

## INTRODUCTION

# A Heart-Healthy and Stroke-Free World Using Data to Inform Global Action



George A. Mensah, MD,<sup>a</sup> Valentin Fuster, MD, PhD,<sup>b,c</sup> Gregory A. Roth, MD, MPH<sup>d,e</sup>

## HISTORICAL PERSPECTIVES

Cardiovascular diseases (CVD), including ischemic heart disease (IHD), stroke, heart failure, peripheral and aortic arterial disease, arrhythmias, and valvular diseases constitute the leading cause of global mortality and a major contributor to health loss worldwide.<sup>1</sup> In 2022 alone, CVD caused an estimated 19.8 million deaths worldwide, corresponding to 396 million years of life lost and another 44.9 million years lived with disability (YLD).<sup>1</sup> Importantly, an estimated 34% of these CVD deaths occur before age 70 and thus should be highly amenable to prevention or treatment using the many safe and effective interventions available today. As stated in the Victoria Declaration on Heart Health >30 years ago, “We have the scientific knowledge to create a world in which heart disease and stroke are rare.”<sup>2</sup> Yet, millions of people continue to succumb prematurely to CVD across the globe.

In 2020, a strategic partnership involving the *Journal of the American College of Cardiology (JACC)*, the National Heart, Lung, and Blood Institute (NHLBI)

at the National Institutes of Health (NIH), and the Institute for Health Metrics and Evaluation (IHME) at the University of Washington, was created to focus attention on the global, regional, and national burden and trends of CVD and its risk factors.<sup>3</sup> Previous installments of the publications in *JACC* focused on findings from the annual updates of the Global Burden of Disease (GBD) Study and highlights from regions and countries where the burden of CVD and risk factors were highest or lowest, were substantially declining or rising,<sup>4-6</sup> and the impact of the coronavirus disease (COVID-19) pandemic on cardiovascular health in 2020.<sup>7</sup>

The current installment of the data, the 2023 Almanac, is based on results from the GBD for the years 1990 through 2022 and provides an update of health estimates for the global, regional, and national burden and trends of CVD and risk factors during that period.<sup>1</sup> In this editorial, we address the scope of the 2023 Almanac, the methodological changes made, and the major trends in global CVD and risks and their implications for clinical and public health practice. We also address the research implications with special emphasis on dissemination and implementation research needed to help accelerate the development, testing, and deployment of evidence-based strategies for the prevention, treatment, and control of CVD worldwide.

## SCOPE OF THE 2023 ALMANAC, METHODOLOGICAL CHANGES, AND KEY INSIGHTS

The GBD is a multinational effort with >10,000 collaborators. Several important updates have been made to these new results, reflecting new input data and new disease modelling methods. New mortality data has been added including for COVID-19 pandemic years in some locations. New estimates of all-cause mortality and population are also used. Population-level data on disease incidence during the

From the <sup>a</sup>Center for Translation Research and Implementation Science, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, Maryland, USA; <sup>b</sup>Mount Sinai Heart, Icahn School of Medicine at Mount Sinai, New York, New York, USA; <sup>c</sup>Centro Nacional de Investigaciones Cardiovasculares (CNIC), Madrid, Spain; <sup>d</sup>Department of Health Metrics Sciences, Institute for Health Metrics and Evaluation, School of Medicine, University of Washington, Seattle, Washington, USA; and the <sup>e</sup>Division of Cardiology, Department of Medicine, University of Washington, Seattle, Washington, USA.

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COVID-19 pandemic remains limited in important ways. For example, no data was available to inform our estimate of myocarditis incidence beyond the year 2019. GBD models are updated as new data becomes available.

An important update has been made to the estimation of the prevalence of YLD due to IHD. Previously, the prevalence of IHD represented the aggregate of 3 separately estimated IHD-related conditions: those with and surviving myocardial infarction, those experiencing stable angina, and those with ischemic cardiomyopathy. This approach has been replaced with a new disease model that makes use of new kinds of input data to better represent the burden of nonfatal IHD. Estimates of stable angina have been replaced by a disease model for the prevalence of significant coronary artery disease (CAD), defined as >50% epicardial coronary stenosis, history of coronary revascularization, inducible myocardial ischemia based on diagnostic testing, or past myocardial infarction. Estimates for the prevalence of IHD are therefore approximately 20% greater at the global level compared with previous estimates from the GBD, reflecting use of this broader CAD case definition. Estimates of CAD make use of a new systematic review of the published and gray literature, administrative health facility data, and population surveys.

