



The Continuing Epidemiological Transition in Sub-Saharan Africa: A Workshop Summary

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Thomas J. Plewes and Kevin Kinsella, Rapporteurs; Committee on Population; Division of Behavioral and Social Sciences and Education; National Research Council

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THE CONTINUING EPIDEMIOLOGICAL TRANSITION IN SUB-SAHARAN AFRICA

A Workshop Summary

Thomas J. Plewes and Kevin Kinsella, *Rapporteurs*

Committee on Population

Division of Behavioral and Social Sciences and Education

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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Steering Committee for the workshop were chosen for their special competences and with regard for appropriate balance.

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Acknowledgments

This report summarizes the presentations and discussions from a workshop convened in October 2011 that featured invited speakers on the topic of epidemiological transition in sub-Saharan Africa. The workshop was organized by a National Research Council (NRC) panel of experts in various aspects of the study of epidemiological transition and of sub-Saharan data sources. The panel provided invaluable guidance in developing the workshop, in securing expert presentations, and in conducting the workshop. Although the panel members played a central role in designing and conducting the workshop, they did not actively participate in writing this workshop summary.

A special acknowledgement is owed to Richard Suzman, director of the Division of Behavioral and Social Research of the U.S. National Institute on Aging, who not only played an important role in developing and refining the workshop but also actively participated in discussions that helped frame the issues and enhance the general understanding of the subject matter.

The staff of the University of Witwatersrand, which hosted the conference, played an important role in preparing for and conducting the workshop. In particular we would like to acknowledge Stephen Tollman both for his work during workshop preparations and for his contributions during the workshop itself, when the information and comments he offered greatly enhanced the value of the event.

The task of describing the overall changing context for these issues was taken on by the chair of the panel, Barthélémy Kuate Defo. Dr. Defo and the other presenters played a critical role in the workshop, identifying the key issues in the area and laying the basis for the robust discussions that were to follow; these discussions were also facilitated by a series of discussants. Peter Byass, Mark Collinson, Riku Elovainio, Majid Ezzati, Gilles Pison, and Stephen Tollman served as presenters, and their presentations were ably discussed by Ayaga Bawah, Hosen Coovadia, Karen Hofman, Alan Lopez, Moffat Nyirenda, Thomas Rehle, and Eric Udjo.

The panel also acknowledges the excellent work of the staff of the Committee on Population (CPOP) and the NRC for support in developing and organizing the workshop and providing rapporteur services for this report. The workshop was carried out under the direction of Barney Cohen, who served as director of the Committee on Population until August 2012. Tom Plewes and Kevin Kinsella served as rapporteurs. The panel was ably assisted by Barbara Boyd, who handled much of the administrative load in organizing the meeting and Danielle Johnson, who prepared the report for final production.

This workshop summary was reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise in accordance with procedures approved by the Report Review Committee of the NRC. The purpose of this independent review is to provide candid and critical comments that assist the institution in making its report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

The panel thanks the following individuals for their review of this report: Chodziwadziwa Whiteson Kabudula, MRC/Wits Rural Public Health and Health Transitions Research Unit (Agincourt), South Africa, and W. Henry Mosley, Department

of Population (emeritus), Family and Reproductive Health, Johns Hopkins Bloomberg School of Public Health.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Mark D. Hayward, Population Research Center, University of Texas at Austin. Appointed by the NRC, he was responsible for making certain that the independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered.

The purpose of this report is to serve as a factual summary of what occurred at the workshop. The steering committee's role was limited to planning and convening the workshop. The views contained in this report are those of individual workshop participants and do not necessarily represent the views of all workshop participants, the committee, or the NRC. Responsibility for the final content of the report rests entirely with the rapporteurs and the NRC.

1

Introduction

BACKGROUND

Among the poorest and least developed regions in the world, sub-Saharan Africa has long faced a heavy burden of disease, with malaria, tuberculosis, and, more recently, HIV being among the most prominent contributors to that burden. Yet in most parts of Africa—and especially in those areas with the greatest health care needs—the data available to health planners to better understand and address these problems are extremely limited. The vast majority of Africans are born and will die without being recorded in any document or appearing in official statistics (Setel et al., 2007). With few exceptions, African countries have no civil registration systems in place and hence are unable to continuously generate vital statistics or to provide systematic information on patterns of cause of death, relying instead on periodic household-level surveys or intense and continuous monitoring of small demographic surveillance sites to provide a (partial) epidemiological and demographic profile of the population. Complicating matters further, large parts of Africa still operate a dual health care system with large numbers of traditional healers operating alongside modern hospitals and clinics. It is not surprising, therefore, that good medical recordkeeping exists for only a tiny percentage of the population concentrated in a few areas and that even major disease registries and tracking systems either are not comprehensive or are lacking altogether.

Given the difficulties of constructing a comprehensive picture of the current epidemiological situation at a national or even sub-national level, let alone understanding how the epidemiological situation is changing over time, any attempts to predict how demographic and epidemiological changes will play out in the future must be somewhat speculative and be accompanied by an acknowledgment of significant uncertainty.

In 1991 the Committee on Population of the National Academy of Sciences organized a workshop on the epidemiological transition in developing countries. The workshop brought together medical experts, epidemiologists, demographers, and other social scientists involved in research on the epidemiological transition in developing countries to discuss the nature of the ongoing transition, identify the most important contributors to the overall burden of disease, and discuss how such information could be used to assist policy makers in those countries to establish priorities with respect to the prevention and management of the main causes of ill health.

The workshop, which resulted in the publication of *The Epidemiological Transition: Policy and Planning Implications for Developing Countries* (National Research Council, 1993), was timely because it provided an opportunity to review

progress at the midpoint towards the goal, set forth in the 1978 Alma Ata Declaration, of achieving "Health for All by the Year 2000." Given the paucity of resources available for health services in many developing countries, most public health programs up to the time of the 1991 workshop were focused more on eradication or at least control of preventable childhood infectious diseases, such as measles and diarrhea, than they were on treatment of chronic diseases or responding to the health-care needs of the elderly (National Research Council, 2006). This was not surprising given the extremely high rates of infant and child mortality in some parts of the developing world, particularly Africa, where the majority of such deaths were preventable with low-cost interventions such as oral rehydration salts or vaccinations.

The 1991 workshop coincided with the development and rapid acceptance of new measures of healthy years of life lost to various diseases as the basis for making comparisons of the cost-effectiveness of alternative health programs; this approach would get even more support in the years following the workshop, with the publication of the seminal 1993 report *Investing in Health* (World Bank, 1993) and the publication of the first edition of the World Health Organization's *Global Burden of Disease* study (Murray and Lopez, 1996a; 1996b) that elevated the science of assessing mortality and disability from diseases, injuries, and risk factors to a new level. The workshop also took place at a time of mounting concern about how the human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS), then a fairly new and geographically limited disease, would affect patterns of health and development (Merli and Palloni, 2006).

