Informing global efforts to improve the health and wellbeing of low and middle-income populations: The INDEPTH Network of Health and Demographic Surveillance Systems

(a) AIMS OF THE PROPOSAL

Context / Vision / Framework

Introduction

Chronic non-communicable diseases (hypertension, stroke, diabetes, chronic respiratory disorders, cancers) in sub-Saharan Africa and South Asia are escalating with a momentum that is taking scientists and policymakers by surprise. In many of these settings, though more so in Africa, this is not paralleled by any sustained decline in infectious illness. Fuelled by the pervasive spread of HIV and AIDS and accompanying tuberculosis, as well as persisting malaria, parasitic and nutritional conditions, the steadily rising burden of chronic NCDs is taking place in the face of widespread infection. Patterns of risk, vulnerability and resilience are changing: the behavioural bases of HIV and AIDS and other chronic infections, as well as NCDs, are well recognised, but we are seeing marked differences in behavioural responses by social group even among the poorest communities. New awareness of the risks associated with sub-optimal foetal and infant development for later health, productivity and cognitive performance provoke deep concern for human resource development in resource poor settings.

Socio-economic development paths in industrialized and lower-income settings differ markedly. This is reflected in unfamiliar patterns of health and demographic transition. While development in high income European and North American populations was critical to demographic change, first in mortality, then fertility and increased life expectancy, patterns of development in middle and low income countries are far more diverse. While industrialisation and knowledge-based economic development is evident in several South American countries and parts of South Asia, much of sub-Saharan Africa is lagging behind. Insights into the social and life course determinants of health – educational attainment, migration patterns, labour force participation, livelihood strategies in resource poor settings – are weak and compromise policy responses. Further, mortality trends in poorer settings are closely linked to recent unprecedented investments in health interventions targeting especially HIV and AIDS, tuberculosis and malaria, and may skew health awareness and investment away from non-communicable disease.

The effect on policy of widely divergent transitions between and within countries is amplified by a profound lack of data, and weak or absent data systems, to track epi-demographic levels and trends. Such information is critical to effective programming and service delivery; its lack is reflected in poorly informed policy tied to weak evaluation of health impacts. Evidence to-date makes clear that new and innovative approaches to interventions, health systems and policy are needed, based on a mix of health promoting, preventive and clinical approaches, as well as social interventions, and more effective partnering with local communities.

The INDEPTH Network\textsuperscript{1} links research centres across three continents that run health and demographic surveillance systems providing the population-level longitudinal data in microcosm that is unavailable at national level in many low and middle-income countries. Pooling such data greatly

\textsuperscript{1} INDEPTH: International Network for the Demographic Evaluation of Populations and Their Health in developing countries \url{www.indepth-network.org
increases sample size and provides the potential to capture geo-social variability across multiple contrasting settings. INDEPTH thus is unusually well positioned to address major scientific questions about health and population dynamics, clinical care, health and social policy. These include:

**Health and population dynamics**

- What are the dynamics of demographic and epidemiological transition – mortality and fertility trends, patterns of risk and cause of death, changes in population composition and life-expectancy – within and across countries? What drives these changes, what is comparable across settings, and how much can be predicted?
- How do these changes differ by age, sex, social group, rural and urban setting, and amongst the poorest? Are health and social inequalities between groups narrowing or widening; how do these inequalities interrelate?
- Who is most vulnerable or resilient? At what ages – childhood, adolescence, working-age, elders – shaped by which risk factors and social conditions?

**Clinical care, policy and systems**

- How to apply population-based information to the evaluation of policies and interventions, locally and at national level?
- What forms of patient risk assessment and clinical management are effective and accessible in low-resource primary care and community settings?
- What are the likely health benefits from introducing new ‘point of care’ diagnostics and information technologies (such as mobile phones) to patient care in primary and community settings?
- How to reshape primary health care systems, specialized to provide acute care, to address the growing burden of chronic infectious and non-communicable diseases?
- Given the extent of behaviourally-based risk and illness in children and adults, what mix of preventive interventions, health promotion and clinical care is cost-effective in resource-poor settings?
- What approaches to community-based care can support the growing number of older persons?

Importantly, how can ‘newer’ sciences such as multilevel statistical analyses, demographic modeling and projections, life-course epidemiology, genetics/genomics and bioinformatics be harnessed to elucidate the pathways and consequences of health and illness in poorer environments with weak infrastructure and limited capacity?

**INDEPTH: a platform of health and demographic surveillance systems**

Health and demographic surveillance systems (HDSS) are exceptional research platforms located in low and middle-income settings with which we can address these questions. Critical properties of an HDSS include full enrolment of a geographically defined community at baseline; systematic follow-up of all births, deaths and migrations; and rigorous time-sequencing of vital events and qualifying variables with (largely) unbiased ascertainment of exposure and outcome.