The new model also uses a network meta-analysis that corrects systematic bias in health surveys where respondents reported a history of coronary artery disease or where an old myocardial infarction was detected on ECG based on standard criteria. It also includes data from a growing number of population-representative studies using computed tomography coronary angiography. The severity distribution for IHD used to estimate YLD is now derived from a global sample of Seattle Angina Questionnaire data among individuals with obstructive CAD.<sup>8</sup>

A new method based on a broader range of country-level covariates has been developed to estimate which countries have endemic levels of incident rheumatic heart disease (RHD). New health facility administrative data is used to estimate RHD prevalence in nonendemic countries. Medicare data has been incorporated into estimation for many CVD in the United States. Estimates of the level of systolic blood pressure and low-density lipoprotein (LDL)-cholesterol now includes new microdata from >180 and >125 health examination surveys, respectively. Estimates of the prevalence of stroke now include new microdata from 182 health surveys.

The 2023 Almanac includes figures that scatter each country's age-standardized cardiovascular

mortality rate against the sociodemographic index (SDI). The SDI is a summary measure of development for each country that is informed by income level, education level, and fertility rate. SDI is estimated for every year since 1990 and is calculated from representative data collected from the general population. The analysis reveals substantial variation in CVD mortality at very similar levels of SDI. CVD risk factor exposures also vary widely among countries with similar levels of development. This variation at similar levels of SDI suggests that opportunities for more rapid improvements in health may be possible without the need to wait for longer-term social and economic development.

## 5 MAJOR TRENDS IN GLOBAL CVD AND RISKS: PRACTICE AND RESEARCH IMPLICATIONS

Findings from the GBD for the period of 1990 through 2022 have been presented for each of the 21 GBD regions and for all GBD regions collectively in the 2023 Almanac.<sup>1</sup> In the sections below, we address the 5 major trends in global CVD and risks and their implications for clinical and public health practice and research.

**1. RISING GLOBAL CVD DEATHS.** Although the global age-standardized CVD mortality rate declined by 34.9% from 358.4 per 100,000 in 1990 to 233.2 per 100,000 in 2022, actual CVD death counts rose. Overall, global death counts due to CVD increased from 12.4 million in 1990 to 19.8 million in 2022, reflecting global population growth and aging and the contributions from preventable metabolic, behavioral, and environmental risks. Between 2015 and 2022, even the age-standardized CVD mortality increased in 27 locations. Additionally, we found high levels of disease burden due to metabolic, behavioral, and environmental risk factors. Attributable age-standardized disability-adjusted life years (DALYs) exceeded 500 per 100,000 for the following CVD risks: high systolic blood pressure, dietary risks, ambient particulate air pollution, high LDL cholesterol, high body mass index (BMI), high fasting plasma glucose, and smoking.

The implications for clinical and public health practice and research are clear. First, the persistent, often profound variations in CVD burden and trends by region and at the national and subnational levels should spur further population science research to seek deeper understanding for the variations. CVD is not a necessary feature of human aging but instead almost entirely the result of modifiable risk factors. Extreme geographic variation also indicates a need for increased research to leverage insights from

regions with low burden to inform actions in high-burden locales. Second, increased attention to strategies that promote healthy aging across all regions can mitigate the cardiovascular impact of population aging.<sup>9-13</sup> This is particularly important because of the World Health Organization's estimate that by 2030, the end of the Decade of Healthy Ageing (2021-2030), the number of people aged  $\geq 60$  years will be 34% higher, increasing from 1 billion in 2019 to 1.4 billion; and that, by 2050, the global population of older people will have more than doubled, to 2.1 billion.<sup>13</sup> These estimates are also a great concern for low- and middle-income countries (LMICs) in Africa, Latin America, the Caribbean, and Asia, where the number of older people is increasing the fastest.<sup>13</sup>

**2. GROWING GLOBAL BURDEN OF CARDIOMETABOLIC RISKS.** The growing global burden of cardiometabolic risks is a trend that calls for renewed emphasis on prevention, treatment, and control strategies. For example, the 2023 World Obesity Atlas estimated that by 2035, global levels of overweight and obesity (BMI  $\geq 25$  kg/m<sup>2</sup>) may reach >4 billion people, compared with >2.6 billion in 2020.<sup>14</sup> Obesity alone is expected to increase from 14% to 24% of the population during that period and is expected to affect approximately 2 billion adults, children, and adolescents by 2035.<sup>14</sup> Excluding children aged <5 years, this growth in overweight and obesity reflects an increase of 38% of the world's population in 2020 to >50% by 2035.<sup>14</sup> As night follows day, so too will the global burden of diabetes follow the continuing rise in global obesity. The GBD 2021 Diabetes Collaborators estimated that the number of people living with diabetes will soar to 1.3 billion in 2050, compared to 529 million in 2021.<sup>15</sup>

