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Population surveillance of cardiovascular diseases in low-income to middle-income countries should leverage existing international collaborations

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INTRODUCTION

Non-communicable diseases (NCDs), especially cardiovascular diseases (CVDs), are the leading cause of death globally, with approximately 80% of NCD-related deaths occurring in low-income and middle-income countries (LMICs). NCDs disproportionately affect individuals in LMICs. Consequently, it is imperative to set up viable disease surveillance systems to accurately assess the burden of NCDs in these countries and design appropriate management and prevention strategies. Public health surveillance is the systematic and continuous tracking of population-level health status, events, outcomes, risk factors and other determinants through the collection, integration, analysis and interpretation of data and the timely dissemination of the information to instigate action.[1] Surveillance is pivotal in public health by providing useful information for policy and decision-making regarding population-level or individual-level preventive, curative or palliative interventions, and is relevant for healthcare providers and consumers.

Although surveillance was originally geared towards controlling infectious diseases, its basic conceptual definition has been extended to chronic NCDs, and CVD in particular. Indeed, CVD surveillance is still a developing field worldwide, especially in LMICs, compared with infectious diseases.[2] Most LMICs are yet to develop the best strategies and tools for monitoring the changing patterns of diseases and the effects of potential interventions. A strategic use of existing international frameworks by these countries has potential advantages as against setting up country-specific systems. Several of such international frameworks exist; examples include the WHO STEPwise approach to Surveillance (STEPS), Monitoring and Evaluation to Assess and Use Results Demographic and Health Surveys (MEASURE DHS) project, Global Tobacco Surveillance System, INDEPTH Network, Living Standards Measurement Study, Global School-based Student Health Survey, Survey of ageing and health, and the Global Burden of Disease project.[3–9] The

Summary box

- Non-communicable diseases (NCDs) are the leading cause of mortality globally, and particularly high in low-income and middle-income countries (LMICs), where the response is still below optimal.
- The scope of surveillance data needed for NCDs and more specifically cardiovascular diseases and the related risk factors as well as health service utilisation is broad.
- No single data gathering system is sufficient to provide the data required for comprehensive NCD surveillance. Hitherto, LMICs have seldom applied the most appropriate and timely surveillance strategies and tools for monitoring the changing disease patterns and the effects of interventions.
- The global threat of NCDs combined with unplanned urbanisation and unhealthy habits, including sedentary lifestyles and improper dietary pattern, calls for new surveillance methods with direct input from national control programmes to decipher existing health systems programmes in LMICs and design viable policies targeted at population ageing.
- Consideration for resource mobilisation to establish a sustainable surveillance system in LMICs includes host government collaborations, dedicated national research funding institutions, and international and donor agencies.

significance of using these frameworks in CVD surveillance includes cross-country learning, resources and expertise sharing, and performance. These frameworks are described in detail in table 1. The details on the components of the STEPS survey components, including the stroke survey, are provided in online supplementary tables 1 and 2. Additional details on the elements assessed in the DHS are also shown in online supplementary table 3.

The cost of implementing population surveillance in LMICs is a major challenge to the overall national and multicountry health systems. Because of budgetary constraints in LMICs, health departments are suboptimally funded to undertake surveillance. In an ideal situation, national governments would allocate resources to the health sector in general and specifically to NCD surveillance. However, achieving appropriate NCD surveillance may require resource mobilisation from international donor agencies to develop a functional surveillance system and provide funds for consistent implementation and further planning of outreach activities. Subnational-level NCD funding mechanisms may also be needed to strengthen surveillance efforts.[10]

DEVELOPMENT OF CHRONIC DISEASE SURVEILLANCE IN LMICS

Although public health surveillance dates back to the time of Pharaoh Mempses in the First Dynasty, its application to NCDs is relatively recent.[10 11] In the USA for instance, cancer reporting commenced in 1911, with the first population-based cancer registry established in 1935, and later landmark community-based cohort studies such as the Framingham Heart Study started in 1948.[12] In the 1980s, the USA established the nationwide Behavioral Risk Factor Surveillance System to continuously collect data on key behavioural determinants of health.[13] At a global level, the potential utility of surveillance in addressing NCDs was recognised at the 21st World Health Assembly, which recommended the application of surveillance principles to non-infectious health problems like atherosclerosis, cancers or social problems (eg, drug addiction).[14] However, interest for NCD surveillance had mostly remained the concern of developed countries until the 1990s, when it became evident that the greatest impact of NCDs would be in LMICs. Interestingly, the 53rd World Health Assembly adopted the *'Global strategy for prevention and control of non-communicable diseases'*.[15] The resolution positioned surveillance as a key objective of a global strategy and stressed the need for mapping emerging NCD epidemics. In order to provide guidance for policy, legislative and financial measures related to the development of an environment supportive of prevention and control, exploring NCD determinants with particular reference to disadvantaged populations was brought into the limelight.[15]

