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Future of the Study of the Demography of Aging: A Planning Meeting

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Meeting Summary

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Acronym Definitions

ADD Health	National Longitudinal Study of Adolescent to Adult Health
BSR	Division of Behavioral and Social Research
CPOP	Committee on Population
CRP	C-reactive protein
CVD	Cardiovascular disease
DBASSE	Division of Behavioral and Social Sciences and Education
GWAS	Genome-wide association studies
HRS	Health and Retirement Study
NAS	National Academy of Sciences
NHATS	National Health and Aging Trends Study
NIA	National Institute on Aging
NIH	National Institutes of Health
NRC	National Research Council
NTA	National Transfer Accounts
PSID	Panel Study of Income Dynamics
RCT	Randomized controlled trial
SES	Socioeconomic status
SNP	Single nucleotide polymorphism
UK	United Kingdom

MEETING SUMMARY

On June 25, 2015, the Committee on Population (CPOP) at the National Research Council (NRC) Division of Behavioral and Social Sciences and Education (DBASSE) convened a meeting sponsored by the Division of Behavioral and Social Research (BSR) at the National Institute on Aging (NIA), National Institutes of Health (NIH) to solicit expert input on the state of the science and most promising future directions for the demography of aging research. The meeting agenda included introductory remarks followed by invited presentations and discussions.

The following themes emerged from presentations and discussion:

- There has been meaningful progress in methods development and research in the demography of aging, yet much remains to be done.
- Multidisciplinary research organized by topic will be more productive than research organized by scientific discipline. The involvement of social, economic, biologic, medical, genetic, big data, psychologic, and environmental disciplines is needed.
- The use of mobile devices to measure concepts relevant for studying the demography of aging (e.g., physical activity, sleep, social interactions, cognitive impairment, and physiologic measures of health) is an intriguing approach that might become more operationally feasible in large studies in the future.
- Demography of aging research should be conducted not only in populations of older adults but also over the lifecourse. This is especially true for family studies and biodemography.
- Demography of aging and family studies should address changing family structure and its impact on cohort succession, differences across racial and ethnic populations, and the impact of immigration on older adults.
- The potential benefits of linking demographic data with economic data sources are substantial. However, concerns about data security should be addressed.
- Comparative demography of aging research that explores differences across countries is important, but data harmonization is challenging.
- There is a clear need for replication of demography of aging study findings, especially those related to biomarkers and genetics.

This report summarizes the presentations and discussion that occurred during the seminar. Appendix 1 contains the meeting agenda, and Appendix 2 contains the list of participants.

Introductory Remarks

John G. Haaga, Division of Behavioral and Social Research, National Institute on Aging

NIA has a major ongoing investment in demography research through its Centers for Demography and Economics of Aging, research awards, and T32 institutional training awards. These and other investments have led to remarkable growth in the field. It is important to identify the aging-related problems this field of research should aim to solve, including determining the types of studies and methodologies needed. This meeting will help provide

direction for what demographic researchers could accomplish during the next decade with resources available today.

Although some scientists prefer a narrow definition of demography that focuses on its technical core,¹ meeting participants are charged to consider demography as belonging to a broader field of population studies that absorbs insights from the social sciences as well as the life sciences and epidemiology in the quest to solve population problems and understand the causes and consequences of population patterns. Topics for discussion include, but are not limited to, families and social networks, informal caregiving, regional science and spatial demography, immigration, biodemography, research on mechanisms and causality, and opportunities provided by new data sources.

A great deal of health research investigates phenomena at the lowest possible level of analysis. However, social science makes a valuable contribution to human health through the understanding of processes that work above the level of an individual organism. The social environment needs to be understood when considering any variable that impacts health.

Invited Presentations

State of the Science in Understanding Connections Between Social and Environmental Factors and Mortality, Morbidity, and Life Expectancy

Eileen Crimmins, University of Southern California

The goals of demographers studying mortality, morbidity, and life expectancy have traditionally focused on changes over time, differences within populations, and individual trajectories of change. Over the past 30 years, the field of demography has seen improved conceptual clarity, statistical models and methods, and data complexity and availability. It has become apparent that the most appropriate way to organize the research is by topic, rather than by research discipline.