The 5 metabolic risks highlighted in the 2023 Almanac include high systolic blood pressure, high LDL cholesterol, high BMI, high fasting plasma glucose, and kidney dysfunction—all of which are preventable and controllable through individual lifestyle and behavioral interventions as well as multi-sectoral, multifaceted, social, environmental, and policy changes at the population and community levels (**Central Illustration**). For metabolic risks in all, high systolic blood pressure accounted for the largest contribution to attributable age-standardized CVD DALYs at 2,564.9 per 100,000 globally. Dietary risks were the leading contributor to age-standardized CVD DALYs among the behavioral risks, while ambient particulate matter pollution led the environmental risks.

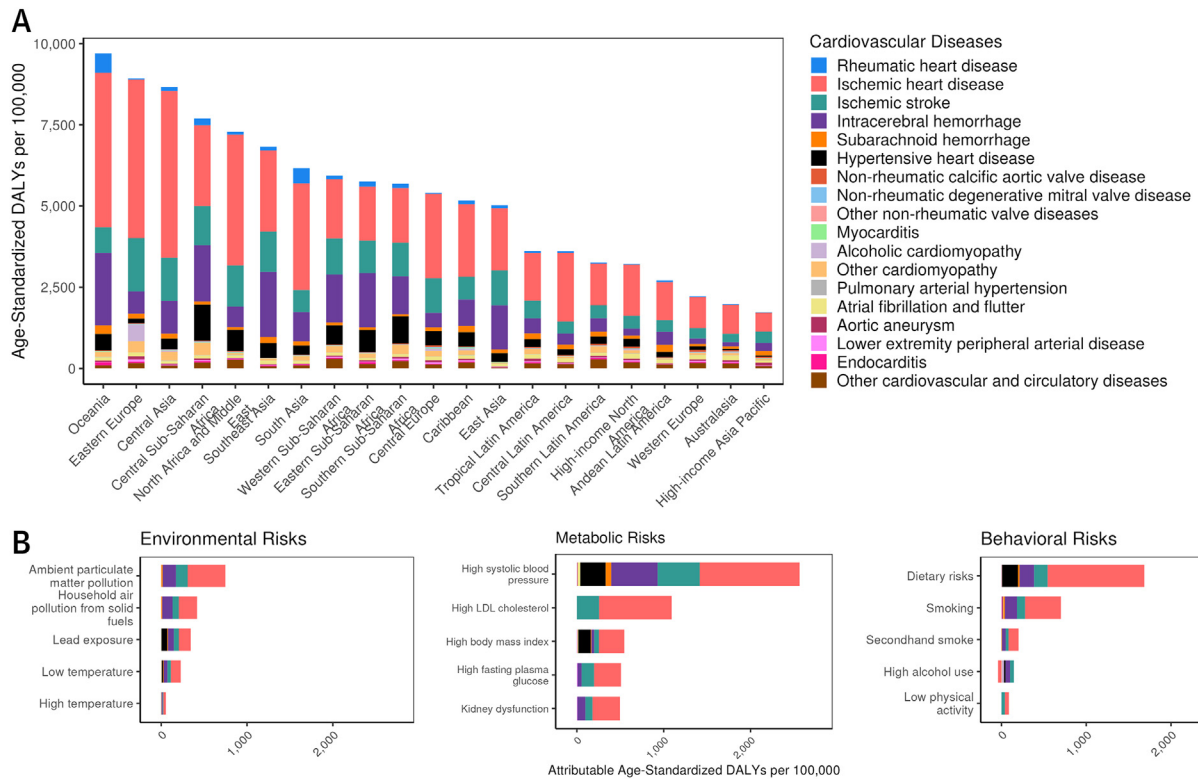
**3. PROFOUND REGIONAL VARIATION IN CVD BURDEN.** For all CVD health estimates, profound geographic

variation by GBD region is the rule rather than the exception (**Central Illustration**). For example, age-standardized CVD mortality rates per 100,000 by region in 2022 ranged from 73.6 in High-Income Asia Pacific to 432.3 in Eastern Europe—nearly a 6-fold difference. Similarly, age-standardized prevalence of CVD per 100,000 was highest in Central Asia (11,342.6) and lowest in South Asia (5,881.0). IHD was by far the leading cause of global CVD mortality, with an age-standardized rate per 100,000 of 108.8 deaths, followed by intracerebral hemorrhage and ischemic stroke. All 3 leading causes of CVD mortality manifest similarly profound regional variation. These marked variations have their roots in multiple complex, upstream, inter-related factors, including socioeconomic, sociodemographic, cultural, environmental, metabolic, behavioral, lifestyle, and health care-related factors.

