Reducing the cardiovascular disease burden for people of all ages in the Americas region: analysis of mortality data, 2000–15

Peter Lloyd-Sherlock, Shah Ebrahim, Ramon Martinez, Martin McKee, Pedro Ordunez

Summary

Background In accordance with the age parameters specified in Sustainable Development Goal target 3.4, current policy and monitoring of non-communicable disease (NCD) mortality trends focus on people aged 30–69 years. This approach excludes the majority of NCD deaths, which occur at older ages. We aimed to compare cardiovascular mortality for different age groups in the WHO Region of the Americas.

Methods We extracted mortality data from the Pan American Health Organization regional mortality database for 36 countries for the period 2000 to 2015. We calculated age-standardised mortality rates (ASMRs) from cardiovascular diseases for different age groups for these countries. Joinpoint regression models were used to estimate mortality trends, providing estimates of the average annual percentage change for the period 2000–15.

Findings Individuals aged 70 years or older accounted for the majority of cardiovascular disease deaths in all countries (range 52–82%). Considerable variation in cardiovascular deaths was observed between countries for all age categories. Between 2000 and 2015, in most countries, the largest reductions in ASMR were observed in the older age groups (aged ≥70 years). The total number of regional cardiovascular disease deaths that hypothetically could have been averted in 2015 for people aged 30–79 years was 440,777, of which 211,365 (48%) occurred among people aged 70–79 years.

Interpretation Data for the WHO Region of the Americas are sufficiently robust to permit comparative analysis of cardiovascular disease mortality trends for people aged 70 years and older over time and across countries. Although the reduction of cardiovascular disease mortality in individuals aged 30–69 years is a valid policy goal for the Americas region, this objective should be expanded to include people at older ages.

Funding None.

Copyright © 2019 The Author(s). Published by Elsevier Ltd. This is an Open Access article under the CC BY 4.0 license.

Introduction

The WHO Independent High-level Commission on Noncommunicable Diseases has raised justifiable concerns about the slow progress towards reducing non-communicable disease (NCD) mortality in all WHO regions, including the Region of the Americas.1 Consistent with the Sustainable Development Goal target 3.4, global monitoring of NCD mortality exclusively focuses on people aged 30–69 years. For example, 2018 WHO country NCD profiles2 provide no information on mortality among older people (aged ≥70 years). However, individuals aged 70 years and older account for the majority of NCD deaths in all WHO regions with the exception of Africa, where they account for 38% of all NCD deaths.3

The Lancet NCD Countdown 2030 Collaborators observed that NCD targets that exclude certain age groups are inconsistent with the wider Sustainable Development Goals principle of leaving no one behind, and call for a more inclusive approach. The extent to which this is possible in different WHO regions is a matter of debate. Estimation of cause-specific death rates becomes increasingly uncertain at older ages because an increased proportion of deaths are coded as due to ill-defined causes, multimorbidity is high, and uncertainty exists about precise ages recorded in mortality and population data sources.4

We aimed to assess the viability of including people aged 70 years and older in NCD monitoring for the Region of the Americas with reference to cardiovascular disease, which is the leading cause of death in the region. We examined the distribution of cardiovascular disease deaths across different age groups, compared age-standardised mortality rates (ASMRs) for cardiovascular disease for different age groups across countries, and compared national trends in cardiovascular disease ASMRs for different age groups between 2000 and 2015. We also considered the implications of our findings for health policy targets in the Americas and other regions.

Methods

Data sources We extracted mortality data from the Pan American Health Organization regional mortality database (updated...
in July, 2017), which comprises deaths registered in national vital registration systems and reported annually to the Pan American Health Organization by national authorities in all 36 countries of the WHO Region of the Americas.6 This dataset contains information on sex, age, date of death, place of residence, and underlying cause of death coded using the International Classification of Diseases, tenth revision (ICD-10).7