Such multidisciplinary research is made more practical by the similarity of research models across disciplines. For example, models for demographic analysis of health are very similar to models for epidemiological, sociological, and biomedical research, and all include consideration of a large number of interrelated factors (e.g., demographic, behavioral, physiological, social factors, biological, and psychological). Researchers should consider these variables within the context of time, place, and environment. For example, examination of differences in the impact of various factors on aging across countries is an intriguing area of research. Furthermore, the ultimate focus is on how these factors affect health outcomes, such as physical or cognitive functioning, mortality, disability, etc.

A multidisciplinary view has also led to an increased conceptual clarity of various dimensions of health, such as a focus on the transition across stages of health, beginning with risk for diseases and conditions, progressing to their development, then to frailty, loss of function and disability, and, finally, death. An understanding of how individuals move from one stage to the next is

¹ Samuel H. Preston, "The Contours of Demography: Estimates and Projections," *Demography* 30, no. 4 (November 1, 1993): 593–606, doi:10.2307/2061808.

crucial to endeavors to stop or slow the process of deteriorating health. This research is best conducted through multiple studies, with each focused on one dimension of the many stages from risk factors to death.

It is important that this research include the study of biological indicators of not only the onset of, but also changes in, diseases and conditions over time through the use of longitudinal cohort studies. This approach will require development of indicators and biomarkers of aging mechanisms, study of life cycle change, and a better understanding of systemic and multisystem change. Indicators of mixed behavioral and biological import, such as mechanisms of stress, diet, and physical activity are also needed.

The past decade has witnessed a fast-paced evolution of genetics research in demography and aging. The field has advanced from small-scale and candidate-gene based single nucleotide polymorphism (SNP) research to genome-wide association studies (GWAS). Only a few major contributors of risk (e.g., the apolipoprotein E [APOE] allele in Alzheimer's disease) were found, forcing researchers to use more sophisticated methods such as polygenic risk scores, functional interaction networks, and gene-environment interactions. In addition, recent advances in epigenetics have explained additional variation in phenotypes that are not inherited through the germ-line. All of these research methods require contextual data, including information about the social, physical, and policy environment. Crimmins and colleagues now seek to incorporate contextual data into analyses of the genetic datasets from the Health and Retirement Study (HRS) and its sister studies.

Other advances in demographic methods include use of life tables based on multistate methods, changes in rates of health outcomes over time, comparisons of active life expectancy by childhood health,² and simulation models. Some simulation research suggests that delayed aging has the largest impact on the number of healthy older adults.³ For example, models suggest that a 5-year delay in aging would reduce the population with Alzheimer's disease by 41 percent by 2050.⁴

Future efforts should focus on integrating demography and aging research with big data efforts, with consideration to the representation of populations, effects of selection, and complexity of causation. The field should also integrate results of randomized controlled trials (RCTs) to clarify the effects of changing individual and social behavior, medical advances, etc. Finally, investigators should integrate biology and biomedical advances to better understand social science findings.

² Jennifer Karas Montez and Mark D. Hayward, "Cumulative Childhood Adversity, Educational Attainment, and Active Life Expectancy among U.S. Adults," *Demography* 51, no. 2 (April 2014): 413–35, doi:10.1007/s13524-013-0261-x.

³ Dana P. Goldman et al., "Substantial Health and Economic Returns from Delayed Aging May Warrant a New Focus for Medical Research," *Health Affairs (Project Hope)* 32, no. 10 (October 2013): 1698–1705, doi:10.1377/hlthaff.2013.0052.

⁴ "The Value of Delaying Alzheimer's Disease Onset: Forum for Health Economics and Policy," accessed August 5, 2015, [http://www.degruyter.com/dg/viewarticle/j\\$002ffhep.2015.18.issue-1\\$002ffhep-2014-0013\\$002ffhep-2014-0013.xml](http://www.degruyter.com/dg/viewarticle/j$002ffhep.2015.18.issue-1$002ffhep-2014-0013$002ffhep-2014-0013.xml).

Discussion

Multidisciplinary Collaboration

There is a need for multidisciplinary collaboration among social scientists to use new data and new ways of thinking. Understanding the tensions that exist among various perspectives is valuable. Crimmins noted that bringing the expertise of multidisciplinary teams to bear on problems or issues would yield more progress than if disciplines are working separately. Dow added that environmental health scientists, in particular, should be involved in this multidisciplinary work as well to explore the implications of environmental exposures on aging populations.