In 1999, the first global conference on risk factor surveillance, co-organised by the US Centers for Disease Control and Prevention (CDC), the Finnish National Public Health Institute (KTL) and the NCD surveillance department of WHO, was a landmark event for the development of an international collaboration towards global NCD surveillance.[16] Subsequent conferences were held in Finland (2001), Australia (2003), Uruguay (2005), Italy (2007), Canada (2011) and China (2013).[17] In 2008, a Global Working Group termed World Alliance for Risk Factor Surveillance (WARFS) was created by the International Union for Health Promotion and Education (IUHPE).[18] The WARFS mission is to support the development of behavioural risk factor surveillance (BRFS) as a tool for evidence-based public health, thus acknowledging its importance to inform, monitor and evaluate disease prevention and health promotion policies, services and interventions.[19] By creating a framework revolving around producing, drafting and updating white papers on surveillance, and co-organisation of global BRFS conferences, the WARFS aims to integrate surveillance as a tool into the mainstream of health promotion; serve as a reference for researchers, risk factors surveillance practitioners and countries that are developing risk factors surveillance; and to share findings and results and experiences with the IUHPE community to facilitate a dialogue regarding the role of risk factor surveillance. For example, an effort that is enhanced by the WARFS is a 6-year partnership established and jointly supported by the IUHPE and the US CDC to build capacity for cardiovascular health promotion and chronic disease prevention and control in the African region.[20]

In general, NCDs and more specifically CVD surveillance in LMICs is largely driven by WHO-led efforts, or bilateral collaborations between countries.[21 22] For example, since 2006, the CDC has collaborated with Brazil for NCD surveillance, by providing extensive technical support for the development of BRFS system across Brazil's state capitals. The CDC has also provided guidance on policy development, programme planning and evaluation of physical activity in about 300 municipalities in Brazil.[23] A similar collaboration for BRFS exists between the CDC and China.[24]

THE SCOPE OF CVD SURVEILLANCE

The spectrum of CVD surveillance includes various aspects such as determinants, events, health service utilisation and outcomes of care. Selection of conditions to include in the surveillance system varies across countries/settings, with the preference often given to important NCDs and risk factors amenable to prevention and control (table 2). Surveillance systems and requirements for NCDs have evolved over time, largely paralleling the progress in our understanding of the complex aetiology of these diseases, to include monitoring of trends in health behaviour, occupational and environmental risk factors, as well as health conditions such as disabilities. Furthermore, there has been increasing awareness of the impact of the built environment on the physical and mental health of populations.[25] Therefore, new surveillance methods have

Table 1 Overview of major existing international frameworks relavant for non-communicable chronic diseases surveillance in low-income and middle-income countries

