (Grundgesetz) |
| GGS | Generations and Gender Survey |
| GHS | Gutenberg Health Study (Gutenberg-Gesundheitsstudie) |
| GLHS | German Life History Study (Deutsche Lebensverlaufsstudie) |
| GWK | German Joint Science Conference of the federal and state governments (Gemeinsame Wissenschaftskonferenz) |
| HAPIEE | Health, Alcohol and Psychosocial Factors in Eastern Europe |
| HESA | Higher Education Statistics Agency |
| HGF | Helmholtz Association (Helmholtz-Gemeinschaft) |
| HRS | Health and Retirement Study (Studie zu Gesundheit und Berentung) |
| HSE | Health Study of England |
| IAB | Institute for Employment Research (Institut für Arbeitsmarkt- und Berufsforschung) |
| INSERM | National Institute on Health and Medical Research (Institut national de la santé et de la recherche médicale) |
| INSERM-UMS 011 | Research group "Population-Based Epidemiological Cohorts" at the INSERM and the University of Versailles |
| ISCED | International Standard Classification of Education |
| ISCO | International Standard Classification of Occupations |
| ISER | Institute for Social and Economic Research |
| KiGGS | German Health Interview and Examination Survey for Children and Adolescents (Studie zur Gesundheit von Kindern und Jugendlichen in Deutschland) |

| | |
|----------------------|---|
| KORA | Cooperative health research in the Augsburg region (Kooperative Gesundheitsforschung in der Region Augsburg) |
| LifBi | Leibniz Institute for Educational Trajectories (Leibniz-Institut für Bildungsverläufe) |
| MONICA | Multinational Monitoring of Trends and Determinants in Cardiovascular Disease |
| Morbi-RSA | Equalization of risk differences among health insurances based on their members' morbidity rate (Morbidityorientierter Risikostrukturausgleich) |
| MPG | Max Planck Society (Max-Planck-Gesellschaft) |
| MPI | Max Planck Institute (Max-Planck-Institut) |
| MRC | Medical Research Council |
| NAKO | National Cohort (Nationale Kohorte) |
| NEPS | National Educational Panel Study (Nationales Bildungspanel) |
| NIA | National Institute on Aging |
| NIH | National Institutes of Health |
| NCDS | National Child Development Study |
| NORFACE | New Opportunities for Research Funding Agency Co-operation in Europe |
| NSHD | National Survey of Health and Development |
| pairfam | Panel Analysis of Intimate Relationships and Family Dynamics (Beziehungs- und Familienpanel) |
| PASS | Labour Market and Social Security Panel (Panel Arbeitsmarkt und soziale Sicherung) |
| PHF | Panel on Household Finances |
| PIAAC | Programme for the International Assessment of Adult Competencies |
| PIAAC-L | German PIAAC long-term panel (PIAAC-Langzeitstudie deutschlandweit) |
| PISA study | Programme for International Student Assessment by the OECD |
| PROCAM study | Prospective Cardiovascular Münster Study |
| PSID | Panel Study of Income Dynamics |
| Recall | Heinz Nixdorf Recall Study and Intergenerational Study (Heinz Nixdorf Recall Studie und MehrGenerationenStudie) |
| Rltrain | Research Infrastructure Training Programme |
| SAVE | Savings and Pension Schemes in Germany (Sparen und Altersversorgung in Deutschland) |
| SCORE project | Systematic Coronary Risk Evaluation Project of the European Society of Cardiology |
| SHARE | Survey of Health, Ageing and Retirement in Europe |
| SHIP | Study of Health in Pomerania (since 1997) |
| SHIP-Trend | new cohort of the Study of Health in Pomerania (since 2008) |
| LLS | Society for Longitudinal and Lifecourse Studies |
| SOEP | German Socio-Economic Panel (Sozio-oekonomisches Panel) |
| SOEP Core | a SOEP subsample on living conditions in private households |
| SOEP-FiD | SOEP "Families in Germany" (SOEP „Familien in Deutschland“) |
| SOEP-IS | SOEP Innovation Study (SOEP Innovationsstudie) |
| SUF | Scientific-Use-File |
| UCL | University College London |