Within Country Variation

Participants agreed on the value of examining cross-national differences; however, more could be done with existing datasets to examine within country variation. Crimmins noted that HRS investigators have developed a contextual data file that includes information on economic context and change, physical, social, and policy environment, and information on health care resources. Although data will be de-identified and information on state of residence will not be available, comparisons across environmental contexts would be possible. The contextual data are currently available as restricted data and in the future might become available more broadly through the HRS virtual data enclave. Haywood suggested that multiple levels of data and ways to integrate them are needed to enable study at different units of analyses (e.g., state, local, environmental context).

Mortality Data

Although there have been intense efforts to harmonize data from living people across international studies, there has been little effort to track or harmonize mortality data. Many studies do not record whether study participants have died, others do not collect the date of death, and there is often a delay in reporting. Most analyses would benefit from precise information on timing and cause of death, and funders could do more to ensure accurate and timely collection of death statistics in all longitudinal studies of aging.

Tools and Techniques for Understanding Aging, Disability, and Well-being

Vicki Freedman, University of Michigan

To understand the latest tools and techniques for measuring disability and subjective well-being, it is useful to review recent related conceptual advances. The National Health and Aging Trends Study (NHATS) has developed an expanded disability framework that builds upon traditional models of the disablement process, which link health conditions to impairments in body functions and structures, to limitations in essential self-care, and to household activities. NHATS has expanded on this framework by explicitly distinguishing between the capacity to carry out activities and the ability to perform activities, by highlighting aspects of the physical, social, service, and technological environments that influence the process, and by focusing on

how activities are carried out.⁵ In addition, NHATS goes beyond essential self-care and household activities by also including participation in productive, generative, community, and social activities.

NHATS has re-engineered existing tools and developed new items to measure each of the components of the NHATS expanded disability framework. Physical capacity is measured by both self-reported items and physical performance tests. Analysis of NHATS data suggests that self-report measures, such as Nagi-like items, discriminate well at the lower end of physical functioning. In contrast, performance-based measures (e.g., balance, walking test, chair stands, grip strength, peak airflow) discriminate across a fuller spectrum of functioning.

The use of tools in the field to measure cognitive capacity also has expanded. Some of the more common tests are naming the day, month, year, and day of the week to measure orientation, recall word lists, and self-ratings to measure memory. In addition, NHATS includes a computerized version of the Stroop test and a clock drawing test to measure executive function. Other studies, such as the HRS, include word and number problems to measure verbal and numeracy skills.

NHATS has developed new, validated measures of how older adults accommodate declines in capacity, that is, changes that are made in response to gaps between capacity and demands of a task or activity. The NHATS protocol includes self-reported measures of the use of assistive devices or environment modifications, behavior change (e.g., doing activities less often or in a different way), and receiving help from another person. NHATS's focus on how individuals accommodate changes in capacity to carry out activities is especially relevant for understanding subjective well-being. Freedman et al. demonstrated, for example, that a five-category hierarchy (being fully able to perform an activity, successfully accommodating an activity, reducing the frequency of an activity, having difficulty performing an activity despite accommodations, if used, and receiving assistance from others) is more predictive than age of subjective well-being.⁶

An alternative way of conceptualizing and measuring participation in activities is to focus on time use. Although there is no standard approach to aggregating activities for studying disability, four broad categories have been studied: self-care, household, productive, and leisure activities. Activities can be described in various ways. For example, activities can be rated according to their physical, cognitive, and social intensity.

Time use and activities are commonly measured one of three ways:

1. Stylized questions that ask about time in the past month or week spent on broad categories of activities (such as the HRS Consumption and Activities Mail Survey);

⁵ Vicki A. Freedman, "Adopting the ICF Language for Studying Late-Life Disability: A Field of Dreams?," *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences* 64, no. 11 (November 2009): 1172–1174; discussion 1175–1176, doi:10.1093/gerona/glp095.

⁶ Vicki A. Freedman et al., "Behavioral Adaptation and Late-Life Disability: A New Spectrum for Assessing Public Health Impacts," *American Journal of Public Health* 104, no. 2 (February 2014): e88–94, doi:10.2105/AJPH.2013.301687.