ORGANIZATION OF THE WORKSHOP

Recognizing the need to continuously monitor how mortality patterns are changing in sub-Saharan Africa over time, the National Institute of Aging asked the Committee on Population of the National Academy of Sciences to convene a workshop to review a number of issues related to the epidemiological transition in sub-Saharan Africa.

Statement of Task

An ad hoc committee will plan, organize and commission papers for a public workshop on the epidemiological transition in sub-Saharan Africa. Papers may be commissioned either to develop the workshop or to be presented at the workshop. Following the workshop, a rapporteur will summarize the presentations and workshop discussions.

The workshop will feature invited presentations and discussion. Among the issues to be considered are the following:

- A review of the changes that have taken place in the past 15 years in this rapidly moving area of inquiry.
- An update of trends and their implications for health policy.
- The coordination of data analysis across demographic surveillance sites and from new surveys and other sources.
- Methodological challenges for dealing with data from demographic surveillance sites.

- New theoretical perspectives on demographic modeling and their application to modeling the epidemiological transition.

To address the statement of task, the National Academy of Sciences appointed an ad hoc panel of experts in epidemiology, demography, and public health from Africa, Australia, Europe, and North America. Biographical sketches for the panel members are provided in Appendix C. The panel, chaired by Barthélémy Kuate Defo, had a dual charge:

1. to develop a two-day workshop wherein leading scientists from relevant disciplines could come together to discuss the nature of the ongoing transition, to identify the most important contributors to the overall burden of disease, and to discuss how such information could be used to better assist policy makers in those countries establish priorities with respect to the prevention and management of the main causes of ill health as well as to plan for the likely demand for certain types of health care in the future; and
2. to build on the workshop discussions by developing a research agenda focused on novel analyses and data collection strategies that would afford policy makers a better understanding of current and emerging health-related needs and enhance their assessment of the potential impact of policy options.

The public workshop was held in Johannesburg, South Africa, on October 21–22, 2011. The workshop reviewed the changes that have taken place in the past 15 years in this rapidly moving area of inquiry, updated trends and their implications for health policy, coordinated data analysis across demographic surveillance sites and from new surveys and other sources, considered methodological challenges related to dealing with data from demographic surveillance sites, and explored new theoretical perspectives on demographic modeling and their application to modeling the epidemiological transition. The agenda for the October 2011 Johannesburg workshop is found in Appendix A and a list of the workshop participants is offered in Appendix B.

In advance of the workshop the panel commissioned a set of background papers from prominent researchers in order to summarize extant research findings and further the goals of the meeting. These papers covered a range of research topics related to the epidemiological transition in sub-Saharan Africa, including changing patterns of child and adult mortality and causes of death in Africa (Masquelier, Reniers, and Pison), the uniqueness of the sub-Saharan Africa context (Defo), the role of migration in epidemiological transitions (Collinson et al.), risk exposures and comparative risk assessment (Ezzati), comparisons between the emerging epidemiological transition in Africa and Asia (Tollman et al.), the economic implications of the epidemiological transition (Elovainio and Evans), and the state of data collection (Byass, de Savigny, and Lopez). These commissioned papers became the basis for the presentations. They will be published separately in an appropriate journal.

2

The Changing Context of the Transition in sub-Saharan Africa

Researchers have long recognized the value of epidemiology and demography—and the interplay between them—in analyzing trends in mortality changes and have, conversely, recognized the role that health plays as both cause and consequence of various demographic and socioeconomic changes. In particular, the concepts of demographic, epidemiological, and health transitions have proved quite valuable in the study of population changes in countries throughout the developed world. Thus it is not surprising that most of the studies of population trends in the developing world have also relied upon these concepts, even though their usefulness in understanding population trends in developing countries has been repeatedly called into question. The issue is particularly relevant for the study of health trends in sub-Saharan Africa, as the history and experience there differs substantially from that of Western Europe and North America, for which the concepts were originally developed. Thus it is important to ask whether these frameworks are the most suitable for studies of sub-Saharan Africa.

The purpose of the workshop's first presentation was to describe the major challenges to human health in Africa within the context of a comparative cross-national research framework. Kuate Defo provided descriptions and explanations of epidemiological change in Africa over the last 60 years, and he discussed three frameworks for analyzing changing patterns of population health and mortality: the demographic transition, the epidemiological transition, and the health transition frameworks. He also described a detailed analysis of trends in health, disease, and mortality in African regions and countries from 1950 to 2010; the analysis was based on existing literature and time-series data on mortality statistics and characteristics involving 55 African countries derived from databases of major international organizations.¹

Defo presented some relatively simple methods for analyzing changes and developing quantitative indicators to test how well the demographic transition, epidemiological transition, and health transition frameworks apply to the patterns seen in Africa over the past half dozen decades. Both theoretical criticisms and empirical

¹These databases include the United Nations World Population Prospects 2010, available at <http://esa.un.org/unpd/wpp/unpp/p2k0data.asp>; the World Bank Africa Development Indicators 2011, available at http://data.worldbank.org/sites/default/files/adi_2011-web.pdf; the WHO/UNICEF 2012 Immunization Summary, available at: http://www.who.int/immunization_monitoring/data/en/; World Health Organization estimates, available at <http://www.who.int/research/en/>; International Labour Organization statistics, available at <http://www.ilo.org/stat/lang--en/index.htm>; and data from the United Nations Educational, Scientific and Cultural Organization Institute for Statistics, available at <http://stats.uis.unesco.org/unesco/tableviewer/document.aspx?ReportId=143>.

evidence indicate that these frameworks have a number of limitations in describing and explaining trends in demographic and health trajectories in Africa.

In light of these limitations, Defo proposed a new conceptual framework for analyzing African countries, one that he calls an “eco-epidemiologic life-course framework” for understanding the patterns of health and disease in human populations. Defo’s analysis of 60 years of data indicates that Africa is a continent of uncertainties and emergencies where trends in health, disease, and mortality are marked by discontinuities and abrupt changes that reflect the enduring fragility and instability of its countries and the vulnerabilities of its individuals and populations. The analysis also shows that Africa as a whole—and sub-Saharan Africa in particular—remains the poorest of the world’s regions in terms of health improvements and longevity. Specifically, the research demonstrates: (1) a marked variation in trends in health, disease, and mortality patterns as well as in fertility and life-expectancy trajectories among African countries and regions over the past 60 years; (2) a rapid decline in mortality—specifically, declines in infant mortality and increases in life expectancy—throughout the continent from the 1950s through the 1990s, a period during which communicable diseases were responsible for most deaths in Africa; (3) growing rates of adult mortality since the 1990s, which have been mostly ascribed to HIV/AIDS and its comorbidities and which have played a major role in reversing the trend of declining mortality, interrupting improvements in life expectancy, and reversing gender differences in life expectancies in several countries with highest prevalence of HIV/AIDS because of the disease’s disproportionate impact on women; and (4) the major role that wars have played in reversing the trends in under-five mortality decline in sub-Saharan countries in the 1990s and beyond, notably in middle Africa and Eastern Africa.