| | |
|--------------|---|
| UNICE | Union of Industrial and Employers' Confederation of Europe |
| WGL | Scientific Association Gottfried Wilhelm Leibniz, Leibniz Association (Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz e. V., Leibniz-Gemeinschaft) |
| ZA | Central Archive for Empirical Social Research (Zentralarchiv für empirische Sozialforschung) |
| ZUMA | Centre for Survey Research and Methodology (Zentrum für Umfragen, Methoden und Analysen) |

9 Glossary

Aggregate data

Data containing personal characteristics (e.g. school leaving qualification), but only in the form of percentages, sums or averages of a particular group of individuals (e.g. the proportion of people with A levels in a residential area or their average income).

B cells

Cells of the lymphocyte subtype and the only cells that can produce antibodies. They therefore play a crucial role in the immune system.

Bias

In statistic, bias refers to a systematic error or a systematic deviation from an unknown true value. Cf. e.g. recall bias. Bias control, for instance in survey results, is an important issue in quality-conscious research (e.g. by randomisation).

Case-control study

Study design used in epidemiology, retrospectively comparing the extent of exposure to risk factors of individuals with a certain disease to those of healthy people.

Cohort

In demography, a cohort signifies a group of people who were born within a specific time period and are hence subject to the same socioeconomic and historical constellations. In epidemiology, a cohort signifies a population group which is prospectively examined from the same date onwards (cf. cohort study).

Cohort Study

Longitudinal study of a population group being prospectively tracked, i.e. examined, from the same date onwards (e.g. birth cohort study: sample of new-borns born in the same year or on the same day). Cohort studies are useful for discovering new risk factors for a target disease

in population groups that were not affected by the respective disease when the study started.

Cross-sectional study

The empirical study of a collective body, conducted only at one point in time. Hence, no reliable statements can be made as to changes or cause-effect relationships.

Cytokine IL-6

A protein regulating the inflammatory response in the body.

Cytotoxicity

The property of a chemical, a virus or a specific immune cell, to damage or destroy living cells and tissues.

Demography

The study of populations; scientific analysis of the structure and development of populations.

Epidemiology

Scientific discipline dealing with the distribution of diseases (descriptive epidemiology), their determinants (analytical epidemiology) and their prevention (interventional epidemiology).

Etiology

Cause of a disease or disorder or factors associated with its development.

Gen \times environment interaction

This describes cases where the effect of environmental influences depends on the individual's genetic condition.

Genotypical

A property determined by the individual genotype.

Granger causality

A definition of causality proposed by Clive Granger. It is based on the principle of “post hoc, ergo propter hoc”. A variable X “Granger-causes” a variable Y when the explanation of Y at the point in time t (under consideration of a certain number of values the variable Y had taken on before t) can be improved by adding values of X that likewise occurred before the point in time t.

Incidence

The frequency of new occurrences of a disease in a defined period.

Individual data

Unlike aggregate data, they always refer to an individual person, i.e. they were collected about or from individuals.

Intervention study

Study resorting to the specific modification of an important influence factor (e.g. the risk factor of a disease) in order to examine the effect of that factor on the target variable (e.g. reducing the risk of lung cancer by abstaining from smoking cigarettes). A particularly conclusive form of an intervention study is the randomised controlled trial.

Killer cells

Immune cells capable of recognising and killing altered, abnormal body cells, e.g. tumour cells.

Latency model

A model claiming that social disadvantages of parents will reflect on their child, particularly manifesting themselves in an unfavourable course of pregnancy (foetal programming) and in precarious material and socio-emotional conditions during sensitive postnatal stages of the child's development.

Longitudinal data analysis

cf. longitudinal study.