2. Time diaries that capture all activities in the past 24 hours (such as the Panel Study of Income Dynamics [PSID] studies of disability and time use among older adults and the American Time Use Study);
3. Experiential sampling methods that contact individuals at random times of day to assess activities within a very recent time period (e.g., the past 15 minutes).

The latter two approaches allow rich descriptors to be collected, such as duration, location, who is with the individual, and how the individual feels. The physical intensity or sedentary nature of activities can be measured using accelerometers. Unlike self-reported physical activity, accelerometers provide objective data that are not influenced by social norms or limited recall. Data quality is influenced by a number of factors including compliance, placement, and proper translation of the raw output into meaningful estimates. Newer devices recognize one another, potentially allowing for the study of social aspects of time use as well.

Attention to subjective well-being in the population sciences has grown in recent years. There is also growing interest in tracking subjective well-being measures to supplement national economic indicators. For example, the Office for National Statistics in the United Kingdom (UK) now conducts annual surveys of the UK population to measure life satisfaction, happiness, anxiety, and mental well-being.

Various approaches are available for measuring the different aspects of subjective well-being. Self-reported survey instruments have been developed to capture eudemonic well-being (purpose, meaning, and growth) and evaluative well-being (overall and domain-specific satisfaction with life). Time diaries and experiential sampling methods have been developed to measure experienced well-being (e.g., feelings of happiness, sadness, frustration, and worry). There are also a number of relatively brief clinical instruments to measure psychological well-being (e.g., distress and symptoms of depression and anxiety).

Discussion

An increasing number of mobile devices are available to measure concepts related to late-life disability and well-being. A growing number of devices are available to measure physical activity and sleep. There are also mobile audio- and video-recording devices that can capture social interaction data. Emerging tools for measuring cognitive function include passive monitoring devices placed in the home that record minute variation in activities and redundancy of activities that may be associated with cognitive impairment.

There are, however, still significant operational challenges to the use of these devices in large-scale research. For instance, studies need to provide participants with proprietary applications and/or devices. In addition, many proprietary devices do not allow researchers access to the underlying data, impeding the ability to demonstrate reliability and validity. As big data and precision medicine initiatives gain momentum, more devices will likely be available. There is a role for NIA to facilitate incorporation of such devices into research while ensuring the confidentiality of study participants. Regardless of what measurement technologies are used in demography of aging research, the key issue is to match the research questions with the appropriate information from the devices.

Demography of Aging and the Family

Emily Agree, The Johns Hopkins University

Changes in family structure over the past 30 years and the availability of more comprehensive data on extended family relationships have fundamentally altered the study of the demography of aging and the family. There has been progress in this field; however, the progress has not kept pace with other areas of demographic research. For many years, demographic studies of late-life families relied on data from household surveys and selected long-living families. We now have available enhanced survey data with data linkages, kinship simulation and agent-based modeling, game theory approaches, time use studies, social network analysis, and multi-level modeling. All of these new tools allow for sophisticated approaches to demographic research on the aging family.

Factors contributing to changes in family structure include changes in fertility and marital patterns, compositional changes in the population, increased immigration, and changes in the co-residence and proximity of adult children to parents. All of these factors have implications for family change and the level of support for older adults. Researchers must determine the best approaches to learning more about the impact of these changes on family dynamics on older individuals.

Increases in divorce, remarriage, cohabitation, and multiple partner fertility have led to a proliferation of family ties that are more diffuse and possibly weaker or more ambiguous. These patterns diverge by socioeconomic status (SES): higher rates of cohabitation and earlier, multi-partner fertility are increasingly concentrated among lower SES families while individuals with more education experience later childbearing and longer survival, leading to an increase in potential for sandwich generations, in which mid-life adults have responsibilities for children as well as aging parents. Although research has provided some insight into this complex situation, a better understanding of the structure and support these relationships provide for older adults is needed.

Most of the family transitions that lead to such diverse relationships occur at younger ages and alter late-life families through cohort succession. For example, the current aging cohort—the baby boomers—is entering old age with fewer traditional sources of support (spouses and biological children) but with more ex-spouses, stepchildren, and surviving siblings.