3

Mortality and Causes of Death

The second workshop session, which featured a presentation by Gilles Pison, focused on changes in the patterns and trends of mortality and causes of death in sub-Saharan Africa. Work done by Masquelier, Reniers, and Pison prior to the workshop showed that, after decades of declining mortality rates in sub-Saharan Africa during the latter half of the twentieth century, such progress is no longer the norm. Several countries have experienced important setbacks which can be traced to such factors as political instability, the advent or resurgence of infectious diseases, and possibly also an increase in mortality rates from noncommunicable diseases. The lack of full-fledged vital registration systems in most sub-Saharan countries has made it difficult to perform detailed assessments of mortality rates. Adult mortality measurements in particular are difficult to perform in the absence of vital registration statistics, and for that reason most United Nations (UN) agencies estimate adult mortality by matching indices of child survival to model age patterns of mortality.

Pison provided an overview of the trends in mortality among children under age 5 (${}_5q_0$) and for individuals between the ages of 15 and 60 (${}_{45}q_{15}$) in sub-Saharan Africa which were based on data on the survival of children and siblings collected in Demographic and Health Surveys. They used generalized additive models to smooth mortality rates and made adjustments to correct for recall bias. Except for some conspicuous periods of stagnation in several countries in the 1990s, child mortality mostly declined over the past 30 to 40 years. Adult mortality patterns, by contrast, were much more diverse. Most Eastern and Southern African countries witnessed enormous surges in adult mortality (with ${}_{45}q_{15} > 0.67$ in some populations) that were clearly correlated with earlier increases in HIV incidence. In Eastern Africa, adult mortality levels have begun to decline, and, surprisingly, in some cases that happened even before the large-scale expansion of antiretroviral therapy programs in 2005. Even more surprising is the lack of sustained improvements in adult survival that have been observed in some African countries without severe HIV epidemics.

Most sub-Saharan African countries have registered considerable progress in child survival over the past 30 to 40 years but are still far removed from reaching the UN Millennium Development Goals. Overall the region has been characterized by an increasing convergence in mortality rates for children under age 5. Adult mortality rates and trends are characterized by a much greater heterogeneity and sometimes move in opposite directions from the child mortality trends in the same country. AIDS mortality is dominating many of these all-cause mortality patterns, but the first indications of a reversal in adult mortality rates in Eastern African countries are now visible.

During this session Pison discussed what might be learned about child mortality from the experience of Senegal, a country with low AIDS prevalence. He noted that Senegal experienced a rapid decrease in child mortality in the 1970s and 1980s followed

by a period of no change in the 1990s and then a return to progress in the 2000s. The earlier decrease was due largely to success with vaccination programs, he said, while the lack of improvement in the 1990s can be attributed to increases in malaria mortality and to stagnation in vaccination efforts. Renewed efforts to combat malaria (new treatments, rapid diagnostic tests, and impregnated bed nets) and progress in vaccine coverage were largely responsible for the resumption of the decline in mortality during the past decade. The presenters acknowledged that improvements in socioeconomic conditions might also have had an influence, but the results of that influence would be visible only over the long term and would not explain relatively rapid changes such as the mortality decline in the 2000s. A key takeaway point of the session was that vaccinations and efforts to combat malaria have “non-specific” effects, meaning that in addition to lowering mortality due to the specific disease being addressed, they also tend to lower mortality due to other causes.

4

Risk Factor Transitions: Exposures and Comparative Risk Assessment

The third session of the workshop began with a presentation by Majid Ezzati from Imperial College, London. Since chronic diseases generally take years or often decades to develop, it is possible to project future trends for these diseases by looking at the current incidence of their risk factors. In the case of sub-Saharan Africa, an examination of the risk factors indicates that the trends for chronic diseases in the future will be a mixed bag. Data on diet patterns and obesity indicate that people in sub-Saharan Africa can expect to see rising levels of diabetes, cardiovascular disease, and certain types of cancer, and data on blood pressure paint a similarly discouraging picture for future cardiovascular health in sub-Saharan Africa. On the other hand, neither blood glucose levels nor cholesterol levels yet show the effects of the region's nutrition transition, as they are among the lowest in the world. Furthermore, the rates of smoking remain low in sub-Saharan Africa, at least for the time being, which is another bit of good news.

Ezzati cautioned that while these broad statements may be true in terms of averages across the region, there are large variations in risk factors from country to country and, within individual countries, between rural areas and cities. For example, the risk factors tend to follow economic development, and such development can differ strikingly from place to place. Furthermore, just as is the case with data on morbidity and mortality, the availability of data on risk factors varies greatly from risk factor to risk factor and also from region to region.

The most comprehensive exploration of risk factor transitions on the global level has been the work done by various institutions under the rubric of the Global Burden of Disease (GBD). Ezzati reported on recent GBD work that sought to estimate trends in four important metabolic risk factors for chronic diseases—body mass index, systolic blood pressure, serum total cholesterol, and fasting plasma glucose—by age, sex, and country/region between 1980 and 2008.

The primary model used in the analysis was fitted using the Markov chain Monte Carlo (MCMC) algorithm, with specific emphasis placed on computational efficiency and convergence. Ezzati noted that sensitivity analyses and a validity assessment of this model found high predictive power and robust performance using various subgroups of data.

Results using this enhanced model showed that (1) there has been a worldwide rise in body weight and glycaemia, with only a few rare regions in which they have been stable, including among men in parts of sub-Saharan Africa; (2) average blood pressures have decreased in high-income countries and, increasingly, also in the countries of South America, while they have remained stable in East Asia and have risen in sub-Saharan Africa; (3) Western countries have successfully lowered serum total cholesterol, which has, by contrast, risen in East and Southeast Asia; and (4) significant heterogeneity exists

in trends among Africa's subregions. The next steps in the evolution of the GBD and related projects will include the incorporation of trends in other risk factors, such as child and maternal undernutrition, tobacco use, poor water and sanitation, and household solid fuel use.