Quality of data on registered deaths was assessed by measuring data completeness, including variables with missing values (sex and age with unknown categories), and years with no reported data; cause-of-death diagnostic and coding quality, by quantifying the proportion of death with ill-defined causes of death and so-called garbage codes; and estimation of the coverage level (appendix p 20). Mortality data were validated according to ICD-10 classification standards and corrected to overcome data quality issues following standard methods.8 Briefly, underlying cause-of-death codes are validated against a list of accepted mortality codes and verified against age and sex restrictions. Deaths with unknown sex or age were redistributed pro rata among deaths with known sex and ages. Deaths with underlying causes coded as ill-defined causes of death (ICD-10 codes R00–R94 or R96–R99) were redistributed proportionally among deaths with non-injury causes of death by strata of country, year, sex, and age group. Deaths with underlying causes coded as events of undetermined intent (ICD-10 codes Y10–Y34) were redistributed proportionally among deaths due to injuries. Registered deaths for countries with estimated under-registration higher than 3% and available data in the WHO life table4 were corrected according to their level of under-registration by strata of year, sex, age, and underlying cause of death. After addressing data quality issues, the number of deaths was estimated by country, sex, age group, and four-digit code of cause-of-death for the whole time period (2000–15) with reported data as part of annual estimation cycles.

We used mid-year population estimates obtained from a database that integrates data from the World Population Prospects, 2017 Revision9 (for countries with population size of 90 000 or more) and data from the US Census Bureau International Database10 (for countries and territories with population of less than 90 000) to calculate death rates. The WHO Standard11 was used to calculate ASMRs. Deaths due to cardiovascular disease were defined as all deaths classified using ICD-10 codes I00–I99.

11 countries and territories with a population size of less than 90 000 were excluded from the analysis. Additionally, Bolivia, Haiti, and Honduras were excluded because of low data quality and poor data completeness (appendix p 20). Overall, the countries and territories excluded represent only 3% of the total population of the Americas.

### Data analysis

We calculated the number of cardiovascular disease deaths by 5-year age group and sex, and the proportion of cardiovascular disease deaths by age group (0–30, 30–49, 50–69, 70–79, and ≥80 years), by broader age group (30–69 and ≥70 years), and by sex. We computed age-specific and sex-specific death rates from cardiovascular disease per 100 000 person-years among age groups (aged <70 years), albeit with large national variations, among older age groups (aged ≥70 years) than younger age groups (aged <70 years), albeit with large national variations, suggesting that a large proportion of deaths among people 70 years or older are avoidable. Consequently, individuals aged 70 years and older should not be excluded from global health targets, several of which aim to reduce premature mortality.

### Added value of this study

This is the first study to compare age-standardised cardiovascular disease mortality across different age groups for the Region of the Americas, using the most recent data available (up to 2015).

### Implications of all the available evidence

Between 2000 and 2015, in the Region of the Americas, reductions in cardiovascular disease mortality were larger among older age groups (aged ≥70 years) than younger age groups (aged <70 years), albeit with large national variations, suggesting that a large proportion of deaths among people 70 years or older are avoidable. Consequently, individuals aged 70 years and older should not be excluded from global health targets, several of which aim to reduce premature mortality.
if the rate of change over time is not constant. In such circumstances many studies now estimate the AAPC using Joinpoint, which provides segmented analysis of rates over the entire time period.\textsuperscript{12,13} Each p value is calculated using the Monte Carlo method,\textsuperscript{14} and the overall asymptotic significance level is maintained through a Bonferroni correction. We used 4499 randomly permuted datasets (default setting in the Joinpoint software). These tests also consider situations with non-constant variance to account for rates with Poisson variation and possibly autocorrelated errors.

The AAPC is a summary measure of the trend over a prespecified fixed interval, which is computed as a weighted average of the annual percent change from the Joinpoint model, with the weights equal to the length of the annual percent change interval. The AAPC is considered statistically significant when its value differs from zero at a level 0·05. To interpret the AAPC, a constant trend was considered when the zero value was within the lower and upper limits of the 95% CI of the AAPC; an increasing trend was considered present when both limits of the 95% CI were positive, and a decreasing trend was considered present when both limits of the 95% CI were negative.

Incidence rates were compared with those in Canada and presented as incidence rate ratios.

To determine the number of cardiovascular disease deaths that could have hypothetically been avoided, we compared the actual number of deaths in 2015 with the expected number of deaths that would have occurred assuming there was no change in ASMRs between 2000 and 2015.