Race, ethnicity, and immigration are also associated with changing family relationships. For example, minority populations are younger, have higher fertility rates, and are more likely to live in extended family households than are non-minority populations. This is a neglected area of research of immense potential in an increasingly diverse society. Another promising area of research is the demography of trans-national immigrant families. Immigrants are often connected to family members across national boundaries, and we know little about how these relationships function or affect the well-being of older immigrants in the United States.

Research has shed some light on how these diverse changing family patterns affect older adults. Spouses and children continue to be the main source of support for older adults, and grandparents are often actively involved with grandchildren. Most aging adults live near at least one adult child. However, divorce and remarriage are negatively associated with support of

aging parents. Stepchildren provide less support of all kinds than do biological children. The type and amount of support provided in step-relationships varies depending on the age of the children when the union was formed.

There are several research priorities in this area, including the implications of increasing complexity of family structure and histories for later-life well-being and family support. Research is also needed on ethnic and class differences and implications of immigration for older families. Other priorities include the role of cohort succession in shaping the observed family life of older generations and a broader study of family caregiving as a multi-person dynamic phenomenon.

Discussion

There has been little research to assess how changing family patterns will affect the well-being of aging adults. Part of the problem is a lack of consistent data across the lifecycle. Studies tend to include different categories of data for early-life, mid-life families, and late-life families. Data are needed on when relationships are formed, the ages at the time of formation, critical periods of family transitions, and patterns of family interaction. With the exception of the PSID, most datasets used in demography of aging research are highly individualistic and are not designed for family studies. Therefore, much of the relevant intergenerational information is missing.

Issues to consider in future research include behavior of children toward older stepparents and changes in behavior based on changes in the environment, such as savings patterns among millennials and timing of fertility. Geographic variations among families, migration patterns, commercialization of care for older adults, and language and communication issues are also worth exploring.

Research shows a later onset of disability at higher SES levels, but also an older age of fertility. It is difficult to determine how these SES differences will affect intergenerational transfers.

Emerging Tools, Techniques, and Approaches to Understanding the Economics of the Demography of Aging

William Dow, University of California, Berkeley

There are a number of increasingly important issues to be explored in the economics of the demography of aging. These include widening economic inequality in conjunction with ongoing concerns about poverty among the elderly, the economic uncertainty created by potential threats to government safety nets and employer benefits, and the growth in health care spending that places pressure on Medicare and Social Security programs. The consequences of a possible slowdown or reversal in the trend compression of morbidity also create concerns about disability benefits. Another issue is the determinants and consequences of expanded female and declining male labor force participation. The aging of the baby boomers creates associated concerns about dependency ratios, or consumption versus investment of elderly assets. Economists are also deepening engagement in interdisciplinary teams thinking about how to change risk behaviors to prevent chronic disease and cognitive decline.

Integration of economic constructs with health and demographic measurement has led to dramatic improvement in data available to explore the demographic and causal effects of these important issues. Researchers continue to use the well-established tool of longitudinal panels and are improving harmonization of data across surveys, including among international cohorts. The field is innovating in sampling methods, including use of internet panels and inferences from convenience samples from precision medicine cohorts. New availability of biomedical data adds great value to demographic research on aging, although better integration of socioeconomic characteristics with medical data is needed to benefit fully from these databases.

The use of linked data has great potential to contribute to demography of aging research. Such usage may include the linkage of historical datasets and administrative data sources, including pensions, Medicare, and death registries. Other important linkage sources include health care, employer, tax, and unemployment insurance records, as well as financial data and credit reports.

In conjunction with data improvements, the field of economics has made advances in theory-based research that impact demography of aging research. For example, there is a huge potential for the use of behavioral economics and neuroeconomics in demography research. This has led to advances in understanding and interventions related to health behavior change and financial decision-making for retirement. Components of this approach include the study of non-standard preferences that inform the potential development of commitment devices and sin taxes, non-standard beliefs that may contribute to mistaken prediction of future financial status, and non-standard decision making, which has implications for choice architecture, checklists, and behavioral nudges.