Longitudinal study

Observational study of a population over a longer period, in which the same individuals are interviewed repeatedly. It is thus possible to gauge the individual changes in their characteristics over time.

Mental resilience

The ability to manage crises and to benefit from the process in terms of personal development.

Metadata

Data providing information on characteristics of other data. Response rates (the percentage of the sample having actually participated in the survey) or data on the methodical implementation of a study are examples of metadata.

Millenium Cohort

Large birth cohort study, initiated in the UK in 2000.

Mitogen-induced cell proliferation

Rapid growth or proliferation of tissue induced by a protein stimulating cell division.

Morbidity

Measurement of the frequency of a particular disease, in contrast to mortality, which indicates the frequency of deaths in a population during a defined period.

Odds ratio

In epidemiology, the odds ratio is a measure expressing how much higher the probability is for an exposed person to suffer from a disease associated with the exposure than a person not exposed to the respective risk (the risk of the latter group being defined as 1.0). The odds ratio is closely related to the relative risk.

Oversampling

The overrepresentation of a subpopulation in a sample selection with regard to their proportion of the overall population

Panel Study

Study repeatedly conducted over a defined period of time with the same content and in the same population group. If different objectives are pursued with such a design, it is called a multi-purpose panel.

Paradat

Data obtained as by-product of a survey in addition to the data the survey was originally conducted for.

Phenotypical

Relating to the set of characteristics of an organism (e.g. height, weight, etc.). Nowadays, socio-economic characteristics are likewise included.

Prevalence

A figure showing the incidence of disease within a population at a given time.

Primary data

Data newly collected for the purpose of answering a scientific research question (cf. also secondary data).

Primary prevention

All measures aiming at preserving the health of individuals, groups of people or a population, or at preventing a disease or slowing down its development.

Prospective study

A longitudinal study suited to test hypotheses about cause-effect relationships (to the extent possible within observational studies) (cf. also cohort study).

Public Health

Scientific programme for the research and improvement of the health status of whole populations. Public Health consists of a population-related branch (epidemiology) and a systemic branch (health systems and healthcare research).

Randomised controlled trial (RCT)

An experimental study design primarily used in clinical medicine. It is based on the principle that the researchers randomly assign an intervention to the study participants. The RCT is considered the gold standard for evaluating the effectiveness of interventions/therapies, since it is more effective in controlling a possible bias than observational studies (cf. also bias).

Randomised experiments

Experiments in which the test persons are assigned to different groups by a random mechanism.

Recall bias

A source of error in retrospective studies due to memory errors or cognitive bias.

Register

A usually official data collection covering the entire population and documenting data (register data) on various topics according to uniform criteria (e.g. civil register, tax register, disease register).

Representative sample

A group of people selected from a population by a selection process ensuring that the selected group of people is representative of that population as regarding the central characteristics.

Retrospective data

Data obtained in surveys on past events or while investigating the past.

Secondary data

Data not obtained in a direct survey, but generated from primary data through certain processing steps.

Secondary prevention

All measures aiming at the early detection of diseases in order to allow for their timely treatment.

Set Point Theory

Hypothesis maintaining that the weight of the human body is largely genetically programmed and cannot be changed at will. According to this theory, most people have a relatively stable “set point”, to which their weight will tend to automatically fall back in case of deviations in either direction. It is also referred to as the “settling point” of the body weight, in recognition of the fact that the body weight may be subject to minor short-term fluctuations.

Survey Bias

In a sample any error occurring in the recording of the true values of the characteristics in question as a consequence of the survey’s design.

T cells

White blood cells important for the immune defence. Along with the B cells, they are responsible for the acquired immune response of the body.

Trajectories

Development processes that are enabled by certain conditions and where the outcome is uncertain.