Many of these complex inter-relationships remain incompletely understood. Thus, continuing population science research to understand the underlying causes of these variations is necessary for effective prevention and control strategies from the clinical and public health perspectives. In the interim, as stated earlier, we know enough to use proven-effective interventions, guided by the CVD and risk factor burden data to inform global and regional action. Importantly, these actions need to be culturally and contextually attuned to the unique needs of each region.

**4. DISPROPORTIONATE BURDEN OF CVD IN LMICs.** A major concern is the increasing, disproportionate burden of CVD in LMICs.<sup>1</sup> More than 75% of the global CVD burden is found in the LMICs in Oceania, Eastern and Central Europe, sub-Saharan Africa, North Africa and the Middle East, the Caribbean, and East and South Asia. An important driver of this disproportionate burden is population growth and aging, coupled with the continuing epidemiologic transition leading to rising burden of noncommunicable diseases such as CVD and related risk factors. Among the risk factors identified, high systolic blood pressure remains the most worrisome because of its direct contribution to the leading cardiovascular causes of death including IHD, ischemic and hemorrhagic stroke, and hypertensive heart disease.

In addition to the healthy aging strategies identified earlier, this trend calls for increasing health-systems strengthening in LMICs to promote heart-healthy living overall and locally and contextually congruent strategies for the prevention, treatment, and control of CVD and risk factors. Additionally, improving the availability,

**CENTRAL ILLUSTRATION Global Burden of Cardiovascular Disease in DALYs by Cause, Region, and Risk Factors**Mensah GA, et al. *J Am Coll Cardiol.* 2023;82(25):2343-2349.

Age-standardized disability-adjusted life years (DALYs) per 100,000 in 2022 for (A) cardiovascular diseases by region and (B) burden attributable to selected risk factors, globally, compared to the theoretical minimum risk exposure level.

affordability, accessibility, and acceptability of safe and effective medications and devices for CVD prevention and control in LMICs will be essential. Several strategies for addressing these challenges exist.<sup>16</sup>

**5. DRAMATIC DECLINES IN ATTRIBUTABLE CVD BURDEN FOR HOUSEHOLD AIR POLLUTION.** Beyond the traditional metabolic and behavioral risks of interest in the prevention and control of CVD, the environmental risks deserve attention. The 2023 Almanac highlights data for the impact on CVD of ambient particulate matter pollution, household air pollution from solid fuels, lead exposure, and nonoptimal temperature (low and high). The dramatic 65.1% decline in attributable age-standardized CVD DALYs observed for household air pollution from solid fuels over the period from 1990 through 2022 represents the fifth important trend. Similarly dramatic declines were also seen over that period for

attributable YLD, years of life lost, and CVD mortality when analyzed by age-standardized data or data for all ages. Practices and policies that help sustain these declines, especially in the context of adverse climate change impact, will play important roles in continuing the reductions in attributable CVD mortality. The good news here, as shown for the other metabolic and behavioral risks, is that we have safe and proven-effective interventions and strategies for tackling these risks. The increasing adoption of clean cookstoves and associated reduction in household air pollution is an important example.<sup>17</sup> The challenge is for broad, sustained, impactful, and equitable implementation.<sup>18</sup>

#### IMPLICATIONS FOR DISSEMINATION AND IMPLEMENTATION RESEARCH

Several recent journal publications and scientific statements have reaffirmed the crucial role of

dissemination and implementation research in helping to use research evidence and data to advance quality and equity in cardiovascular health and health care.<sup>19-23</sup> These calls for action have focused on several cardiovascular conditions and settings including hypertension,<sup>19,22,24</sup> heart failure,<sup>21,25</sup> dyslipidemia management,<sup>24,26,27</sup> cardiovascular surgery,<sup>28-31</sup> CVD genomics,<sup>32-35</sup> meaningful engagement of communities and stakeholders,<sup>36-38</sup> and cardiovascular clinical practice guideline implementation.<sup>24,39</sup> The health estimates in the 2023 Almanac provide compelling evidence of where in the world the burden of total CVD or specific cardiovascular causes and related risk factors remain high, are rising or declining, or demonstrate significant disparities and thus require attention.