Harnessing virtually all HDSS in developing countries\(^2\) – in areas where vital registration is weak or absent – positions INDEPTH as an unparalleled resource for population-based longitudinal and comparative data on mortality, fertility and their social and biological determinants. Interventions now considered routine (vitamin A supplementation, measles, tetanus and pertussis vaccines, insecticide-treated bednets) were all initially trialed on HDSS research platforms. REFS Scope exists to establish

\(^2\) In most settings, HDSS comprise core research infrastructures of population-based research centres; these centres may be free-standing, associated with universities or linked to other parent institutions.
further clinical and population cohorts supporting intervention-evaluations and lifecourse studies. Multi-site work to establish baseline levels and social/clinical determinants of chronic NCDs, wellbeing and disability among older persons is producing the evidence for programme development and intervention-evaluations.(1)

Notably, HDSS platforms tend to align with the boundaries used in health service delivery – districts or sub-districts, clinics, health centres and local hospitals and their catchment areas. This ensures that data generated is highly relevant locally as well as nationally/internationally. Applications to priority setting, programme monitoring, and health policy and systems impact-evaluation are high. Being community-based, and depending on long-term stable partnerships with host communities, can heighten the responsiveness and accountability of researchers to local needs and ethical concerns.

Aims

This proposal seeks to achieve a profound shift in the INDEPTH Network – from a credible, high-potential research and training network to a world-leading African-Asian platform of health and demographic surveillance centres engaged in ground-breaking comparative and collaborative population-based, policy-oriented research.

INDEPTH will realize this through an intensive, well-coordinated Network-wide effort to:

- Harness its scientific potential and accelerate the output of scientific knowledge to guide health and social policy, and support the evaluation of programmes / interventions at national, regional and international levels
- Revitalise its approach to cross-site data management by applying best practice methods of harmonising, storing, curating and sharing epi-demographic data from health and demographic surveillance systems (HDSSs), and
- Boost training efforts that target persisting deficits in capacity – by developing the skills of the most promising field scientists in research data management, measurement and study design.

A series of systematic, well-directed efforts will enhance the capacity of the INDEPTH Secretariat, based in Accra, Ghana, to energetically support a high-performance research network (management and governance detail in (f) below and Annex).

In this way, the INDEPTH Network expects to:

- Significantly enhance scientific productivity from multi-site research initiatives and collaborations
- Scale-up the Network’s policy-relevant contributions globally, regionally, nationally and locally
- Facilitate much wider access to and use of the longitudinal population-based data generated from these studies
- Establish INDEPTH as a partner of choice for other leading research networks and regional / international initiatives.

Figure 1 highlights links and synergies between the main focuses of this proposal. The Scientific programme is central but requires concurrent advances in data management. Similarly, the needs of vigorous scientific development will influence priorities in capacity strengthening. Advanced data handling will depend on sufficient ‘spread’ of research-oriented data managers with essential skill-sets. The programme of work and expected deliverables for each of these core elements – Science, Data and Capacity – is detailed in this proposal. In concert, they will ensure a profound, sustained...
shift in the capacity and productivity of the INDEPTH Network, extending significantly its contributions to the health and wellbeing of persons and communities in Africa and Asia.

Figure 1. Interlinked components of INDEPTH proposal: Science, Data and Capacity Strengthening
(b) BACKGROUND

Since the 1960s, household-level health and demographic surveillance systems (HDSS) have been established in many countries with incomplete vital registration systems to provide data on mortality and fertility and information on health service utilisation; equally, to support rigorous evaluation of interventions and assess the effects of policy. Individual HDSS make important contributions to science. However, there is much to be gained from constituting a robust platform of multiple HDSS for comparative or pooled studies, and multisite intervention-research.

Founded in Dar-es-Salaam in 1998, with a Secretariat in Accra, Ghana, the INDEPTH Network today comprises 42 health and demographic surveillance system (HDSS) sites in 19 African, Asian and Oceanian countries (see map). Community-level data on geographically-defined populations ranging from 10,000 to 300,000 people is collected at least annually, providing empirical longitudinal information on nearly three million people worldwide (2.91 million). Surveillance-based infrastructure and methods are outlined in (c) below.

A decade of INDEPTH development has seen steadily rising scientific output reflected in the publication of books, articles and journal collections (see Annex). These address critical gaps in evidence and tackle issues that range from previously unrecorded trends in mortality and derivation of African model lifetables, to fine-grained documentation of African-Asian migration patterns and their health consequences. Other work examines health inequalities in apparently uniformly poor populations, and provides new baseline and comparative data on chronic disease and self-reported disability among adults and elders in Asia and Africa. Drawing on site-specific data with comparative interpretation, multi-site analyses with harmonised variables and integrated or pooled datasets are a growing feature, undertaken recently to examine inequalities in health among older persons in Africa and Asia.