10 Appendixes

Appendix 1: Ongoing population-based longitudinal studies in Germany

| Name | Number of observations | Publications in professional journals | Academic Director | Launch | Wave cycle | Available waves | Regional coverage | Age groups | Focus | Link |
|---|----------------------------------|---------------------------------------|---|--------|--------------------------|--------------------|-------------------|--------------|--|---|
| AID:AID:A II <i>Growing up in Germany: Everyday worlds (Aufwachsen in Deutschland: Alltagswelten)</i> | 25 337 | 40 | Walter Bien | 2009 | | 1 | Germany | 0–55 | age and family constellations | http://surveys.dji.de/index.php?m=msg.0&fid=20 |
| BASE-II <i>Berlin Age Study II (Berliner Altersstudie II)</i> | 2 200 | 30 | | 2009 | triennially | 5 (for subsamples) | Berlin | 20–35, 60–80 | health, social conditions | https://www.base2.mpg.de/de |
| Best Up <i>Berlin Panel on persons with higher education entrance qualification (Berliner-Studienberechtigten-Panel)</i> | 1 600 | – | Heike Solga, Katharina Spiels | 2013 | at least annually | 3 | Berlin | pupils | transition from school to training, higher education and professional life | http://www.best-up.eu/bestup.html |
| BIKS <i>educational processes, competence development and selection decisions at preschool and school age (Bildungsprozesse, Kompetenzentwicklung und Selektionsentscheidungen im Vorschul- und Schulalter)</i> | 2 400 | 60 | Cordula Artelt, Hans-Peter Blossfeld, Gabriele Faust, Hans-Günter Roßbach, Sabine Weinert | 2005 | semiannually / annually | | Bavaria, Hesse | 3–18 | learning development, influencing factors, educational choices | http://www.uni-bamberg.de/index.php?id=2713 |
| DEAS <i>German Ageing Survey (Deutscher Alterssurvey)</i> | 4 000 + 6 000 (extended in 2014) | 80 | Katharina Mahne | 1996 | triennially (since 2008) | 4 | Germany | over 40 | demography, work, health, values and norms | http://www.dza.de/forschung/deas.html |

| Name | Number of observations | Publications in professional journals | Academic Director | Launch | Wave cycle | Available waves | Regional coverage | Age groups | Focus | Link |
|--|-------------------------------------|---------------------------------------|---------------------------------------|--------|----------------------|-----------------|-------------------|------------|--|---|
| DEGS <i>German Health Interview and Examination Survey for Adults (Studie zur Gesundheit von Erwachsenen in Deutschland)</i> | 8 152 | 110 | Bärbel-Maria Kurth | 1997 | appr. every 10 years | 2 | Germany | over 18 | health, living conditions, health care system | http://www.degs-studie.de/deutsch/studie.html |
| DONALD <i>Dortmund Nutritional and Anthropometric Longitudinally Designed</i> | 1 400 | 80 | Ute Nöthlings, Thomas Remer | 1985 | varying | n/a | Dortmund region | 0–25 | nutrition and health | http://www.ernaehrungsepide-miologie.uni-bonn.de/forschung/donald-1 |
| EU-SILC/Leben in Europa <i>European Union Statistics on Income and Living Conditions</i> | 23 587 | n/a | Klaus-Jürgen Duschek, Christian Prinz | 2005 | annually | 6 | Germany | over 16 | income, poverty, deprivation, exclusion, living conditions | http://ec.europa.eu/eurostat/web/microdata/european-union-statistics-on-income-and-living-conditions |
| GESIS Panel | 4 900 | n/a | Michael Bosnjak, Wolfgang Bandilla | 2014 | bimonthly | 7 | Germany | 18–70 | Open Omnibus Access Panel | http://www.gesis.org/unser-angebot/daten-erheben/gesis-panel/ |
| GGS <i>Generations and Gender Survey</i> | 10 000 | 40 | Robert Naderi | 2005 | triennially | 2 | Germany | 18–79 | ways of life, demography, gender | http://www.bib-demografie.de/DE/Forschung/Surveys/GGS/ggs_node.html |
| GHS <i>Gutenberg Health Study (Gutenberg-Gesundheitsstudie)</i> | 15 000 | 120 | Philipp Wild | 2007 | n/a | n/a | Rhine-Main region | 35–74 | health and mental health | http://www.gutenberg-gesundheitsstudie.de/ |
| GIP <i>German Internet Panel</i> | 1 603 + 4 034 (extended in 2014/15) | n/a | Annelies G. Blom | 2012 | bimonthly | 12 | Germany | 16–75 | society in transition | http://reforms.uni-mannheim.de/internet_panel/home/ |