Surveillance framework	Year available	Country/Region covered	Accessibility	Strength	Limitation	information included	Further description
The WHO STEPwise approach to Surveillance (STEPS)	2005	African, North and South America, South-East Asia, European, Eastern Mediterranean and Western Pacific	http://www.who.int/ncd_surveillance/en/steps_framework_dec03.pdf	This allows for the development of an increasingly comprehensive and complex surveillance system depending on resources and local needs. STEPS data are being used to inform NCD policies and track risk factor trends.[28]	The STEPS surveys are conventionally household-based and interviewer-administered and falls short of institutional data.	It is based on sequential levels of surveillance of different aspects of NCDs, allowing flexibility and integration at each step by maintaining standardised questionnaires and protocols to ensure comparability over time and across locations.	The STEPwise approach to risk factor surveillance is implemented through STEPS instruments, which cover three different levels of 'steps' of risk factor assessment, including (1) a questionnaire, (2) physical assessments and (3) biochemical measurements.
The MEASURE Demographic Health Surveys (DHS) project	1984	Global	https://dhsprogram.com/what-we-do/survey-Types/dHs.cfm	It collects comparable population-based data on fertility, contraception, maternal and child health and nutrition.[4] DHS data have expanded considerably, with new questions and modules on behaviours such as alcohol consumption, tobacco use and other biomarkers.	The DHS is proposed to take place once every 5 years. However, several countries have surveys at irregular intervals.[29] More so, the high traditional focus on children and women is a limitation for its use for surveillance.[30]	Many countries including the poorest have conducted at least one DHS survey.[30] For instance, of the 236 DHS conducted between 1985 and 2010, 49% were in Sub-Saharan Africa, 20% in Asia and 18% in Latin America and Caribbean.[4]	There is an opportunity to use the DHS platform for acquiring data for NCD surveillance (as a by-product), an approach already been used in some countries. For example, the 2002 DHS survey in Uzbekistan measured blood pressure and levels of other common CVD risk factors, including biological markers, and was subsequently used to describe their epidemiology in the country.[31 32]
The Global Tobacco Surveillance System (GTSS)	1999	Global	https://www.cdc.gov/tobacco/global/gtss/index.htm	The GTSS aims to enhance country capacity to design, implement and evaluate tobacco control interventions, and monitor key initiatives of the WHO Framework Convention on Tobacco Control and components of the WHO MPOWER technical package.[33]	The first Global Youth Tobacco Survey (GYTS) was conducted in 1999.[34] Since then, other comparative reports, based on data from an increasing number of countries, have been made available[5 33 35–43]; however, this has not addressed the misuse of tobacco products.	The GTSS is the largest public health surveillance system ever developed and maintained.[5]	The GTSS includes four surveys: the GYTS; the Global School Personnel Survey (GSPS); the Global Health Professions Student Survey (GHPSS); and the Global Adult Tobacco Survey (GATS). The GYTS focuses on youth aged 13–15, and collects information in schools. The GSPS surveys teachers and administrators from the same schools that participate in the GYTS. The GHPSS focuses on third-year students pursuing degrees in dentistry, medicine, nursing and pharmacy. The GATS is a nationally representative household survey that monitors tobacco use among people aged 15 years and older.
The INDEPTH Network	1998	Global	http://www.indepth-network.org/	INDEPTH strengthens global capacity for Health and Demographic Surveillance Systems (HDSS), and mount multisite research to guide health priorities and policies based on scientific evidence.	There is a limited potential to monitor non-fatal NCDs-related health outcomes across INDEPTH sites.	The network comprised 48 HDSS sites operated by 40 centres in 20 countries across participating continents where about 3.2 million people were studied over time.[6 44 45]	The focus of INDEPTH on mortality is a huge asset for monitoring the contribution of CVD to overall mortality. The extent of data collection on NCD determinants also varies significantly across INDEPTH sites. While it is inexistent in some centres, few others have evolved with time into community-based laboratories for studying and monitoring NCDs.[46–48]

Continued

Table 1 Continued

Surveillance framework	Year available	Country/Region covered	Accessibility	Strength	Limitation	information included	Further description
Living Standards Measurement Study (LSMS)	1980s	Global	http://surveys.worldbank.org/lsms	It collects household data useful to assess household welfare, understand household behaviour and evaluate the effect of various government policies on the living conditions of the population.[7]	The LSMS use complex multiple survey instruments to obtain data to ensure high-quality relevant data.	The health module has been expanded to incorporate questions on depression in order to measure its incidence and identify its links with other aspects of welfare and labour market participation.[49]	A potential utility of the LSMS survey in informing NCD research and surveillance is supported by the LSMS working paper number 131 on chronic illness and retirement in Jamaica.[50]
Survey of ageing and health	2004	Global	http://www.who.int/healthinfo/sage/en/	SAGE is a source of valuable information on the distribution of risk factors and health inequalities across participating countries.[51–56]	SAGE is limited to chronic diseases and risk factors.	The WHO Study on global AGEing and adult Health (SAGE) is an ongoing initiative by the WHO to compile longitudinal information on the health and well-being of adult populations and the ageing process.[8]	The core SAGE collects data on adults aged 50 years and older, including a smaller comparison sample of younger adults aged 18–49 years, from nationally representative samples. There are eight health and demographic surveillance sites in Bangladesh, Ghana, India, Indonesia, Kenya, South Africa, Tanzania and Vietnam, with an additional combined sample size of over 45 000 people as part of SAGE.[8 57]
The Global School-based Student Health Survey (GSHS)	2003	Global	http://www.who.int/ncds/surveillance/gshs/en/	The GSHS is a relatively low-cost, school-based survey which uses a self-administered questionnaire to obtain data on young people's health behaviour and protective factors related to the leading causes of morbidity and mortality among children and adults.	The GSHS examines cardiovascular risk factors and is restricted to children and adolescents.	This is the largest surveillance enterprise worldwide examining cardiovascular risk factors among children/adolescents. The GSHS has contributed important data on the distribution of CVD risk factors (obesity, physical activity, tobacco use and dietary intake) and their clustering among adolescents in LMICs.[58] The specificity of this surveillance endeavour is that it includes important data on lifestyle factors, namely physical activity and dietary intake.	The GSHS measures and assesses the behavioural risk factors and protective factors in 10 key areas (alcohol use, dietary behaviours, drug use, hygiene, mental health, physical activity, protective factors, sexual behaviours, tobacco use, violence and unintentional injury) among adolescents.

