Trends in premature avertable mortality from non-communicable diseases for 195 countries and territories, 1990–2017: a population-based study

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Summary

Background The reduction by a third of premature non-communicable disease (NCD) mortality by 2030 is the ambitious target of Sustainable Development Goal (SDG) 3.4. However, the indicator is narrowly defined, including only four major NCDs (cardiovascular diseases, cancer, diabetes, and chronic respiratory diseases) and only for people aged 30–70 years. This study focuses on premature avertable mortality from NCDs—premature deaths caused by NCDs that could be prevented through effective public policies and health interventions or amenable to high-quality health care—to assess trends at global, regional, and national levels using estimates from the Global Burden of Disease, Injuries, and Risk Factors Study (GBD) 2017.

Methods We reviewed existing lists of NCD causes of death that are either preventable through public health policies and interventions or amenable to health care to create a list of avertable NCD causes of death, which was mapped to the GBD cause list. We estimated age-standardised years of life lost (YLL) per 100 000 population due to premature avertable mortality from NCDs, avertable NCD cause clusters, and non-avertable NCD causes by sex, location, and year and reported their 95% uncertainty intervals (UIs). We examined trends in age-standardised YLL due to avertable and non-avertable NCDs, assessed the progress of premature avertable mortality from NCDs in achieving SDG 3.4, and explored specific avertable NCD cause clusters that could make a substantial contribution to overall trends in premature mortality.

Findings Globally, premature avertable mortality from NCDs for both sexes combined declined –1·3% (95% UI –1·4 to –1·2) per year, from 12855 years (11809 to 14051) in 1990 to 9008 years (8329 to 9756) in 2017. However, the absolute number of avertable NCD deaths increased 49·3% (95% UI 47·3 to 52·2) from 23·1 million (22·0–24·1) deaths in 1990 to 34·5 million (33·4 to 35·6) in 2017. Premature avertable mortality from NCDs reduced in every WHO region and in most countries and territories between 1990 and 2017. Despite these reductions, only the Western Pacific and European regions and 25 countries (most of which are high-income countries) are on track to achieve SDG target 3.4.

Since 2017, there has been a global slowdown in the reduction of premature avertable mortality from NCDs. In 2017, high premature avertable mortality from NCDs was clustered in low-income and middle-income countries, mainly in the South-East Asia region, Eastern Mediterranean region, and African region. Most countries with large annual reductions in such mortality between 1990 and 2017 had achieved low levels of premature avertable mortality from NCDs by 2017. Some countries, the most populous examples being Afghanistan, the Central African Republic, Uzbekistan, Haiti, Mongolia, Turkmenistan, Pakistan, Ukraine, Laos, and Egypt, reported both an upward trend and high levels of premature avertable mortality from NCDs. Cardiovascular diseases, cancers, and chronic respiratory diseases have been the main drivers of the global and regional reduction in premature avertable mortality from NCDs, whereas premature mortality from substance use disorders, chronic kidney disease and acute glomerulonephritis, and diabetes have been increasing.

Interpretation Worldwide, there has been a substantial reduction in premature avertable mortality from NCDs, but progress has been uneven across populations. Countries vary substantially in current levels and trends and, hence, the extent to which they are on track to achieve SDG 3.4. By accounting for premature avertable mortality while avoiding arbitrary age cutoffs, premature avertable mortality from NCDs is a robust, comprehensive, and actionable indicator for quantifying and monitoring global and national progress towards NCD prevention and control.

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Introduction

In response to resolutions made at the 2011 UN High-Level Meeting on non-communicable diseases (NCDs), the WHO Global Action Plan for the Prevention and Control of NCDs urges member states to reduce mortality from four major NCDs (cardiovascular diseases, cancers, diabetes, and chronic respiratory diseases) among people aged 30–70 years by 25% between 2010 and 2025. Sustainable Development Goals (SDGs) target 3.4 aims to reduce mortality from NCDs...
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Evidence before this study
We did not do a formal literature review. National and global progress towards the Sustainable Development Goal (SDG) target 3.4—a one-third reduction, relative to 2015 levels, in the probability of dying aged 30–70 years from any major non-communicable disease (NCD), including cancers, cardiovascular diseases, chronic respiratory diseases, and diabetes, by 2030—has been reported in other studies. However, the standard indicator is narrowly defined to include only four major NCDs and only for people aged 30–70 years. The NCD Countdown 2030 report proposed a more comprehensive indicator, but it still excludes people aged 80 years and over. A comprehensive and actionable measure of premature mortality from NCDs is needed for the informed analysis of epidemiological trends, health system performance, and effect of policies.