| Name | Number of observations | Publications in professional journals | Academic Director | Launch | Wave cycle | Available waves | Regional coverage | Age groups | Focus | Link |
|--|------------------------|---------------------------------------|---|--------|------------------------------------|----------------------------|--|------------|-------------------------------------|---|
| GLES <i>German Longitudinal Election Study; Long-time Panel, component 7</i> | 2 700 | n/a | Harald Schoen, Sigrid Roßteutscher, Rüdiger Schmitt-Beck, Bernhard Weßels, Christoph Wolf | 2009 | at elections, with interim surveys | 2 (plus 3 interim surveys) | Germany | over 16 | election research | http://gles.eu/wordpress/design/lfp/ |
| KIGGS <i>German Health Interview and Examination Survey for Children and Adolescents (Studie zur Gesundheit von Kindern und Jugendlichen in Deutschland)</i> | 17 641 | 260 (all publications) | Bärbel-Maria Kurth | 2003 | quinquennially | 2 | Germany | from birth | health of children and adolescents | http://www.kiggs-studie.de/ |
| KORA <i>Cooperative Health Research in the Region of Augsburg (Kooperative Gesundheitsforschung in der Region Augsburg)</i> | 20 000 | 600 (all publications) | Annette Peters | 1984 | quinquennially | 4 | Augsburg city, Augsburg district, Alchach-Friedberg district | 25–74 | health | http://www.helmholtz-muenchen.de/kora/ueber-kora/index.html |
| LAP <i>Panel of Student Teachers (Lehramtstudierenden-Panel)</i> | 5 500 | n/a | Hildegard Schaeper | 2014 | annually | 1 | Germany | students | student teachers vs. other students | https://www.lifbi.de/de-de/weiterestudien/lap.aspx |

| Name | Number of observations | Publications in professional journals | Academic Director | Launch | Wave cycle | Available waves | Regional coverage | Age groups | Focus | Link |
|---|--|---------------------------------------|---|--------|-------------------|-------------------------------|----------------------------|------------------------------|---|---|
| MOP <i>German Mobility Panel (Deutsches Mobilitäts panel)</i> | 3 000 | n/a | | 1994 | annually | 18 | Germany | over 10 | mobility behaviour | http://mobilitaetspanel.ifv.kit.edu/ |
| NAKO <i>National Cohort (Nationale Kohorte)</i> | 200 000 (planned) | n/a | Karl-Heinz Jöckel, Wolfgang Ahrens, Wolfgang Hoffmann, Rudolf Kaaks | 2014 | quinquennially | 0 | Germany | 20–69 | widespread diseases, lifestyles | http://www.nako.de |
| NEPS <i>National Educational Panel Study</i> | SC1: 3 481 SC2: 2 949 SC3: 5 778 SC4: 15 629 SC5: 18 252 SC6: 11 649; some increases in w3 | 20 | Hans-Günther Roßbach | 2009 | at least annually | 1–5 (depending on the cohort) | Germany | 5 initial cohorts from birth | educational processes, skills development | https://www.neps-data.de/ |
| pairfam <i>Panel Analysis of Intimate Relationships and Family Dynamics</i> | 12 400 | 100 | Josef Brüderl, Karsten Hank, Johannes Huinink, Bernhard Nauck, Franz Neyer, Sabine Walper | 2008 | annually | 5 | Germany | 15–37 | development of intimate relationships and generational ties | http://www.pairfam.de/ |
| PaLea <i>Panel on Student Teachers' Development (Panel zum Lehramtsstudium)</i> | 6 380 | 10 | Olaf Köller, Jens Möller, Manfred Prenzel | 2009 | three-monthly | 16 | 13 universities in Germany | students | developmental progress of students | http://www.palea.uni-kiel.de/ |