5

The Role of Migration

Migration is often the route through which people seek a wider world. There are economic, demographic, cultural, and social transitions associated with various forms of migration which have implications for the speed and nature of an epidemiological transition in the area affected by migration. The act of migration obviously exposes migrants to a different spatial environment, which in itself may be potentially beneficial or harmful. For example, migration may involve movement out of a malarial zone (a positive) to a slum area in a peri-urban settlement where the risk of airborne disease caused by pathogenic microbial agents is substantially higher (a negative). Migration can also involve a shift in social environment which may lead to changes in people's behaviors and norms; this in turn may be associated with changes in diets and lifestyles. Of particular importance are changes that lead to increases in various risk factors, such as a more sedentary lifestyle and increased levels of smoking, alcohol use, and consumption of salt, sugar, and unhealthy oils and fats. In many cases migrants also experience increased stress from the disruption associated with leaving home.

To explore the connection between migration and epidemiological transitions, Mark Collinson offered an analysis of data from 1997–2008 from the Agincourt (Republic of South Africa) Health and Demographic Surveillance System. Significant levels of migration were reported, especially temporary labor migration among men and, increasingly, among women, Collinson said, and the average age of migrants appeared to be getting younger. Three types of migrants were considered in the analysis: one-way immigrants, short-duration labor migrants, and long-duration labor migrants. Even though the data covered only a fairly short time period, it was possible to observe changes in the causes of death in the Agincourt surveillance system. Communicable disease mortality and migration were both concentrated in the 25–49 age group. The most important age- and sex-related associations between migration and cause of death were seen between (1) one-way migrants (both sexes) and communicable disease; (2) short-duration female labor migrants or long-duration male labor migrants and communicable diseases; and (3) short-duration female labor migrants or long-duration male labor migrants and noncommunicable diseases.

The discussion during this session highlighted several general findings from an analysis of data collected by the International Network for the Demographic Evaluation of Populations and Their Health (INDEPTH) for Eastern and Southern Africa. The first was that high levels of circulation have exposed migrants to higher risks of HIV than would otherwise be the case. Second, return migration was said to be associated with higher adult mortality compared to that of local residents. Extant data suggest that rural households and health systems have an elevated burden of disease. Furthermore, given the intensity of population movements to and from INDEPTH sites, it is important to take migration into account in the formation of policies and programs. It was noted that

attrition from INDEPTH study populations is not random, which implies that migration affects the results obtained from surveillance-site data. Analysts should therefore consider adjusting for selection bias due to immigration and emigration.

6

Health Financing in sub-Saharan Africa

An important issue that came up repeatedly throughout the workshop was how the epidemiological transition will affect health-financing systems and attempts to achieve universal coverage. Riko Elovainio presented a conceptual framework for addressing this question, based on the *World Health Report 2010: Health Systems Financing: The Path to Universal Coverage* (World Health Organization, 2010), which outlines the types of health-financing levers available to policy makers in three broad areas: raising funds for health, reducing financial barriers to access through prepayment, and pooling of resources (spreading the financial risks of paying for care across the population) and efficiency.

In 2009 low-income countries around the world spent an average of 6.1 percent of their gross domestic products (GDPs) on health in 2009, lower-middle-income countries spent 6.2 percent, and upper-middle-income countries spent 7.0 percent. The region of sub-Saharan Africa spent 6.1 percent of its total GDP on health, far less than the 9.5 percent of GDP that the countries of the OECD spend on health.

In terms of U.S. dollars, low-income countries spent \$25 per person on health in 2009 versus the more than \$4,600 per person spent in high-income countries. In the Africa region of the World Health Organization (which includes all countries of Africa, not just the low-income countries), per capita health spending was \$83, less than 2 percent of the average spending in high-income countries.

Elovainio commented that economic growth will facilitate additional spending on health in the low-income countries. The International Monetary Fund projects that, beginning in 2012, economic growth across the whole of sub-Saharan Africa should average 5 percent per year, which corresponds to a per capita GDP growth rate of around 3.5 percent per year (International Monetary Fund, 2011). This suggests that even if health receives the same share of GDP as it does now, health expenditures will grow, but it is likely that health spending will receive an increasing share of GDP and thus grow at an even greater rate.

All of the countries of sub-Saharan Africa have ways in which they can raise more funds domestically for health spending if they chose to do so. The pressure to find new funding sources is especially high in countries in which large informal economic sectors make it difficult to collect revenues, either in the form of taxes or in the form of health insurance contributions. This situation is often accompanied by tax collection systems that are inefficient and inequitable. Wage-based deductions are generally the easiest to administer and collect, and thus they offer the greatest potential for achieving an equitable system in which people earning more would pay more. However, in those low-income countries in which a relatively low (although usually growing) percentage of the workforce has formal paid employment, other options also need to be pursued. These other options might include “sin taxes,” that is, taxes on harmful products such as alcohol

and tobacco, which have repeatedly been shown to be effective in reducing consumption and improving health (see, e.g., Chaloupka, 1999; Wagenaar, Salois, and Komro, 2009). Data from 22 low-income countries suggest that a 50 percent increase in the excise tax on tobacco would bring in \$1.4 billion of additional revenue to those countries (Stenberg et al., 2010). Such taxes are now also being explored for use in discouraging the use of foods high in sugar or salt. The share of the resources from sin taxes allocated to health spending—that are, in economics terms, *hypothecated* for health spending—will be, of course, one of the main issues from the health financing point of view. Intuitively, the case for allocating a large percentage of sin taxes to health spending seems compelling. From the point of view of national ministries of finance, however, this is not always the case, and ministries of health will need to be persuasive in order to receive at least a part of the revenue. Furthermore, ministries of health need to ensure that the eventual hypothecation of sin taxes to health spending will not lead to cuts elsewhere in the health budget. The same questions concerning hypothecation are, of course, equally relevant to other earmarked taxation mechanisms that do not fall under the “sin tax” category.

Judging from the examples of countries that have already introduced them, a variety of other direct or indirect taxation mechanisms are also feasible. Ghana, for example, increased its value added tax by 2.5 percentage points; these revenues that go directly to the National Health Insurance System. Gabon introduced a specific tax on certain profitable economic sectors, such as agencies that receive and transfer money overseas; revenue from this tax is hypothecated to cover the insurance contributions of people who are financially unable to contribute to the national health insurance fund. In 2009 Gabon collected the equivalent of \$25 million with this levy on highly profitable corporations (Musango and Aboubacar, 2010).