In addition, structural modeling continues to be refined in its use of economic theory to predict how people will respond to different types of stimuli, such as policy change. There is also increasing success in the use of microsimulations, such as the Future Elderly Model's predictions of future aggregate costs and health benefits under different policy and technological scenarios. Scaling relationships up to a macro level is a key feature of demography, and in this regard National Transfer Accounts (NTA) modeling is a crucial tool in understanding the macroeconomic implications of aging. With NIA's support, NTA has successfully matured into a tool now adopted by the United Nations and used in more than 40 countries, with new innovations in progress to further understand generational accounting by gender and SES.

There is tremendous potential for the expanded use of these theoretical and empirical advances for policy-relevant demography of aging research. For example, the rapidly expanding implementation of economic RCTs with long-term follow-up and complementary data for structural modeling can facilitate simulation of potential interventions. Applying randomized and quasi-experimental methods to evaluate policies and interventions at scale is increasingly enabled by big data and complementary machine learning methods. Decision science methods to then explore cost-effectiveness, along with Bayesian modeling for evidence synthesis, are improving as tools for the future. Implementation science is another growing area of research that informs how to scale and adapt advances in heterogeneous real-world settings.

Discussion

Security Issues with Linked Data

The potential benefits of linking demographic research data with data from health, tax, and geographic sources are substantial. However, the need to protect the security of these data, which are variously housed across a number of agencies and institutions, is equally important. Meeting participants discussed the level of security risk inherent to linked research data. Although there have been recent reports of security lapses involving data from government and private organizations, meeting participants were unaware of any similar breaches in or threats to research data. Researchers do not pose a significant risk for inappropriate disclosure; however, the data collected can be sensitive. The technical capacity to maintain data security is increasing. Removal of identifiers from linked data is one means of protecting privacy. It would be useful for a trans-NIH panel to consider the best mechanisms to create a secure system for linked data.

Interdisciplinary Research

Areas with potential for increased interdisciplinary research with economists include microsimulation and behavior economics. In both areas, the tendency of researchers to work within their own disciplines results in wasted effort. In contrast, the involvement of economists in population health research has increased substantially within the past 20 years, in part through NIA efforts.

Lessons Learned in CPOP Studies of the Demography of Aging

David Weir, University of Michigan

The CPOP has held recent meetings in Asia and Latin America, and two volumes have been published on the proceedings. Both meetings aimed to promote the HRS model of longitudinal multidisciplinary studies in these regions. A secondary aim was to consider the context of aging across countries and to broadly address issues of aging.

It is clear that the paradigm of aging differs across regions. For example, the China one-child policy and India's process of declining fertility are creating unique aging environments. Parts of Latin America are quickly changing to appear more like southern Europe in terms of aging. The diversity of regional environments, individual histories, and contemporary experiences make comparative aging studies interesting and valuable.

The most recent CPOP meeting was held in Latin America in May 2015, hosted by the Mexican National Institute of Geriatrics. There was much enthusiasm from Mexico for the Mexican Health and Aging Study and for aging research in general. Meeting attendees discussed several large-scale aging studies, including the Chilean Social Protection Survey, which is strong in economics, and the Columbia-based Salud, Bienestar y Envejecimiento (Health, Wellbeing and Aging in Latin America), an international set of health-focused, urban-based studies with an ambitious design. NIA is producing a summary report of this meeting.

Discussion

Meeting participants discussed obstacles to international comparative demography of aging research. Study sections tend to be skeptical of comparative studies, making it challenging to obtain funding by the NIH. In general, researchers need to develop a better understanding of the measures used in comparative studies as well as the context in which the measures are used. Data providers could facilitate an understanding of measures. For example, the NIA-funded University of Southern California Gateway to Global Aging initiative seeks to harmonize measures across various studies.⁷ This initiative supplies country-specific software programs that investigators can apply to data that they acquire in their research. It might benefit the field if a mechanism could be developed by which harmonized datasets were created for distribution to investigators. However, the risk of data misuse would need to be addressed.

Another approach is to harmonize the data and assess differences in relationships that affect aging across countries to suggest future research directions. The development of the tools needed to perform the more complicated analyses inherent in comparative demographic research is also needed.

Contribution of Biodemography to Understanding the Demography of Aging

Maxine Weinstein, Georgetown University

There are several broad areas of overlapping interest between biodemography and demography of aging research. These include studies of intergenerational transfers, reproduction, sociality and hierarchy, genetics, comparisons across time and geography, and biosocial surveys. A key need in these research areas is the replication of study findings and exploring the extent to which study findings are reproduced in other contexts.