| Name | Number of observations | Publications in professional journals | Academic Director | Launch | Wave cycle | Available waves | Regional coverage | Age groups | Focus | Link |
|--|--|---------------------------------------|---|--------|-------------------------------|-----------------|--|--------------------|--|---|
| PASS <i>Labour Market and Social Security Panel (Arbeitsmarkt und soziale Sicherung)</i> | 18 954 | n/a | Mark Trapmann | 2006 | annually | 6 | Deutschland | over 16 | labour market, poverty, social policy | http://fdz.iab.de/de/FDZ_Individual_Data/PASS.aspx |
| PHF <i>Panel on Household Finances</i> | 3 565 (w1), 4 500 (w2); households | n/a | | 2010 | triennially | 1 | Germany | from the age of 17 | financial situation and wealth of German households | https://www.bundesbank.de/Navigation/EN/Bundesbank/Research/Panel_on_household_finances/panel_on_household_finances.html |
| PIAAC-L <i>Programme for the International Assessment of Adult Competencies</i> | n/a | n/a | Beatrice Rammstedt, Jutta von Maurice, Jürgen Schupp | 2013 | annually | 0 | Germany | 18–67 | skills in adult age and their significance for the life course | http://www.gesis.org/forschung/drittmittelprojekte/projektuebersicht-drittmittel/piaac |
| Recall <i>Heinz Nixdorf Recall Study (Heinz Nixdorf Recall Studie)</i> | 4 814 | 100 (only peer-reviewed) | | 2000 | annually | | Bochum, Essen and Mülheim/Ruhr | 45–75 | cardiovascular diseases | https://www.uni-due.de/re-call-studie/ |
| Rheinland Studie <i>Rhineland Study</i> | 30 000 | – | Monique Breteler | 2015 | triennially/ quadrennially | 0 | Rhineland | over 30 | well-being, way of life, brain | http://www.dzne.de/wissenschaft-gesellschaft/rheinland-studie.html |
| SHARE <i>Survey of Health, Ageing and Retirement in Europe</i> | 3 000 (w1), 900 (w2), 4 500 (w5) | 500 | Axel Börsch-Supan | 2004 | biennially | 5 | Germany | over 50 | demography and health | http://www.share-project.org/ |
| SHIP <i>Study of Health in Pomerania</i> | 4 308 | 660 | Dietrich Alte | 1997 | varying | 4 | Stralsund, Greifswald, Anklam (incl. the respective districts) | 20–79 | health | http://www.medin.uni-greifswald.de/cm/fv/ship.html |

| Name | Number of observations | Publications in professional journals | Academic Director | Launch | Wave cycle | Available waves | Regional coverage | Age groups | Focus | Link |
|--|--|---------------------------------------|---|--------|----------------|-----------------|--|---|--|---|
| SHIP-TREND <i>Study of Health in Pomerania</i> | 4 420 | n/a | Henry Völske | 2008 | quinquennially | 1 | Stralsund, Greifswald, Anklam (incl. the respective districts) | 20–79 | health, mental health, lifestyle, demography | http://www.medicin.uni-greifswald.de/cm/fv/ship.html |
| SL <i>Longitudinal Study in Saxony (Sächsische Längsschnittstudie)</i> | 1 407 | 50 | Hendrik Berth, Elmar Brähler, Peter Förster, Yve Stöbel-Richter | 1987 | annually | 27 | GDR (2 districts) | 1973 birth cohort | physical and mental transition from citizens of the GDR to citizens of the Federal Republic of Germany | http://www.wiedervereinigung.de/sls/index.html |
| SOEP <i>Socio-Economic Panel (Sozio-oekonomisches Panel) (SOEP Core and SOEP IS)</i> | 12 290 (w1), 13 972 (w7), 51 028 (w30) | 2 700 | Jürgen Schupp | 1984 | annually | 30 | Germany | from birth (since 2002, before: after school enrolment) | personality, income, occupation and health, preferences and satisfaction | http://www.leibniz-soep.de |
| TwinLife | 2 009 (twin families) | – | Martin Diewald, Rainer Riemann, Frank M. Spinath | 2014 | annually | 0 | Germany | 5–23 | education, career, social participation, quality of life, health, abnormal behaviour | http://www.twin-life.de |