Continued

Table 1 Continued

Surveillance framework	Year available	Country/Region covered	Accessibility	Strength	Limitation	information included	Further description
Global Burden of Disease (GBD) project	1991	Global	http://www.who.int/healthinfo/global_burden_disease/about/en/	This measures the health loss from disability or death from over 300 diseases in more than 100 countries. The GBD study continues to supply data to measure progress in the global efforts and set priorities for the control of increasing burden of NCD.[59]	This has not been implanted in some countries of the world for several reasons, specifically due to individual country factor.	The GBD study provided the latest synthesis of the evidence for risk factor exposure and the attributable burden of disease. The subnational and national assessments extending across about three decades informed debates on the need of addressing risks in context.	GBD is a comparative risk assessment framework developed for previous iterations of the GBD study to estimate attributable deaths, disability-adjusted life-years (DALYs), and trends in exposure for several environmental, behavioural and metabolic risk factors from 1990 to 2015. Some highly preventable risks, such as smoking, remain major causes of attributable DALYs, even as exposure is reducing.[27]

CVD, cardiovascular diseases; LMICs, low-income and middle-income countries; NCD, non-communicable diseases.

Table 2 Cluster risk factors and determinants of preventable non-communicable chronic diseases

Risk and protective factors	Biological risk factors/markers	Preventable chronic disease and conditions
Behavioural factors ► Diet. ► Physical activity. ► Smoking. ► Alcohol misuse. Psychosocial factors ► 'sense of control'. ► Social support/ social exclusion. ► Resilience and emotional well-being. Early life factors ► Maternal health. ► Low birth weight. ► Childhood infections. ► Abuse and neglect.	► Obesity. ► Hypertension. ► Dyslipidaemia. ► Impaired glucose regulation. ► Proteinuria.	► Ischaemic heart disease. ► Stroke. ► Type 2 diabetes. ► Renal disease.

Non-modifiable factors: age, sex, ethnicity, genetic make-up and family history.
Socioenvironmental determinants (may or may not be modifiable): socioeconomic status, community characteristics (eg, presence/absence of social capital), work conditions, environmental health and so on.

been developed to monitor the health of populations in the context of their residential communities, involving a complex interaction of health determinants, health outcomes, physical measurements, biological samples, policies and the built environment.[26]

Population-based data are essential to surveillance and provide valuable information for planning and evaluating disease prevention and control strategies.[2] However, data sources for NCD surveillance may vary substantially, including a notifiable diseases system, vital statistics, sentinel surveillance, registries, health surveys, administrative data collection systems and census (table 3). The nature of diseases renders some data gathering systems less attractive. Indeed, the aspects of NCD most amenable to public health interventions are risk factors for the disease and present years before the disease becomes evident. Furthermore, some risk factors for diseases and related complications simply do not operate at the individual level, and there are future issues for planning related to comorbidity.[1]

THE FUTURE OF NCD SURVEILLANCE AND THE POTENTIAL CONTRIBUTION OF TECHNOLOGY

The use of technology may potentially help in improving disease surveillance. Electronic health records can

Table 3 Scope and potential sources of data required for chronic disease surveillance[1]