7

Data Collection and Validation in Resource-Poor Settings

Much of the input to the workshop emphasized the point that patterns of morbidity and mortality are shifting both in terms of cause and in terms of age distribution. The workshop paper by Byass, de Savigny, and Lopez notes that changing therapeutic options tend to increase prevalence as compared with incidence for some key diseases; perhaps the most obvious example of this phenomenon in sub-Saharan Africa can be found in the use of antiretroviral therapy against HIV/AIDS, which keep AIDS patients alive for longer periods of time, thus increasing rates of prevalence. Changing patterns of risk factors—such as the prevalence of mosquito breeding sites in the case of infectious diseases, or factors such as tobacco and alcohol consumption in the case of noncommunicable diseases—constitute a further critical factor in the changing patterns of mortality and morbidity (Dalal et al., 2011; Danaei et al., 2011). All of these factors are changing rapidly against a background of sparse and sometimes dubious detailed information about what is actually happening, which makes it even more vital to proactively consider changes in health data systems in sub-Saharan Africa in order to increase the visibility of the continent's long-term trends and needs in population health (Byass, 2009).

Nevertheless, it is unrealistic to suppose that over the next 10 to 20 years all the countries of sub-Saharan Africa will develop national health information systems that have sufficiently high coverage and achieve global standards of timeliness, completeness, and quality. Thus it is necessary to consider a transitional approach to improving the supply of health information in the short term in ways that are relevant to the essential policy actions that sub-Saharan African countries will need to take as the epidemiological transition unfolds.

In his presentation for the session on data collection and validation, Peter Byass identified several key questions that countries and international agencies should consider:

- What mix of national and local-area data sources are needed for monitoring epidemiological transition, and with what sampling approaches?
- How can continuous longitudinal, repeated cross-sectional, and one-time survey data be effectively integrated within a national information system to reveal epidemiological transitions?
- What are the economic and human resource implications for upgrading national health information systems in order to measure epidemiological transitions?
- What are the ethical and political issues related to long-term improvements in national health information systems?

Byass, de Savigny, and Lopez also described a typology of data sources that can potentially contribute to national health information (see Table 7-1).

TABLE 7-1 Typology of Data Sources That Potentially Contribute to National Health Information

Level	Model	Sample	Approach	Examples
National	National census	All	Complete cross-section	Most countries
	Ongoing registration	All	Complete longitudinal	Industrialised countries
	Sentinel districts	1-2% of population	Longitudinal sample	China
	Cluster surveys	Cluster sample size	Repeatable cross-section	DHS surveys, WHO-SAGE
	Fixed panel surveys	Cohort sample size	Longitudinal cohort	Millennium Cohort Study
	At health facilities	All or sample of facilities	Self-selected group	Annual health reports
Provincial	Complete population	All	Complete longitudinal	In registered countries
	Cluster surveys	Cluster sample size	Cross-section	Vaccine coverage
	At health facilities	All or sample of facilities	Self-selected group	Annual health reports
Local area	Individual surveillance	Defined area population	Complete in defined area	INDEPTH centers
	One-time surveys	Survey sample size	Cross-sectional	
	Specific research	Context-dependent	Specific issues of interest	

SOURCE: Byass, de Savigny, and Lopez (2011).

This session also included a discussion of how lessons learned to date from HIV surveillance efforts might be applied. Thomas Rehle described the key features of

second-generation HIV surveillance, which include (1) combining survey methods for greater explanatory power; (2) developing strategic partnership between surveillance and program evaluation; (3) a shift in emphasis toward measuring incidence rather than focusing mainly on prevalence; and (4) recognition of biological (HIV, AIDS, sexually transmitted infections) and behavioral surveillance as integral components adapted to the stage and type of the epidemic. These features imply a surveillance that is more focused on subpopulations at high risk of infection and that has an emphasis on trends over time.

Rehle further described the new South African National Health and Nutrition Examination Survey (SANHANES). It combines questionnaires with physical examinations and biomarker testing, combines longitudinal and cross-sectional design elements, and is designed to make it possible for health and nutritional status to be explored in much greater detail than was previously possible.

8

The Epidemiological Transition in Africa: Are There Lessons from Asia?

Sub-Saharan Africa remains the only major area in the world where the burden of infectious disease still outweighs the burden of noncommunicable disease and injuries. While the rates of decline in fertility and mortality vary considerably across the region, at least one clear pattern is emerging that holds across all of sub-Saharan Africa: a steady rise in noncommunicable disease (including cardio-metabolic and respiratory conditions as well as cancers) in the presence of significant, long-standing infectious disease prevalence.

In the session devoted to asking whether the experience in Asia offers any lessons for understanding the epidemiological transition in Africa, Stephen Tollman began his presentation by noting that while the coexistence of infectious and noncommunicable disease is well documented in the low- and middle-income countries of South America and Asia, the scale and intensity at which infectious and noncommunicable diseases are proceeding concurrently in sub-Saharan Africa is unprecedented. Given the prevalence and trends in HIV/AIDS, the interaction between infectious and noncommunicable diseases is likely to be prolonged in sub-Saharan Africa for decades. This will transpire at the same time that sub-Saharan Africa will see significant population aging, and these trends pose major challenges to economic and social development which the region's health and social systems are—at least for now—unable to address.

In Asia, noncommunicable diseases (NCDs) are now the leading cause of death among adults in nearly every nation. However, the levels of NCDs do vary widely across countries. For example, while acute coronary events (heart attack) dominate death counts in India, stroke accounts for a greater proportion of NCD deaths in China. There are also clear differences in the rates of specific cancers: Indians experience more oral and lip cancers than lung cancers, for example, whereas lung cancer is a leading cause of death among Chinese adults. The growing preponderance of NCDs is a consequence of various factors, not the least of which is the rapid decline in fertility over the past several decades in many Asian nations. This decline, along with a decline in childhood-disease mortality, causes the shift in the age and cause-of-death structure that we call the epidemiologic transition. Much of Asia also has seen the emergence of tobacco use as a major cause of premature mortality among adults. Still, tuberculosis and malaria continue to pose significant burdens in India and also among adults in selected parts of Southeast Asia.

Tollman reported that in spite of the magnitude of the differences in mortality and morbidity between sub-Saharan Africa and much of Asia, the patterns of mortality and morbidity are not so different, with the clear exception of HIV/AIDS and its effects. To better understand the age-cause differences among countries and regions, Tollman described recent work aimed at identifying families of mortality trends, each of which reflects a different underlying mortality pattern. These families were identified by

analyzing standardized, pooled data from 24 INDEPTH data centers representing close to 20 million person-years of data and 207,000 deaths. As more data centers are added, the further goals will be to (1) further develop typical age patterns of mortality using longitudinal data from the INDEPTH network of demographic surveillance sites throughout Africa and South Asia; (2) build an easy-to-use system of model life tables based on the identified age patterns; and (3) use such data to support evaluations of progress towards the United Nations Millennium Development Goals.