Intergenerational transfers include genetic material, wealth, and position in social hierarchies. Research is needed to consider how changes in either upward mobility or increased inequality affect the health of inheritors. Questions surrounding reproduction include the long-term effects of below-replacement fertility, why prolonged post-reproductive life stages have been observed only in a few long-lived species, and how declines in fertility will affect the health of the elderly. Researchers in the area of sociality and hierarchy are exploring the potential association between hierarchy and the effects of stress and inflammation on health.

Genetic studies in demography of aging are complicated by the fact that each measurable phenotype involves not only germ-line mutations but also somatic changes that can blur the contribution of underlying genetic risk. Even at the level of the germ-line, single-gene effects are rare. Usually, complex genetic regulatory mechanisms are at work. Epigenetic effects further contribute to complex phenotypes, masking underlying genetic events.

One potential path forward is the study of the functional organization of the genome, with the expectation that measures of variation in gene regulation can provide insight into how variation in environmental exposures (e.g., social experience) affect aging. In general, genetic studies require large samples to provide statistical power, replication across cohorts, comparative

⁷ See <https://g2aging.org/> for more information about this initiative.

analyses across time and geography, and harmonization of data. However, data harmonization may need to wait until researchers have a better understanding of which data are likely to provide the greatest insights.

Biosocial surveys might lend insight into mortality patterns in various countries, especially in the assessment of how various factors contribute to these patterns. For example, data suggest that the U.S. population has lower cholesterol levels and blood pressure rates than the UK population, but higher cardiovascular mortality.⁸ Biosocial surveys might help to tease out the explanations for these differences.

The complicated relationship emerging among inflammation (e.g., C-reactive protein [CRP]), cardiovascular disease (CVD), and aging provides an example of the need for careful assessment of biodemographic findings. Data from various studies suggest that there may be different pathways connecting CVD with markers for inflammation. For example, an association between inflammation and obesity is more prevalent in the United States than in Taiwan, but an association between inflammation and infection-related, elevated white blood cell count was found to be more prevalent in Taiwan. Furthermore, CVD is more common in the United States than in Taiwan. These results suggest the need to explore the connection between inflammation with CVD in terms of the obesity pathway versus the infection pathway.

Another key question for the field is whether it is better to expand the number of topics studied or focus on expanding the understanding of existing findings, with an emphasis on studies that reproduce analyses using the same techniques across datasets. For example, Goldman et al. analyzed data from four countries showing that of the many potential biomarkers for 5-year mortality studied over the years, few have much predictive power.⁹ Self-reported data and inflammatory markers, such as CRP, appear to be the most predictive.

Discussion

Aging Research across the Lifecourse

Biomarker research that attempts to discern causality is more complicated than research to predict health outcomes. The study of CVD risk provides a relevant example. The Framingham model for prediction of CVD risk mixes biomarkers such as blood pressure and behaviors such as smoking to determine risk scores. However, the model does not work well for determining CVD causality. Because the smoking behavior precedes and contributes to blood pressure changes, it is difficult to determine the relative contribution of each to the development of CVD. It is therefore important to measure relevant biomarkers and behaviors across the lifecourse to determine causality. Studies should collect data at younger ages when the behaviors and associated physiologic responses are developing and at older ages when the health outcomes are observed.

⁸ James Banks et al., "Disease and Disadvantage in the United States and in England," *JAMA* 295, no. 17 (May 3, 2006): 2037–2045, doi:10.1001/jama.295.17.2037.

⁹ Noreen Goldman et al., "What Matters Most for Predicting Survival? A Multinational Population-Based Cohort Study," *Under review*.

However, data on the relevant biomarkers across the life course that could support causal assessments in demography of aging research are not readily available. More cohort studies, such as the National Longitudinal Study of Adolescent to Adult Health (ADD Health), which enroll young people and follow them to old age are needed. Furthermore, effort is needed to determine what types of variables to measure at younger ages.