Added value of this study
This study develops a new measure to quantify the premature avertable mortality from NCDs. It combines a novel list of NCD causes accounting for deaths preventable through public policies and population-based health interventions and amenable to health care, with a health gap measure of years of life lost (YLLs) due to premature mortality. It presents a trend analysis for premature avertable mortality from NCDs at global, regional, and national levels based on 2017 data from the Global Burden of Diseases, Injuries, and Risk Factors Study, and assesses progress towards SDG target 3.4, as measured by premature avertable mortality from NCDs. To our knowledge, this is the first study to apply a metric of premature avertable NCD mortality without arbitrary restrictions by age or disease category.

Implications of all the available evidence
This study describes levels and trends for premature avertable mortality from NCDs globally, for WHO regions, and 195 countries and territories from 1990 to 2017. Between 1990 and 2017 premature avertable mortality from NCDs fell substantially worldwide, in all regions, and in all but 14 countries. Yet, only two WHO regions and 25 countries are on track to reach the SDG target 3.4. Most clusters of avertable NCDs contributed to the overall reduction in premature avertable mortality from NCDs. However, substance use disorders, chronic kidney disease and acute glomerulonephritis, and diabetes attenuated the overall reduction in many countries and regions. Globally in 2017, 8423 years of life per 100 000 people were still lost to conditions that could be averted with effective policies and interventions. YLLs due to premature avertable NCD mortality should become a key indicator to shape policy and identify priorities for interventions.
contribution of NCD clusters to overall trends, and discuss policy implications.

Methods

Estimation of premature avertable mortality

We reviewed lists of causes accounting for deaths considered to be either preventable by public policies and health programmes or amenable to good quality health care. These included lists developed by Nolte and McKee,13,14 Eurostat’s Working Group on Public Health Statistics,15 the Canadian Institute for Health Information and Statistics Canada,16 and the health ministries of Mexico, Brazil, and New Zealand.17–21 From this review, we created a new list of fatal and non-fatal conditions. We included conditions after evaluating evidence that deaths due to the corresponding cause can be averted in the presence of effective health care, public health interventions, or other policies. We mapped each cause category to the GBD cause list22 based on the International Classification of Diseases codes and created a list of 90 causes (appendix 2 p 7). A few conditions from our list could not be mapped, usually because GBD includes them within larger groups of causes that are not considered avertable. Where GBD provides separate categories, we disaggregated our categories accordingly.

To quantify premature avertable mortality from NCDs, we considered eight disease clusters based on the avertable cause list (cardiovascular diseases, neoplasms [cancers], chronic respiratory diseases, digestive diseases, neurological disorders, substance use disorders, diabetes and chronic kidney disease, and other NCDs) covering 43 fatal conditions (table 1). For comparison, causes of non-avertable mortality from NCDs are given in table 2. Rather than impose arbitrary age limits, we used a widely used health gap metric—YLLs due to premature mortality—derived from the standard life expectancy at each age.

Our analysis draws on GBD 2017 estimates.23,24 The GBD study is a multinational research collaboration designed to produce consistent and comparable estimates of health effects related to more than 328 diseases and injuries in 195 countries and territories. Its methods have been described previously23,24 and are summarised in appendix 2 (p 10).

YLLs measure premature death, calculated as the sum of each death observed at each specific age in a certain year multiplied by the standard life expectancy at each age, estimated from life tables.26 Standard life expectancy was taken from the lowest observed risk of death for each 5-year age group in all populations greater than 5 million (appendix 2 p 14). GBD 2017 includes new assessments of population, fertility, migration, and all-cause mortality.27 These components were used to generate population estimates by age, sex, and year.

We extracted estimates of numbers of deaths and YLLs, with 95% uncertainty intervals (UIs), for every cause of death from the GBD cause list, by sex, age group, location (global, six WHO regions, and 195 countries and territories [appendix 2 p 17]), and annually from 1990 to 2017 using the GBD Results Tool. We used GBD 2017 population estimates by sex, age, location, and year from 1990 to 2017,27 which we extracted from the Global Health Data Exchange.27

We estimated age-standardised YLL per 100 000 population with 95% UIs for all avertable deaths from NCDs, and clusters thereof, for non-avertable NCD deaths and all-NCDs deaths by sex, location, and year. First, we computed the number of deaths and YLLs by sex, age group, location, and year from each category of causes by aggregating separately the number of deaths and the number of YLLs, based on the cause list of avertable NCD mortality (table 1). Second, we calculated age-specific and sex-specific YLLs per 100 000 population for each cause group (avertable NCDs, avertable NCD clusters, non-avertable NCDs, and all NCDs) by location for 1990–2017. Third, we calculated age-standardised YLL per 100 000 population by cause, sex, location, and year by direct method using the world standard population,28 as shown in appendix 2 (p 16). We computed the 95% UIs for age-specific and sex-specific YLL and age-standardised YLL by propagating the uncertainty from the GBD estimates of YLLs and population (appendix 2 p 12).