Determinants	Preclinical	Clinical	Outcomes
⇐	⇐	⇐	
Data examples	**Data examples**	**Data examples**	**Data examples**
Genetics ► Prevalence of breast cancer gene familial disease.	Screening ► Blood pressure. ► Blood glucose. ► Blood lipids.	Diagnosis ► Modes of diagnosis. ► Time to diagnosis.	Mortality ► Cause-specific deaths. ► Survival rates.
Risk behaviour ► Smoking. ► Dietary fat intake.	Risk reduction ► Smoking cessation. ► Programme uptake. ► Physical activity rates.	Treatment and procedures ► Surgery. ► Systemic therapy. ► Radiation. ► Palliation.	Morbidity ► Complications. ► Degree of disability. ► Quality of life.
Environment ► Occupational exposure.			
Socioeconomic ► Housing. ► Income level. ► Education.		Service use ► Hospitalisation. ► Physician visits. ► Home care. ► Ambulatory care. ► Palliative care.	
		Pharmaceutical ► Drug use. ► Complications and interactions.	

facilitate the extraction of information from medical files, which implies that hospital-based data could be used for surveillance, but not without practical challenges in majority of LMICs. However, recent initiatives such as the Data for Health initiative, a partnership between the CDC, the CDC Foundation, Bloomberg Philanthropies and other organisations, are geared towards support for surveillance in 20 LMICs across Latin America, Asia and Africa. The partnership will also strengthen birth and death registration systems and improve information on the aetiology of death to bolster policy development. The initiative will provide experts to create mobile phone risk factor surveys for NCDs. Finally, the partnership will help incountry, CDC-supported Field Epidemiology Training Program residents and National Public Health Institute staff to use health data to inform policy development. The Bloomberg Mobile Phone Risk Factor Surveys for Non-communicable Diseases will implement a mobile survey to track CVD data in the selected countries. The project will test the feasibility of using mobile phones to collect data that can supplement household surveys for non-communicable chronic diseases (such as heart attacks, stroke and diabetes), injuries and environmental health factors. The potential limitations of such an undertaking include limited clinical information and diagnostic misclassification such as underdiagnosis, overdiagnosis and misdiagnosis common with cardiovascular and chronic lung diseases.

Whether social networking, as suggested in other parts of the world (eg, USA), has the potential to modify the future of surveillance in LMICs remains unclear. The integration of social networking in surveillance would be challenging, as this requires access to the internet, which may not be commonplace in many parts of the LMICs.

LEVERAGING THE EXISTING RESOURCES IN LMICS FOR CVD SURVEILLANCE AND BUILDING ON EXPERIENCES FROM OTHER PARTS OF THE WORLD

The scope of data needed for NCD surveillance is very broad, and no single data gathering system is able to provide the mix of data required for a comprehensive surveillance.[1 12 17] Hence, population-based data collection requires multiple sources, including a notifiable disease system, vital statistics, disease registries, health surveys, censuses and sentinel surveillance.[12 27] This mix of data feeds is lacking in LMICs, which largely have yet to build the basic blocks for an ongoing NCD surveillance system. Setting up and maintaining a surveillance system require substantial investments in terms of human skills, time and financial resources. Consideration for sources of funding to establish a sustainable surveillance system includes local governments, international public agencies (such as the US Agency for International Development, WHO and CDC), and other dedicated research funding institutions such as the Wellcome Trust, the National Institute of Health and the Medical Research Council.

The level of investments required to achieve a comprehensive surveillance can quickly become prohibitive,

particularly when there is a lack of a baseline framework to build on. It is therefore important for LMICs to make strategic decisions in terms of the scope of their surveillance data needs and possible pathways for making such data available, while accounting for the downstream challenges to process and convert the data collected into outputs that will efficiently inform action. Whenever there are existing opportunities within countries for regular contact with the population, which can be capitalised on to gather surveillance data, building on such an opportunity is likely more feasible and cost-effective than setting up a completely new system. Where countries are contemplating starting new data gathering systems, there are advantages in adapting existing international frameworks as opposed to setting up a country-specific system. Such advantages include cross-country learning, resources and expertise sharing, and performance comparisons. Creating a reliable global NCD surveillance interconnected system would greatly contribute to reaching the United Nation - NCDs 2025 nine global targets/goals, through evaluation of the extent of what would remain to be done in that direction. This is also true for the 2030–2040 Sustainable Development Goals, especially goal 3, which pertains to ensuring healthy lives and promoting well-being for all at all ages.

CONCLUSION

In brief, LMICs are still to develop the best approach to surveillance of NCDs. This will require the appropriate investment, which can involve developing new initiative but also leverage existing international framework to limit costs. Such an undertaking is not devoid of challenges. Given the important human and financial burden of NCD in LMICs, an effective surveillance system would greatly contribute to limiting the costs related to these conditions.

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