Selecting from a wide variety of implementation science models, theories, and frameworks,<sup>40</sup> cardiovascular health investigators and their partners in community-based research, health policy and systems research, and practice-based research networks can use the data from the 2023 Almanac to inform the design, implementation, and evaluation of CVD research. There is a tremendous opportunity to learn from the policies and practices from patient, provider, and health systems levels in 1 or more areas where contrasting patterns of CVD and risk factor burden and trends exist. These data also provide the opportunity for investigators to explore natural experiments to gain additional understanding of the variation in CVD and risk factor burden and trends across the globe.<sup>41</sup> The intrinsic comparability of the GBD health estimates methodology makes this exercise feasible across regions and countries and within countries.<sup>42</sup>

Developing and testing innovative strategies for the implementation of proven-effective interventions or best practices is at the core of implementation research. Often, however, we have to de-implement or stop healthcare practices that offer low value, or for which risks and harms outweigh benefits to patients.<sup>43-46</sup> Shrank, et al<sup>47</sup> estimated that over-treatment or low-value care costs the United States \$75.7 billion to \$101.2 billion annually. They also reported that de-implementation of the identified low-value care would result in \$12.8 billion to \$28.6 billion in estimated annual savings.<sup>47</sup> Of note, de-implementation can be as challenging, if not more so, as implementing proven-effective strategies. Berlin et al<sup>31</sup> have discussed the unique factors that present as barriers to de-implementation and suggest

potential strategies to reduce low-value surgery in the United States; but they admit that, in most circumstances, the multilevel factors contributing to persistent overuse of low-value surgery remain unknown.

## JACC-NHLBI-IHME PARTNERSHIP

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Taken together with the health estimates of the global, regional, and national burden of CVD and risk factors, the challenges described provide an important opportunity for dissemination, implementation, and de-implementation research in cardiovascular care. The ongoing collaboration involving JACC, NHLBI, and IHME remains committed to disseminating current and future findings from the Global Burden of Cardiovascular Diseases and Risks Collaborators based on the GBD studies. The JACC-NHLBI-IHME partnership hopes that these data will be used within their appropriate regional, national, and sub-national contexts to drive local level clinical and population science research as well as spur dissemination and implementation research to inform global and local-level clinical, public health, and health policy change.

To facilitate increased familiarity with the data in the Almanac, the JACC-NHLBI-IHME partnership has also developed a Web-based interactive tool to support clinicians, research investigators, and trainees as they delve more deeply into these global data.<sup>48</sup> The interactive tool helps visualize data from the GBD Study for the years 1990 through 2022, and reports the magnitude of total CVD burden, including presentation by disease state and risk factors across 21 global regions.<sup>48</sup> This tool demonstrates the data in 3 main sections: 1) total CVD mortality rates by region; 2) mortality rates by CVD diagnosis; and 3) cardiovascular risk factors, location metrics, and socioeconomic data.<sup>48</sup> The tool also provides the opportunity to download customizable presentation slides on the data visualized. Detailed results for every country are also available for download online at <https://ghdx.healthdata.org/>.

## CONCLUSIONS

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We know enough to prevent and control most CVD; however, knowing is not enough. We must also take action to disseminate promising practices and implement evidence-based interventions that constitute guideline-directed management of CVD and risks. Multiple validated implementation science

frameworks exist and include those that focus on equitable dissemination and implementation to ensure we reach populations and communities often hardly reached. The data in this Almanac and the 5 major trends in global CVD and risks provide a compelling urgency for global action to reduce the global burden of CVD and risks. Importantly, the vision of heart-healthy, stroke-free, and thriving communities worldwide is achievable through the promotion of healthy aging across the lifespan and aggressive prevention and control of CVD risk factors. We hope you use the data in the Almanac and related Web-based visualization tool as trusted companions on this journey as we chart the future together for

heart-healthy, stroke-free, and thriving communities worldwide.

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**ADDRESS FOR CORRESPONDENCE:** Dr George A. Mensah, Center for Translation Research and Implementation Science (CTRIS), National Heart, Lung, and Blood Institute, National Institutes of Health, One Rockledge Centre, 6705 Rockledge Drive, Suite 6070, Bethesda, Maryland 20892, USA. E-mail: [george.mensah@nih.gov](mailto:george.mensah@nih.gov). [@NHLBI\\_Translate](https://twitter.com/NHLBI_Translate).

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