Potential areas for this type of research include studies of biomarkers of aging that may inform interventions to delay physical aging and studies of biomarkers for mortality in older adults. Research to characterize the link between biomarkers, physiologic processes, and health outcomes within the context of human evolution may be helpful. Research is also needed to elucidate the link between body homeostasis and dysregulation of physical processes and health outcomes. For example, studies to characterize a cycle of stress response and recovery would be useful.

Replication of Findings

Meeting participants agreed that, in all areas of biomarker research and aging, there is need for replication of individual study findings to validate the findings and to account for potential variation among various populations and across countries. Parallel analysis on various datasets using the same harmonized biomarker measures and analytic techniques is another important goal. However, replication of study findings by an independent team of investigators also is necessary. Recently the President of the National Academy of Sciences (NAS) devoted his entire address to the NAS membership to the issue of replication and a recent report by an advisory committee to the NAS, “Social, Behavioral, and Economic Sciences Perspectives on Robust and Reliable Science,” discusses this topic.¹⁰

Another concerning issue is the tendency for the publication of secondary findings that cannot be replicated by another investigator using the same dataset. This issue could be addressed by making the receipt of grant funding contingent on the publication of the data analysis protocol. Some organizations, such as the American Economic Association and the National Bureau of Economics Research, encourage the posting of detailed analysis plans in advance of a study, especially for interventions, and provide websites for that purpose. Similarly, the HRS is responding to the requirement of some journals that datasets be made available to readers with plans to provide registered users with online access to the datasets.

¹⁰ “1 - SBE_Robust_and_Reliable_Research_Report.pdf,” accessed August 13, 2015, http://www.nsf.gov/sbe/AC_Materials/SBE_Robust_and_Reliable_Research_Report.pdf.

Appendix 1 Meeting Agenda

- 1:00 p.m. Welcome and Discussion of Agenda
Mark Hayward, Chair
- 1:15 p.m. National Institute of Aging Demographic Research Program
John Haaga, Division of Behavioral and Social Research, NIA
- 1:30 p.m. State of the Science in Understanding Connections Between Social and Environmental Factors and Mortality, Morbidity, and Life Expectancy
Eileen Crimmins, University of Southern California, Discussion Leader
- 2:00 p.m. Tools and Techniques for Understanding Aging, Disability, and Well-being
Vicki Freedman, University of Michigan, Discussion Leader
- 2:30 p.m. State of the Science in Understanding Role of the Family
Emily Agree, The Johns Hopkins University, Discussion Leader
- 3:00 p.m. Break
- 3:15 p.m. Emerging Tools, Techniques, and Approaches to Understanding the Economics of Demography of Aging
Will Dow, University of California, Berkeley, Discussion Leader
- 3:45 p.m. Lessons Learned in CPOP Studies of the Demography of Aging in Asia, Africa, and Latin America
David Weir, University of Michigan, Discussion Leader
- 4:00 p.m. Contribution of Biodemography to Understanding the Demography of Aging
Maxine Weinstein, Georgetown University, Discussion Leader
- 4:30 p.m. Discussion, Summary and Next Steps
Mark Hayward, Chair

Appendix 2

List of Participants

Invited Speakers

Emily Agree, The Johns Hopkins University
Eileen Crimmins, University of Southern California
William Dow, University of California, Berkeley
Vicki Freedman, University of Michigan
Maxine Weinstein, Georgetown University
David Weir, University of Michigan

Members of the Committee on Population

Kathleen Mullan Harris, The University of North Carolina, Chapel Hill
Mark D. Hayward, University of Texas at Austin
Hillard S. Kaplan, University of New Mexico
John R. Wilmoth, Department of Economic and Social Affairs Population Division, United Nations

National Institutes of Health Staff

Regina Bures, *Eunice Kennedy Shriver* National Institute of Child Health and Human Development
Prisca Fall-Keita, National Institute on Aging
Kate Fothergill, Center for Scientific Review
John G. Haaga, National Institute on Aging
Georgeanne Patmios, National Institute on Aging
John W. R. Phillips, National Institute on Aging
Suzanne Ryan, Center for Scientific Review

National Academies Staff

Robert M. Hauser, Division of Behavioral and Social Sciences and Education
Mary Ghitelman, Committee on Population
Kevin Kinsella, Committee on Population

Other Participants

Chandra Keller-Allen, Rose Li and Associates, Inc.