This session also highlighted the potential for using INDEPTH data on individual and social exposures to explain differences in health outcomes. INDEPTH centers increasingly have the data to support such analyses, which will permit researchers to investigate the reasons for differences and inequalities across settings. Explanations for the observed patterns could include the effects of education, employment, and migration experience as well as the composition and economic status of households.

9

Future Research Directions

The presentations and discussions in the workshop highlighted the importance of improving our understanding of the status and effects of the epidemiological transition in sub-Saharan Africa. The importance and immediacy of the issue was framed by Barthélémy Kuate Defo, who pointed out at the offset of the workshop that (a) since the 1960s, when most countries in sub-Saharan Africa achieved their independence, many contextual changes have affected the epidemiological landscape of the continent and the sub-Saharan African region; (b) urbanization, gross domestic product per capita, improved sanitation and water access, improved per capita agricultural production, improved telecommunications, increases in the number of physicians per 1,000 inhabitants, medical advances, and improved nutrition and living standards are major changes that have taken place in sub-Saharan Africa which have led to improvements in survival rates and substantial gains in life expectancy at birth, paving the way for the ongoing epidemiological transition in sub-Saharan African countries; (c) prospects for durable reductions in mortality are hampered by the high prevalence of communicable and preventable diseases; and (d) the data needed to understand the changes in the epidemiological landscape are thin in most countries in the region.

In the discussion on future directions it was pointed out that the importance of the issue and the paucity of data in sub-Saharan Africa lead to a situation in which estimates of population health parameters must be made but they tend to be made using whatever data are available as inputs to the increasingly sophisticated models that have been developed. These available data are usually at the global level, and the consequence is that national estimates for countries in sub-Saharan Africa tend to be derived from global estimates. As better data become available, national estimates should contribute to the global estimates rather than vice versa, as is now the case.

The presentations and discussions at the workshop identified a need to help countries strengthen their health-information systems so that within-country data become the source of information and country figures can be fed into global estimates. In the face of health transitions it is necessary to measure not only health status but also rates of change, implying that within-country data cycles need to be put into operation on an ongoing basis. This is a prerequisite for ensuring a continuous supply of timely health information, rather than forcing analysts to rely on a series of random snapshots.

In the discussion on the national and local-area data needed to capture the epidemiological transition in African countries, workshop participants emphasized the importance of obtaining complete and timely registration of all births and deaths at the national level, including medical certification of the cause of death. However, for both logistical and economic reasons, it is unlikely that near-complete individual registration of births and deaths will be widely implemented in sub-Saharan African countries any

time in the near future. Thus it will be important to consider what Alan Lopez and others referred to as the “best-buy” strategies for health data in sub-Saharan Africa.

Discussing the choice of data sources, the conferees concluded that it would be useful to combine a variety of sources with different strengths. Such an approach will require research on the quality of various data sources in order to understand which sources are complementary and which are viable in a particular national context and over time. In evaluating the data sources researchers should consider such factors as the size and diversity of a country; the nature and coverage of the country’s health system; the local costs of relevant items such as wages, travel, and communications; and which data strategies have been more or less successful in a particular locality.

One particularly useful resource for informing the design of data-gathering systems for tracking epidemiological transition is AusAID’s Health Information Systems Knowledge Hub (HISHUB; <http://www.uq.edu.au/hishub/>) at the University of Queensland. Although this system was designed primarily for Asian and Pacific countries, the principles it lays out should translate well to sub-Saharan Africa. According to HISHUB, the minimum data set for understanding epidemiological transitions in order to inform health transitions includes:

1. Reliable unbiased documentation of age- and sex-specific mortality, including the major causes of deaths in the population (civil registration with vital statistics and sentinel or sample mortality surveillance systems with verbal autopsy). Several sources of data on causes of death should be considered. Research should focus on means for obtaining physician-certified coverage of all deaths (at least 90 percent) in a country with cause-of-death coding of reasonable quality; the establishment of systems to collect such data has proved elusive for low-income countries as well as for many middle-income countries and will potentially require decades to achieve. In the meantime, the use of the World Health Organization Health Metrics Network and others interim data sources should be explored. Such interim data sources could include sentinel (urban and rural) demographic surveillance sites and, where possible, statistically representative sample registration sites with verbal autopsy on all deaths. It was suggested that designing, funding, and implementing these interim measures within one to two years would be an attainable goal.
2. Periodic documentation of exposure to the top 10 major risk factors of mortality by age and sex (via periodic population-based surveys). Concerning this issue, it was noted that there are standard adapted survey instruments for each risk factor (smoking, nutrition, high blood pressure, obesity, HIV sero-status, solid fuel smoke exposure, etc.) but that these are rarely assembled into an omnibus national sample survey. Future research strategies should include an extension of the Health Metrics Network and the Household Survey Network in order to promote greater integration and more strategic scheduling of national household surveys.
3. Periodic documentation of the effective coverage of key preventive and curative health interventions aimed at the above causes and risk factors

(via periodic health facility surveys or routine health statistics). Information sources for these important measures remain undeveloped. Research is needed to determine a simple methodology that district health managers can apply to understand the annual reach and coverage of their services. Innovative combinations of epidemiological and demographic information would help provide annual estimates at the district level.

Health status in low-income countries is changing more rapidly now than at in any prior time in human history. To track and, eventually, to steer these population health dynamics and to understand what such transitions imply for health systems and policies will require radical changes in and a strengthening of national health-information systems so as to provide essential information. In their summary of the issues, Byass, de Savigny, and Lopez (2011) suggested that strengthening the information systems will require concerted investments on three fronts:

1. Interim investments in sentinel or sample registration systems that provide timely and high-quality longitudinal data on deaths and causes of deaths, combined with a concurrent development of effective civil registration systems for vital statistics;
2. Periodic national cross-sectional omnibus sample surveys of the top 10 major risk factors for the major causes of death; and
3. Annual sub-national sample surveys or routine statistics on effective coverage of the essential health interventions relevant to these causes of death.

The workshop highlighted the need for countries in sub-Saharan Africa and their international funding partners to prioritize these three dimensions of their national strategies for strengthening health systems.

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Appendix A

Workshop Agenda

WORKSHOP ON THE CONTINUING EPIDEMIOLOGICAL TRANSITION IN SUB-SAHARAN AFRICA

Committee on Population
U.S. National Academy of Sciences

and

Medical Research Council/University of the Witwatersrand (MRC/Wits)
Rural Public Health and Health Transitions Research Unit (Agincourt)

October 20–22, 2011

Location: Wits Professional Development Hub (PDH)
University of the Witwatersrand

THURSDAY, OCTOBER 20

OPEN SESSION

2:30 P.M.