Figure 1: Cardiovascular disease deaths by age group in adults aged 30 years and older in selected countries and territories of the Americas, 2013–15

34 of 36 countries or territories had available data for the period 2013-15.
Articles

We analysed data from 36 countries. Individuals aged 70 years or older accounted for the majority of cardiovascular disease deaths in all countries, ranging from 52% in the Bahamas to 82% in Martinique (figure 1).

Role of the funding source
There was no funding source for this study. The corresponding author had full access to all the data in the study and had final responsibility to submit for publication.

Results
We analysed data from 36 countries. Individuals aged 70 years or older accounted for the majority of cardiovascular disease deaths in all countries, ranging from 52% in the Bahamas to 82% in Martinique (figure 1).

The proportion of cardiovascular disease deaths in the 30–49 year age group was highest in the Bahamas (15%) and lowest in Canada (3%).

ASMR varied considerably between countries across all age categories (table 1). For all age categories, the highest incidence rates relative to Canada were observed for Guyana (incidence rate ratio 6.3 for individuals aged 30–49 years; 7.0 for individuals aged 50–69 years; 5.9 for individuals aged 70–79 years; and 3.8 for individuals aged ≥80 years). Countries with the lowest incidence rate ratios relative to Canada varied by age group (1.3 for...
individuals aged 30–49 years in Chile; 0–9 for individuals aged 50–69 years and individuals aged 70–79 years in Martinique; and 0–9 for individuals aged ≥80 years in Puerto Rico).

Between 2000 and 2015, ASMRs decreased in most countries for all age categories (table 2), which reflects the regional trend, although wide variation was observed between countries. Of the more populous countries in the Region of the Americas, Mexico stands out in terms of the limited progress made. Large disparities were identified among smaller countries, although the robustness of the data is limited by small population sizes. Between 2000 and 2015, the cardiovascular disease ASMRs in all age groups in Brazil, Canada, Colombia, Mexico, and the USA generally decreased, with the exception of Mexico, and the largest reductions were observed in the older age groups (70–79 years and ≥80 years; figure 2). ASMR data for all countries are shown in the appendix (p 10).

Table 3 presents the number of cardiovascular disease deaths by age group that could have hypothetically been averted for selected countries. Hypothetically, for the region as a whole, in 2015, 440,777 cardiovascular disease deaths by age group that could have hypothetically been averted for selected countries.
deaths in people aged 30–79 years could have been averted, of which 211365 (48%) occurred among people aged 70–79 years.

**Discussion**

Cardiovascular disease continues to be the leading cause of all deaths in the WHO Region of the Americas, accounting for 1.6 million deaths annually. Around two-thirds of these deaths occur among people aged 70 years and over, reflecting the rate of demographic and epidemiological transition in most countries. The proportion of the population aged older than 70 years is expected to increase from 5.6% in 2000 to 10.5% by 2030.

Available data for the Region of the Americas are sufficiently robust to permit comparative analysis of cardiovascular disease mortality trends over time, across countries, and between age groups. This includes the population aged 70–79 years and, to a lesser extent, people aged 80 years and older, indicating the viability of including these groups in targets and monitoring.

Our findings are consistent with previous studies of the Americas region, which report a 19% decline
in cardiovascular disease mortality at all ages and a 21% decline for people younger than 70 years between 2000 and 2010. These findings are also consistent with a separate analysis of the WHO mortality database, which shows that reduced cardiovascular disease mortality at older ages was one of the most important contributors to overall improvements in life expectancy among older populations in low-income and middle-income countries between 1980 and 2010. Although trends in age-specific cardiovascular disease mortality based on ASMR show a clear reduction between 2000 and 2015, the total number of people with cardiovascular disease and associated mortality has increased, resulting in a higher burden on health services. Globally, the absolute number of cardiovascular disease deaths increased by 41% between 1990 and 2013, of which half is attributed to population ageing and a quarter to population growth, with similar trends observed in the Americas region, highlighting the importance of including older people in NCD policies.

Despite the regional trend of decreasing age-specific cardiovascular disease mortality, large national disparities exist. Variations are to be expected between countries with small populations, as a result of the small numbers of observations. However, we also observed variation between countries with larger populations, such as Chile and Colombia. This is consistent with the findings of a global study of age-specific cardiovascular disease mortality, which reported large variations between countries.