These efforts were paralleled by a vigorous programme of capacity development for younger scientists and data managers targeting methods for longitudinal data handling and analysis; technical and scientific exchanges were encouraged. INDEPTH in partnership with the University of the Witwatersrand established a now well-regarded MSc in Population-based Field Epidemiology.
couples classroom instruction with 6-month field internships at the Africa Centre, Ifakara Institute and Navrongo HDSS centre. Standardised survey instruments were developed,(10-13) and materials provided to new sites during set-up.(14-15) Centre leaders with financial and managerial staff participated in research strategy and grant development workshops.

Markers of achievement include:

**High levels of on-time response to Network-wide calls for data**
- 34 INDEPTH centres provided up-to-date trend data on age-sex mortality in 2010; this will permit publication of a unique mortality series (in preparation, see annex) and release in late 2011 of a well-described, largely unavailable data series
- Mortality and fertility data are the basis of the INDEPTH POPSTATS initiative:(16) a publicly accessible, regularly updated website of health and demographic indices (which can also be specified by site) aimed at researchers, planners and policymakers

**Increasingly productive African-Asian multi-site research initiatives**
- These address adult health and aging, migration and urbanisation, long-term effects of vaccines, population and the environment
- Well-characterised data from 8 African and Asian sites undertaking comparative work on Adult Health and Aging can be accessed through the INDEPTH website as well as that of the online journal *Global Health Action*(17)

**The Malaria Clinical Trials Alliance, under INDEPTH leadership,** with major laboratory, IT and infrastructure strengthening of 7 HDSS centres and a further 6 research institutions to support vaccine and therapeutic trials in East and West Africa

**The INDEPTH Effectiveness and Safety Studies of Antimalarials in Africa initiative (INESS),** involving 7 HDSS centres, which will develop and maintain a Phase IV safety and effectiveness studies platform, and assess the effectiveness of new malaria treatments and determinants of this

**The web-based iSHARE initiative** (INDEPTH Sharing and Access Repository) with publicly accessible data/metadata from 8 Asian and African HDSS centres.(18)

Development of the INDEPTH Network thus evolved in phases:

Since sites/centres generate longitudinal data from among the poorest rural and urban populations, an essential first step was to demonstrate willingness to harmonise and share data. This led to *Population and Health in the Developing World (2002).* Through iSHARE (www.indepth-ishare.org) and POPSTATS (www.indepth-ishare.org/popstats) this information is now publically available to the international scientific community.

Data on levels and trends in mortality and cause-of-death – in settings where vital registration is inadequate, or among harder-to-reach groups such as infants, elders and pregnant women – laid the foundation for *INDEPTH Model Life Tables for sub-Saharan Africa (2004)*,(5) comparative African-Asian studies of mortality,(19) and methodological work on analysis of verbal autopsies.(20-23) This provides a basis for tracking the Millennium Development Goals,(24) and examining the socio-economic determinants (such as migration) of mortality outcomes.(6, 12)

Findings are fostering the multi-site research initiatives outlined in Table 1. The potential of the INDEPTH platform as a test-bed for innovation, intervention-research and policy or programme evaluations is highlighted by MCTA, early work on the impact of vaccinations and micronutrients,
anticipated work on the impact of antiretroviral therapy, and the recently established INESS initiative (INDEPTH Effectiveness and Safety Studies of Antimalarials in Africa).

While the exceptional potential of INDEPTH is evident, its ability to attain and sustain ambitious objectives will depend on both scientific leadership and marked improvements in handling site data and multi-site datasets. Efforts to build a critical mass of well-trained local scientists will enhance performance over the medium term, facilitating contributions to other high-achieving scientific collaborations.
Table 1. Illustrative INDEPTH multi-site initiatives (detail in Appendix)