Appendix 2: Key points for education and advanced training curricula for the management of large research infrastructures

Project and financial management:

- Overall project controlling: monitoring a standardised project schedule
- Financial management
- Public and private funding opportunities in Germany and Europe
- Contract templates and accounting structures with survey institutes
- Data protection issues, ethics committees
- Communication with research teams and survey institutes

Operational management:

- Design and control of the underlying samples
- Design and implementation of trainings for interviewers
- Monitoring and documentation of the data collection process (number and length of the interviews, contact attempts, interviewer activities, monitoring reports)
- Monitoring of ongoing fieldwork
- Test procedures for software and questionnaire testing

Management of questionnaire design:

- Development of complex software tools: computer-based survey instruments (CAPI), electronic contact protocols, sample management software
- Conceptual revision and further development of the questionnaire content
- General questionnaire design: routing and filtering, grammar and spelling, logic and comprehensibility, programming errors, questionnaire encyclopaedia, possibly translations
- Designing the contents and formats of preload variables for longitudinal and refreshment samples

- International standard codes in cooperation with international experts (ISCO, ISCED)
- Non-invasive biomarker technologies (e.g. DBS)
- Techniques for linking data with administrative data (e.g. pension insurance data)

Management of data provision and user communication systems:

- Database and release technologies for the publication of data for scientific research and documentation (release guide, questionnaires, innovations / changes between the waves)
- Calculation of sample weights and multiple imputations, sensitivity analyses
- External communication (e.g. for brochures or the website)
- User strategy, user training

Appendix 3: Key points for a university education and advanced training curriculum for methodological expertise

Epidemiological and social science methods:

- Measures (frequency measures of exposure and outcomes; association measures for exposures and outcomes, (relative, attributable risks, odds ratios)); standardisation
- Epidemiological study types (cross-sectional, cohort, case control studies, clinical trials, randomised controlled trials)
- Assessment of cause-effect relationships (Bradford-Hill criteria)
- Sources of error (selection bias, recall bias, information bias, missing values, confounding)
- Test criteria (validity, reliability, sensitivity, specificity, predictive value)
- Systematic reviews, meta-analyses, scoping studies
- Sampling methods, sample size calculation
- Social science methods (survey methods (quantitative, qualitative interviews), questionnaires, tests, experiments, non-reactive methods, systematic and participatory observation; aggregated or ecological data)
- Mixed-methods approaches; triangulation
- Statistical methods of analysis
 - Descriptive statistics
 - Network analysis, latent class analysis, ANOVA, etc.
 - Regression analyses, multilevel analyses, structural equation modelling
 - Causal analysis with panel data, survival and event analysis, time series analysis
- Ethical aspects of epidemiological and social science population research

Central epidemiological and sociological fields of research:

- Epidemiological transition (infectious diseases, chronic diseases)
- Burden of disease in rich and poor countries
- Preventable morbidity and mortality
- Demographic aging and disease spectrum; compression of morbidity
- Impacts and risks of disease (including urbanization, climate change)
- Social and economic determinants of health and disease (macro-, meso-, micro-level); social gradient and explanatory approaches
- Life course epidemiology (latency, cumulative, path models)
- Central social roles and risks of disease (work, family, social network; sociological models)
- Influences of socio-economic and socio-cultural change on health and disease (migration, globalisation)
- Health policy strategies of prevention and health promotion

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