The drivers of trends in cardiovascular disease mortality might differ between countries and require further study, particularly in a region as heterogeneous as the Americas. Future research should focus on modifiable risk factors associated with both prevention and treatment. Available data do not permit comparative analysis of risk factors or associated policies. However, it is possible to make some broad observations. First, a number of risk factors, especially hypertension, increase in prevalence with age and relative risks usually persist into at least the eighth decade of life. Consequently, tackling risk factors such as uncontrolled hypertension lowers mortality in older people to a similar extent as that in younger people. Second, increasing evidence suggests that improved access to effective treatment can reduce mortality. A Swedish study reported a sustained decline in 28-day case fatality between 1994 and 2010 for older individuals admitted to hospital for myocardial infarction, stroke, and other cardiovascular conditions in people aged up to 99 years. However, in many countries older people continue to be treated much less intensively than younger people.

Reducing cardiovascular disease death rates in older people prevents many more deaths than does a similar reduction in younger people, since mortality is higher in older populations than younger populations. Individuals aged 70–79 years accounted for nearly half of all deaths that could have hypothetically been averted in the Americas region between 2000 and 2015. This finding calls into question the exclusive focus of global NCD targets on people aged 30–69 years and supports calls from The Lancet NCD 2030 Countdown Collaborators for more inclusive monitoring. More generally, our findings demonstrate that describing the deaths of people younger than 70 years as premature (ie, implying that less can, or should, be done to avert deaths at older ages) has no scientific foundation and might lead to discrimination.

There are a number of approaches that could be used in concurrence with premature mortality to track progress in reducing mortality from cardiovascular disease and other causes. One approach would be to raise the threshold.

| Country               | 30–49 years | 50–69 years | 70–79 years | ≥80 years |
|-----------------------|-------------|-------------|-------------|-----------|
| Antigua and Barbuda   | –18         | 4           | 18          | –1        |
| Argentina             | 2419        | 9750        | 9076        | 18137     |
| Aruba                 | 5           | 79          | 77          | 46        |
| The Bahamas           | –56         | 41          | 58          | 160       |
| Barbados              | 6           | 81          | 104         | 129       |
| Belize                | 23          | 268         | 120         | 86        |
| Brazil                | 16190       | 68809       | 50692       | 114607    |
| Canada                | 484         | 8077        | 12323       | 27678     |
| Chile                 | 192         | 2423        | 3493        | 4054      |
| Colombia              | 1453        | 9004        | 6846        | 11380     |
| Costa Rica            | 110         | 568         | 710         | 1208      |
| Cuba                  | 438         | 3208        | 3072        | 4572      |
| Dominican Republic    | 494         | 225         | 207         | 627       |
| Ecuador               | 1042        | 2247        | 1975        | 1929      |
| El Salvador           | 137         | 880         | 1810        | 3180      |
| French Guiana         | 31          | 35          | 22          | 35        |
| Grenada               | 5           | 20          | 17          | 25        |
| Guatemala             | 9           | 100         | 170         | 355       |
| Guatemala             | 316         | –106        | –59         | 641       |
| Guyana                | –99         | –290        | –225        | –106      |
| Jamaica               | 175         | 461         | 392         | 758       |
| Martinique            | 2           | 114         | 183         | 214       |
| Mexico                | 176         | 5216        | –265        | 4856      |
| Nicaugroa             | 358         | 981         | 831         | 1283      |
| Panama                | –28         | 223         | 277         | 738       |
| Paraguay              | 425         | 1284        | 936         | 1476      |
| Peru                  | 762         | 2746        | 3179        | 6219      |
| Puerto Rico           | 116         | 784         | 974         | 1387      |
| Saint Lucia           | 9           | –4          | 18          | 75        |
| Saint Vincent and the Grenadines | 2 | 1 | –8 | –39 |
| Suriname              | 95          | 243         | 134         | 200       |
| Trinidad and Tobago   | 55          | 691         | 404         | 284       |
| USA                   | 5185        | 74888       | 108806      | 221915    |
| Uruguay               | 173         | 834         | 1007        | 2168      |
| Venezuela             | 1880        | 4906        | 3901        | 1249      |
| Virgin Islands        | 11          | 46          | 89          | 80        |
| Overall               | 32576       | 196836      | 211365      | 430382    |

The number of avoidable deaths were calculated based on the assumption that age-standardised mortality rate remained the same between 2000 and 2015.
for what is categorised as a premature death, perhaps to 80 years of age. This is the approach taken by the NCD 2030 Countdown Collaborators. However, across the region of the Americas, substantial reductions were observed in ASMRs for cardiovascular disease for people 80 years and older. Establishing a cutoff for health targets at any age contradicts the view that good health care is a universal right and the Sustainable Development Goals principle of leaving no one behind.