<table>
<thead>
<tr>
<th>Leader</th>
<th>Fred Binka</th>
<th>Stephen Tollman</th>
<th>Sanjay Juvekar</th>
<th>Mark Collinson</th>
<th>Charles Newton</th>
<th>Ayaga Bawah</th>
<th>Peter Aaby</th>
</tr>
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<tbody>
<tr>
<td># of sites</td>
<td>7 African</td>
<td>Africa 4 Asia 4</td>
<td>9 Asian</td>
<td>Africa 10 Asia 4</td>
<td>5 African</td>
<td>5 African</td>
<td>Africa 5 Asia 1</td>
</tr>
<tr>
<td>Aims</td>
<td>To develop a Phase IV safety &amp; effectiveness platform.</td>
<td>To assess the effectiveness of new malaria treatments.</td>
<td>To establish baseline and compare physical and cognitive function in persons 50+; trends over time; associations with mortality.</td>
<td>To establish baseline and compare NCD risk factors across Asian INDEPTH sites.</td>
<td>Who migrates and why? Impact on household left behind? Relationship to mortality, health, fertility, and socioeconomic status.</td>
<td>What are the prevalence, risk factors and mortality associated with epilepsy in Africa?</td>
<td>What is the impact of family planning and reproductive health interventions on livelihoods in African sites?</td>
</tr>
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<td>Funding</td>
<td>Gates Foundation</td>
<td>National Institute on Aging, NIH (WHO supplement)</td>
<td>Core INDEPTH funding</td>
<td>Core INDEPTH funding; Mellon Foundation</td>
<td>Wellcome Trust</td>
<td>Hewlett Foundation</td>
<td>DANIDA and EU</td>
</tr>
<tr>
<td>Future direction</td>
<td>Use evidence generated from platform to effect policy changes. Advocacy and communication.</td>
<td>2nd journal suppl. 2nd wave INDEPTH-SAGE include objective measures. 2011 major proposal to NIH. Increase doctoral students.</td>
<td>Next round NCD risk factor surveillance in 2012; will include African INDEPTH centres.</td>
<td>Grant application for multi-centre study on role of migration in the epidemiological transition and HIV epidemic.</td>
<td>Studies on: genetic determinants; psychiatric comorbidity; cost-effectiveness of treatment; role of traditional healers.</td>
<td>Strengthen evidence for more effective reproductive and health programmes.</td>
<td>Trial of unconventional interventions to reduce child mortality by stimulating immune capacity. PhD students. Papers on non-specific effects of interventions.</td>
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NCD: Non-communicable disease; IDRC: International Development Research Centre
This proposal rests on the motivation that synergies between the INDEPTH Scientific Programme, and programmes in data management and capacity development, are central to enhanced quality and accelerated productivity of INDEPTH scientific initiatives. After a short review of HDSS methods, the planned research programme is outlined below.

The INDEPTH data and research platform comprises multiple comparable surveillance infrastructures. Sited in diverse health and development contexts, most are in rural parts of Africa and Asia, with a growing number in urban or slum settings. In essence, health and demographic surveillance involves the registration then systematic follow-up of all persons in a defined geographic area (Figure 3). Regular household visits by trained local fieldworkers record all vital events (births, deaths, in- and out-migrations) since the previous visit and update the household roster. Verbal autopsy information, to determine probable cause-of-death, is gathered through detailed structured interviews with the closest caregiver of the deceased, in which signs and symptoms leading to the final illness and death are carefully noted.

These research platforms, premised on longitudinal follow-up and temporal sequencing of events, offer a robust sampling frame, accurate denominators, and support for a range of observational and experimental / quasi-experimental intervention studies. Clinical or event-based cohorts (such as birth cohorts, school entry cohorts, cohorts of adolescents or older adults) can be defined for long-term follow-up. Multi-level statistical models can help separate the effects of variables that act at individual, household or community levels. All HDSS centres depend on long-term, stable and respectful relationships with their host communities.

Multi-level analyses have been extended to cellular and molecular studies in a few INDEPTH centres which undertake genomic studies of vectors, pathogens and their human hosts. There is much scope for scaling-up genetic/genomic studies targeting non-communicable as well as infectious conditions, given the potential for thorough phenotyping, documentation of kin relationships and personal / family histories, along with systematic follow-up including migrants.
I SCIENTIFIC PROGRAMME

The Scientific programme will capitalise on core longitudinal data from INDEPTH centres to facilitate unique comparative analyses. Pooling of data will substantially increase sample size and exploit the potential for heterogeneity in analyses. This can improve our understanding of biological and social risk at both individual and community levels. Study scientists will work closely with the data team to prepare analytic datasets; following a pre-determined period, anonymised datasets with supporting metadata description will be made publicly accessible on a Network data repository.

Four research areas are proposed, the first three building naturally on each other (Figure 6). The foundational area will provide detailed, empirically-derived insight into the scale, pace and direction of epi-demographic transitions in contrasting African and Asian settings. Reasons for such patterns will be sought, using available socio-demographic variables such as education or household asset status. Research area 2 will extend these analyses, emphasising the study of inequalities in health status and potential social explanations for these. Research area 3 will examine the implications of the transitions for health, welfare and social systems. By contrast, Research area 4 will address health along the life course, identifying critical points of vulnerability, establishing a foundation for studies and intervention-research on the early life origins of later illness, and drawing on the strength of HDSS’ to effectively follow-up population-based cohorts.

Figure 6. Conceptual framework: INDEPTH initiative to inform global efforts to improve the health and wellbeing of low and middle-income populations

Beyond the Scientific programme presented, the intensive Network-wide effort to strengthen data management and production of analytic datasets will add great value to ongoing INDEPTH initiatives (Table 1). Further, it will boost Network contributions when partnering in regional and international research and policy development.