WELCOME AND INTRODUCTIONS

Barney Cohen
Director, Committee on Population
U.S. National Academy of Sciences

Stephen Tollman
University of the Witwatersrand

Barthélémy Kuate Defo, University of Montreal
Chair, Panel on the Continuing Epidemiological Transition
in sub-Saharan Africa

2:50 P.M.

SPONSOR PERSPECTIVE

Richard Suzman

Director, Division of Behavioral and Social Research
U.S. National Institute on Aging

3:00 P.M.

**SESSION 1: THE CHANGING CONTEXT OF THE
EPIDEMIOLOGICAL TRANSITION IN SUB-SAHARAN AFRICA**

Chair: Barney Cohen, U.S. National Academy of Sciences

Presenter: (20 minutes) Barthélémy Kuate Defo, University of Montreal

Discussants: (10 minutes each)

Peter Byass, Umeå University, Sweden

Hoosen Coovadia, University of KwaZulu-Natal

Q&A and General Discussion

4:00 P.M.

SESSION 2: MORTALITY AND CAUSES OF DEATH IN SUB-SAHARAN AFRICA: PATTERNS, TRENDS, AND PROSPECTS

Chair: Barthélémy Kuate Defo, University of Montreal

Presenter: (20 minutes) Gilles Pison, Institut National d'Études Démographiques (INED)

Paper title: Successes and Failures in the Fight Against Child Mortality in sub-Saharan Africa: Lessons from Senegal, a Country with Low AIDS prevalence.

Discussants: (10 minutes each)

Eric Udjo, University of South Africa

Stephen Tollman, University of the Witwatersrand

Q&A and General Discussion

7:00 P.M.

WORKING DINNER

8:00 P.M.

ADJOURN

FRIDAY, OCTOBER 21

OPEN SESSION

8:30 A.M.

SESSION 3: RISK FACTOR TRANSITIONS IN AFRICA: EXPOSURES AND COMPARATIVE RISK ASSESSMENT

Chair: Ayaga Bawah, Columbia University

Presenter: (20 minutes) Majid Ezzati, Imperial College, London

Discussants: (10 minutes each)

Julie Knoll Rajaratnam, University of Washington

Somnath Chatterji, World Health Organization

Q&A and General Discussion

9:30 A.M.

SESSION 4: THE ROLE OF MIGRATION IN THE EPIDEMIOLOGICAL TRANSITION IN AFRICA

Chair: Michael White, Brown University

Presenter: (20 minutes) Mark Collinson, University of the Witwatersrand

Paper title: Examining Migration as a Factor Contributing to the Epidemiological Transition, in the Agincourt Sub-District of Northeast South Africa.

Discussant: (10 minutes) Ayaga Bawah, Columbia University

Q&A and General Discussion

10:30 A.M.

BREAK

11:00 A.M.

SESSION 5: ECONOMICS OF THE EPIDEMIOLOGICAL TRANSITION

Chair: Stephen Tollman, University of the Witwatersrand

Presenter: (20 minutes) Riku Elovainio, World Health Organization

Paper title: Health Financing Challenges in Low- and Middle-Income Countries in the Context of the Ongoing Epidemiological Transition.

Discussants: (10 minutes each)

Barthélémy Kuate Defo, University of Montreal

Karen Hofman, University of the Witwatersrand

Q&A and General Discussion

12:00 P.M.

SESSION 6: MEASURING HEALTH: PRIORITIES FOR DATA COLLECTION, VALIDATION, AND USE IN RESOURCE-POOR SETTINGS

Chair: Julie Knoll Rajaratnam, University of Washington

Presenter: (20 minutes) Peter Byass, Umeå University, Sweden
Paper title: Understanding Transitions in African Health by Managing Long-Term Transitions in African Health Data.

Discussants: (10 minutes each)
Alan Lopez, Queensland University
Thomas Rehle, Human Sciences Research Council

Q&A and General Discussion

1:00 P.M.

LUNCH

2:00 P.M.

**SESSION 7: THE EPIDEMIOLOGICAL TRANSITION IN AFRICA:
ARE THERE LESSONS FROM ASIA?**

Chair: Somnath Chatterji, World Health Organization

Presenter: (20 minutes) Stephen Tollman, University of the Witwatersrand
Paper title: The Continuing Epidemiological Transition: Lessons from Africa and Asia.

Discussant: (10 minutes) Moffat Nyirenda, College of Medicine/University of Malawi

Q&A and General Discussion

3:00 P.M.

BREAK

3:30 P.M.

**SESSION 8: ROUNDTABLE ON DATA NEEDS AND FUTURE
RESEARCH DIRECTIONS**

Chair: Alan Lopez, Queensland University

Q&A and General Discussion

4:30 P.M.

WRAP-UP/ POINTS TO BE INCORPORATED IN THE FINAL REPORT

Barthélémy Kuate Defo, University of Montreal

5:00 P.M.

ADJOURN

SATURDAY, OCTOBER 22

CLOSED SESSION (*Panel Members Only*)

8:00 A.M. **CLOSED MEETING**

3:30 P.M. **END OF MEETING**

Appendix B

Participant List

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Appendix C

Biographical Sketches of Steering Committee Members and Presenters

MEMBERS

Barthélémy Kuate Defo (*Chair*) is a professor of demography and director of the Research Laboratory of the International Nutrition and Health Program of Canada at the University of Montreal. His research interests include population and global health, fertility and mortality linkages, sexuality and reproductive health, child nutrition, African demography, and demographic methods. He is currently the principal investigator on a large Rockefeller Foundation project examining the determinants and consequences of adolescent/youth sexuality and reproductive health in Cameroon. He is the author of *Sexuality and Reproductive Health during Adolescence in Africa, with Special Reference to Cameroon*. He has an M.S. in epidemiology and a Ph.D. in population studies from the University of Wisconsin–Madison.

Ayaga A. Bawah is principal research associate at the International Network for the Demographic Evaluation of Populations and Their Health in Developing Countries (INDEPTH) in Accra, Ghana. His research interests are in the area of population and health in Africa, particularly infant and child mortality, health equity, reproductive health and methodological issues. He has particular expertise in the analysis of large-scale data including data from longitudinal surveys and national censuses. He has an M.A. in population studies from the United Nations Regional Institute at the University of Ghana and a Ph.D. in demography from the University of Pennsylvania.