A more suitable approach would be to complement or replace the premature mortality targets with a target to reduce avoidable deaths among people of all ages. These targets would combine amenable mortality (deaths avoidable through appropriate personal health-care interventions) and preventable mortality (control of risk factors). A study of 51 countries estimated that 38% of deaths occurring in men aged 60 years or older and 29% of deaths in women aged 60 years or older in 2011 were avoidable. Of those avoidable deaths, 72% occurred among people older than 70 years. Estimates of avoidable mortality are possible even in countries with low-quality civil registration data and do not require an arbitrary age threshold.

Alternatively, the quantification of premature mortality could be complemented by measuring years of life lost (YLLs) due to premature death. YLLs are calculated by subtracting age at death from the longest life expectancy observed for a person at that age in any territory with a population of more than 5 million. Thus, if the longest life expectancy observed at age 72 years was 86 years, the YLLs for someone dying at this age would be 14 years. Emerging evidence suggests that this approach can be effectively applied to NCD mortality trends in regions such as the Americas.

This study has a number of limitations. Death data are not available for country-years without reported data. Consequently, we used an incomplete series of mortality estimates for the study period for some countries. The mortality correction processes do not include the redistribution of some cause of death considered so-called garbage codes. This could minimally affect the analysis, since heart failure (ICD=10 code 150) represents 15% of all garbage codes in the Americas that are included as cardiovascular disease (ICD-10 codes I00–I99). 11 countries and territories were excluded from the analysis because of small populations and three were excluded because of data quality issues. However, these exclusions do not invalidate the results because the level and trends of mortality were analysed by country, and the excluded countries and territories represented a small proportion of the total population of the Americas. Additionally, we did not calculate 95% uncertainty intervals for ASMRs by age group because we did not use a sample population to calculate the ASMRs. However, we corrected the registered deaths to overcome data quality issues. Despite these limitations, the mortality estimates and results from the comparative analysis are valid and robust, and demonstrate country-level reductions in cardiovascular disease mortality for adults of all age groups in the Americas.

Decreasing cardiovascular disease mortality among adults of all ages in the Americas should not lead to complacency. Without sustained action to reduce risk factors through better prevention and treatment, this decrease in mortality might level out, as observed in the USA. Although the reduction of cardiovascular disease mortality in individuals aged 30–69 years is a valid policy goal for the Region of the Americas, this objective should be expanded to include people at older ages.

Contributors
All authors made substantial contributions to the content and writing of this paper. PLS led drafting of the paper. PO and RM led data analysis. MM and SE made substantial intellectual contributions to several drafts.

Declaration of interests
RM and PO are employed by the Pan American Health Organization. The findings and conclusions of this report are those of the authors and do not necessarily represent the official position of the Pan American Health Organization. We declare no competing interests.