Assessment of trends from 1990 to 2017

We did Joinpoint regression analysis29 to assess trends in premature avertable mortality from NCDs, for each NCD cluster, and for non-avoidable NCDs for 1990–2017. We estimated inflexion points (joinpoints) from trends and the average (mean) annual percentage change (AAPC) by regressing a log-linear function of

Panel: Key concepts and terminology

Here we present some concepts and terminology used in this Article, which are frequently used in the literature focused on assessing public health interventions and health-care quality, and the Global Burden of Diseases, Injuries, and Risk Factors Study.

Avertable mortality refers to mortality from diseases where death could be prevented in the presence of effective health policies and population-based interventions, in addition to mortality that can be avoided or postponed in the presence of access to high-quality personal health care once the condition occurs.

Preventable mortality refers to disease mortality that can be avoided through public health programmes or policies focused on wider determinants of health, such as behavioural, biological, and environmental risk factors, and socioeconomic status.30

Amenable mortality refers to mortality from diseases where death can be avoided or postponed by high-quality personal health care.30

With some conditions, premature mortality can be reduced by both personal health care and public health programmes and policies.44

For this study, we use the concept of avertable mortality to quantify the levels of premature avertable mortality from non-communicable diseases. This study does not differentiate between preventable and amenable mortality from such diseases.
### ICD-10

**Neoplasms**

| Cancer Type | ICD-10 Codes | ICD-9 Codes |
|-------------|--------------|-------------|
| Lip and oral cavity cancer | C00-C08.9, D10.0-D10.5, D11-D11.9, Z85.81-Z85.810 | 140-145.9, 210.0-210.6, 235.0, V76.42 |
| Nasopharynx cancer | C11-C11.9, D10.6 | 147-147.9, 210.7-210.9 |
| Other pharynx cancer | C09-C10.9, C12-C13.9, D10.7 | 146-146.9, 148-148.9 |
| Oesophageal cancer | C15-C15.9, D00.1, D13.0, Z85.01 | 150-150.9, 211.0, 230.1 |
| Stomach cancer | C16-C16.9, D00.2, D13.1, D37.1, Z85.02-Z85.028 | 151-151.9, 211.1, 230.2, 209.23, V10.04 |
| Colon and rectum cancer | C18-C18.9, D01.0-D01.3, D12-D12.9, D37.3-D37.5 | 153-153.4, 210.9, 210.9, 209.5-209.57, 211.3-211.4, 230.3-230.6 |
| Liver cancer | C22-C22.9, D33.4 | 155-155.9, 211.5 |
| Larynx cancer | C32-C32.9, D02.0, D14.1, D38.0, Z85.21 | 161-161.4, 212.1, 231.0, 231.6, V10.21 |
| Tracheal, bronchus, and lung cancer | C33-C34.9, D02.1-D02.3, D14.2-D14.3, D38.1, Z12.2, Z80.1-Z80.2, Z85.1-Z85.20 | 162-162.9, 212.2-212.3, 231.1-231.2, 235.7, 209.21, V10.1-V10.20, V16.1-V16.2, V16.4-V16.40 |
| Malignant skin melanoma | C43-C43.9, D03-D03.9, D22-D23.9, D48.5, Z85.82-Z85.828 | 172-172.9 |
| Non-melanoma skin cancer (squamous-cell carcinoma) | C44-C44.99, D04-D04.9, D49.2 | 173-173.9, 222.4, 223.2, 238.2 |
| Breast cancer | C50-C50.929, D05-D05.92, D24-D24.9, D48.6-D48.62, D49.3, N60-N60.99 | 174-175.9, 217-217.8, 233.0, 238.3, 319.3, 610-610.9 |
| Cervical cancer | C53-C53.9, D06-D06.9, D26.0 | 180-180.9, 219.0, 233.1 |
| Oesophageal cancer | C54-C54.9, D07-D07.2, N87-N87.9 | 182-182.8, 232.2 |
| Testicular cancer | C62-C62.9, D29.2-D29.8, D40.1-D40.8 | 186-186.9, 220.0, 222.3, 236.4 |
| Bladder cancer | C67-C67.9, D09.0, D30.3, D41.4-D41.8, D49.4 | 188-188.9, 223.3, 237.3, 237.7, 239.9 |
| Thyroid cancer | C73-C73.9, D09.3, D09.8, D34-D34.9, D44.0, Z85.850 | 193-193.9, 216-216.9 |
| Mesothelioma | C45-C45.9 | 201-201.98 |
| Hodgkin lymphoma | C81-C81.99 | 204-208.82 |