Lisa F. Berkman is director of the Harvard Center for Population and Development Studies and Thomas D. Cabot professor of public policy, epidemiology and population, and international health at the Harvard School of Public Health. Her work is oriented towards understanding social inequalities in health and aging related to socioeconomic status, labor policy, and social networks and social isolation. The majority of her work is devoted to identifying the role of social networks and support in predicting declines in physical and cognitive functioning and the onset of disease and mortality, especially related to cardiovascular or cerebrovascular disease. She is a member of the Institute of Medicine. She has a Ph.D. in epidemiology from the University of California, at Berkeley.

Alan D. Lopez is professor of medical statistics and population health and head of the School of Population Health at the University of Queensland, Australia. Previously, he worked at the World Health Organization in Geneva, where his technical and senior managerial posts included director of the Epidemiology and Burden of Disease Unit and

senior science adviser to the director general. He also chairs the Health and Medical Research Council of Queensland and is a member of Australia's Medical Services Advisory Committee. His principal research interests are analysis of mortality data burden of disease methods and applications and quantification of the health effects of tobacco, particularly in developing countries. He has published widely on mortality analysis and causes of death, including the impact of the global tobacco epidemic, and on the global descriptive epidemiology of major diseases, injuries, and risk factors. He is a foreign associate of the Institute of Medicine. He has an M.S. from Purdue University and a Ph.D. in epidemiology from the Australian National University, Canberra.

Jane Menken is professor of sociology and director of the Institute of Behavioral Science at the University of Colorado. Prior to her current position, she was the UPS Foundation professor in the social sciences at the University of Pennsylvania, where she was also served as director of the Population Studies Center. Her main area of research is fertility. She has developed mathematical models of reproduction and analytic techniques and has carried out studies on female sterility, fertility determinants in Bangladesh, and teenage pregnancy and childbearing in the United States. She is a member of the National Academy of Sciences and the Institute of Medicine. She has served as a member of the board of directors of the Alan Guttmacher Institute and the advisory committee to the director of the National Institutes of Health. She has a B.A. in mathematics from the University of Pennsylvania, an M.S. in biostatistics from the Harvard School of Public Health, and a Ph.D. in sociology and demography from Princeton University.

Julie Knoll Rajaratnam is assistant professor of global health at the Institute for Health Metrics and Evaluation at the University of Washington, where she leads the mortality estimation methods work. Her work has included producing age- and sex-specific mortality estimates for more than 200 countries for the Global Burden of Disease 2005 project. She has also been worked on child injuries in Baltimore, social isolation and its effect on depressive symptoms in mothers with young children, measurement of neighborhood characteristics in the field of maternal/child health, the willingness to pay for an HIV/AIDS vaccine in Uganda, and school and neighborhood variation in youth violence in Baltimore. She has a B.A. in biology from Macalester College and a Ph.D. in public health from the Johns Hopkins University Bloomberg School of Public Health.

Stephen Tollman is professor of community health in the Faculty of Health Sciences at the University of Witwatersrand, South Africa. He leads the Health and Population Division of the University's School of Public Health and directs the Agincourt community demographic and health surveillance system. His work covers numerous aspects of population and health in Africa. He has a Ph.D. in epidemiology and public health from Umeå University, Sweden.

Stig Wall is professor of epidemiology and health care research at the University of Umeå, Sweden, where has served as director of its Centre for Global Health Research and founded its Division of Epidemiology and Public Health Services. His main research areas are epidemiology and international health, environmental and social epidemiology,

prevention and medical technology assessment. He has served as editor-in-chief of the *Scandinavian Journal of Public Health* and is currently editor-in-chief of *Global Health Action*. He is a member of the Scientific Advisory Committee of the INDEPTH Network. He was awarded the Nordic Public Health Prize by the Nordic Council of Ministers, the Medal of Honor in Population Health from the Ministry of Health, Vietnam, and an honorary doctor of medicine by the University of Southern Denmark. He has a Ph.D. in statistics from the University of Umeå, Sweden.

PRESENTERS

Peter Byass is professor of global health at the Umeå University, Sweden, and director of the university's Centre for Global Health Research. He also holds honorary professorships at the University of Aberdeen, Scotland, and the University of the Witwatersrand, South Africa, and works closely with the INDEPTH Network and the World Health Organization. He has worked on a wide range of population health measurement issues in Africa and Asia and has been deeply involved in the development of probabilistic models for interpreting verbal autopsy material, initiating the now widely used InterVA model. He serves as deputy editor of *Global Health Action* and is on the editorial boards of *PLoS Medicine* and *Population Health Metrics*. He has an M.Sc. in information science from Hatfield Polytechnic and a Ph.D. in public health from Nottingham University, both in England.

Mark Collinson is a senior researcher with the MRC/Wits Rural Public Health and Health Transitions Research Unit (Agincourt) of the School of Public Health at the University of Witwatersrand, South Africa. He is the leader of the INDEPTH Network Working Group on Migration, Urbanization, and Health, and he has honorary research positions with the Centre for Global Health Research at Umeå University, Sweden, the Population Studies and Training Center at Brown University, and the Institute of Behavioral Studies at University of Colorado at Boulder. His research has focused on the nexus of migration, livelihoods, and health; on longitudinal statistical analysis in demography and public health; and on health and demographic surveillance systems. He has an M.Sc.(Med) from the University of the Witwatersrand and a Ph.D. in epidemiology and public health from the University of Umeå, Sweden.

Barthélémy Kuate Defo—see above.

Riku Elovainio is a technical officer with the Department of Health Systems Financing, World Health Organization, Geneva, Switzerland. His research interests include the role of health providers in low- and middle-income countries, performance incentives to influence health care provider behavior, strategic contracting in health systems, and health financing policy. He has studied anthropology, medical anthropology, economics and health economics at universities in Montpellier, Aix-en-Provence, and Clermont-Ferrand in France, and holds a master's degree in Health Economics and Maîtrise in Anthropology.

Majid Ezzati holds the chair in global environmental health at Imperial College, London, and he is affiliate professor of global health at the Institute for Health Metrics and Evaluation at the University of Washington. His research focuses on the effects of risk factor exposures and interventions on population health and health disparities, with emphasis on environmental risks, smoking, and nutritional and metabolic risk factors. His research group also conducts field research on air pollution and health in sub-Saharan Africa and Asia. He is a member of several expert and advisory groups in global health and global environmental health. He has a master's degree in engineering from McGill University and a Ph.D. in science, technology, and environmental policy from Princeton University.

Gilles Pison is director of research of the French National Institute for Demographic Research in Paris, where he is in charge of scientific communication; he is also professor at the French National Museum of Natural History. His research interests include aging and life expectancy, mortality and causes of death, the demography and health of twins, population projections (particularly for African countries), and the didactics of demography (multimedia, websites, exhibitions). He serves as editor-in-chief of *Population and Societies*.

Stephen Tollman—see above.