References
1 WHO. Time to deliver: report of the WHO Independent high-level commission on noncommunicable diseases. 2018. http://www.who.int/nmh/publications/nch-profiles-2018/en/ (accessed March 6, 2019).
2 WHO. Noncommunicable diseases country profiles 2018. http://www.who.int/nmh/publications/nch-profiles-2018/en/ (accessed March 6, 2019).
3 WHO. Disease burden and mortality estimates. 2018. http://www.who.int/healthinfo/global_burden_disease/estimates/en/ (accessed March 6, 2019).
4 NCD Countdown 2030 Collaborators. NCD Countdown 2030: worldwide trends in non-communicable disease mortality and progress towards Sustainable Development Goal target 3.4. Lancet 2018; 392: 1072–88.
5 WHO. A comprehensive global monitoring framework including indicators and a set of voluntary global targets for the prevention and control of noncommunicable diseases. 2012. http://www.who.int/nmh/events/2012/discussion_paper2_20120312.pdf?ua=1 (accessed March 6, 2019).
6 PAHO Regional mortality database. Washington, DC: Pan American Health Organization, 2017. http://www.paho.org/data/index.php/en/indicators-mortality (accessed March 6, 2019).
7 WHO. International statistical classification of diseases and related health problems. Tenth revision. 5th edn. Geneva: World Health Organization, 2016.
8 Silvi J. On the estimation of mortality rates for countries of the Americas. Epidemiol Bull 2003; 24: 4.
9 UN. World Population Prospects 2017 http://esa.un.org/wpp/ (accessed March 6, 2019).
10 United States Census Bureau. International Data Base. September 2019. https://www.census.gov/data-tools/demo/idb/informationGateway.php (accessed March 6, 2019).
11 Ahmad OB, Boschi-Pinto C, Lopez AD, Murray CJL, Lozano R, Inoue M. Age standardization of rates: a new WHO standard. Geneva: World Health Organization, 2001. http://www.who.int/healthinfo/paper31.pdf?ua=1 (accessed March 6, 2019).
12 Kim HJ, Fay MP, Feuer EJ, Midthune DN. Permutation tests for joinpoint regression with applications to cancer rates. Stat Med 2000; 19: 335–51.
13 Clegg LX, Hankey BF, Tiwari R, Feuer EJ, Edwards BK. Estimating average annual percent change in trend analysis. Stat Med 2009; 28: 1670–82.
14 Green, PJ. Reversible jump Markov change Monte Carlo computation and Bayesian model determination. Biometrika 1995; 82: 71–32.
15 Orduz-P. Prieto-Lara E, Pinheiro Gawryszewski V, Hennis AJ, Cooper RS. Premature mortality from cardiovascular disease in the Americas–will the goal of a decline of “25% by 2025” be met? PLoS One 2015; 10: e0141685.
16 Marinho de Souza F, Gawryszewski V, Orduñez P, et al. Cardiovascular disease mortality in the Americas: current trends and disparities. Heart 2012; 98: 1207–12.

17 Mathers CD, Stevens GA, Boerma T, White RA, Tobias MI. Causes of international increases in older age life expectancy. Lancet 2015; 385: 540–48.

18 Roth GA, Forouzanfar MH, Moran AE, et al. Demographic and epidemiologic drivers of global cardiovascular mortality. N Engl J Med 2015; 372: 1333–41.

19 WHO. Active ageing: good health adds life to years. Policies and priority interventions for healthy ageing, 2012. http://www.euro.who.int/__data/assets/pdf_file/0006/161637/WHD-Policies-and-Priority-Interventions-for-Healthy-Ageing.pdf?ua=1 (accessed March 6, 2019).

20 Forman DE, Rich MW, Alexander KP, et al. Cardiac care for older adults: time for a new paradigm. J Am Coll Cardiol 2015; 57: 1801–10.

21 Musini VM, Tejani AM, Basset K, Wright JM. Pharmacotherapy for hypertension in the elderly. Cochrane Database Syst Rev 2009; 4: CD000028.

22 Modig K, Andersson T, Drefahl S, Ahlbom A. Age-specific trends in morbidity, mortality and case-fatality from cardiovascular disease, myocardial infarction and stroke in advanced age: evaluation in the Swedish population. PLoS One 2013; 8: e64928.

23 Forti P, Maioli F, Magni E, et al. Risk of exclusion from stroke rehabilitation in the oldest old. Arch Phys Med Rehabil 2018; 99: 87–83.

24 Epstein E, Crome P, Casement J. Ageism in access to critical care. Age Ageing 2006; 35: 209.

25 GBD 2013 Mortality and Causes of Death Collaborators. Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet 2015; 385: 117–71.

26 Martinez R, Soliz P, Caixeta R, Orduñez P. Reflection on modern methods: years of life lost due to premature mortality—a versatile and comprehensive measure for monitoring noncommunicable disease mortality. Int J Epidemiol 2019; published online Jan 9. DOI:10.1093/ije/dyy254.

27 Weir HK, Anderson RN, Coleman King SM, et al. Heart disease and cancer deaths—trends and projections in the United States, 1969–2020. Prev Chronic Dis 2016; 13: 160211.