### Cardiovascular diseases

| Disease Type | ICD-10 Codes | ICD-9 Codes |
|--------------|--------------|-------------|
| Rheumatic heart disease | I01-I01.9, I02.0, I05-I09.9 | 391-391.9, 392.0, 393-393.99 |
| Ischaemic heart disease | I20-I25.9 | 410-414.9 |
| Cerebrovascular disease | I60-I60.91, I60.92, I60.93, I60.94, I60.95, I60.96, I60.97, I60.98, I60.99 | 430-435.9, 436-437.2, 437-437.8 |
| Hypertensive heart disease | I11-I11.9 | 402-402.9 |
| Alcoholic cardiomyopathy | I42.6 | 425.5 |
| Aortic aneurysm | I71-I71.9 | 441-444.9 |

### Chronic respiratory diseases

| Classification | ICD-10 Codes | ICD-9 Codes |
|----------------|--------------|-------------|
| Classifications | D86-D88.2, D86.89-D86.89, G47.3-G47.39, J00-J35.9, J37-J37.9, J36-J36.9, J30-J30.9, J30.1, J30.8, J30.82-J30.89 | 135-135.9, 136.6, 237.2-237.8, 470.470.9-474.9, 476-476.1, 477-477.9, 490-504.9, 506-506.9, 508-509.5, 515, 516-517.8, 518.6, 518.9, 519.1-519.4, 780.57, 786.03 |

### Digestive diseases

| Disease Type | ICD-10 Codes | ICD-9 Codes |
|--------------|--------------|-------------|
| Cirrhosis and other chronic liver diseases due to hepatitis B | B18.0, B18.1 | 702-703 |
| Cirrhosis and other chronic liver diseases due to hepatitis C | B18.2 | 704-705 |
| Cirrhosis and other chronic liver diseases due to alcohol use | B70.0-B70.3 | 571.0-571.2 |
| Peptic ulcer disease | K25-K28.9, K31.1, K31.1-K31.6, K31.8, K31.82-K31.89 | 531-534.91 |
| Appendicitis | K35-K39.9, K38.3-K38.9 | 540-542.9 |
| Inguinal, femoral, and abdominal hernia | K40-K44.9 | 550-551.1, 551.3-552.1, 552.3-553.03, 553.6 |
| Gallbladder and biliary diseases | K80-K83.9, K87-K87.1 | 574-576.9 |
| Pancreatitis | K85-K86.9 | 577-577.9, 579.4 |

### Neurological disorders

| Disease Type | ICD-10 Codes | ICD-9 Codes |
|--------------|--------------|-------------|
| Alzheimer’s disease and other dementias | F00-F03.9, G30-G30.3, G31.8-G31.9 | 290-290.9, 294.1-294.9, 331-331.2 |
| Epilepsy | G40-G41.9 | 345-345.91 |

### Substance use disorders

| Disease Type | ICD-10 Codes | ICD-9 Codes |
|--------------|--------------|-------------|
| Alcohol use disorders | F10-F10.9, G21.2, G72.1, P04.1, Q36.0, R78.0, X45-X45.9, X65-X65.9, Y55-Y55.9 | 291-291.9, 303-303.9, 305.0, 357.5, 790.3, E860 |
| Drug use disorders | F11-F16.9, F18-F19.9, P04.4, P96.1, R78.1-R78.5 | 292-292.9, 304.0-304.8, 305.0-305.9, 760.7, E850 |

*Table 1 continues on next page*
ICD-10 ICD-9

(Continued from previous page)

Diabetes, urogenital, blood, and endocrine diseases

| ICD-10 | ICD-9 |
|--------|-------|
| E10–E10·1 | 25·0–25·0 39, 25·0–25·0 99, 35·7 2, 775·0–775·1, 790·2–790·22 |
| E11·2 | 25·0–25·0 99, 40·3–40·4 93, 581·5–583·9, 585·5–585·9, 589·5–589·9 |

Other non-communicable diseases

| ICD-10 | ICD-9 |
|--------|-------|
| P96·0, Q00–Q07·9, Q10·4–Q18·9, Q20–Q28·9, Q30–Q36, Q37–Q45·9, Q50–Q60·6, Q63–Q86, Q86·1–Q87·8, Q89–Q89·8, Q90–Q93·9, Q95–Q99·8 |
| 740–749·0, 749·2–752·9, 753·4–758·9, 759·0–759·8 |

Table 1: Causes of avertable mortality from non-communicable diseases

| ICD-10 | ICD-9 |
|--------|-------|
| Nasopharynx cancer C11–C11·9, D10·6 |
| Others pharynx cancer C09–C10·9, C12–C13·9, D10·7 |

Other neoplasms D32–D33·9, D35·3–D35·4, D42–D43·9, D45–D47·9, D49·6, K62·0–K62·1, K63·5, N60–N60·9, N84·0–N84·1, N87·5–N87·9 |

Cardiovascular diseases

| ICD-10 | ICD-9 |
|--------|-------|
| Non-rheumatic valvular heart disease |
| Myocarditis B3·2, I40–I41·9, I51·4 |
| Other cardiomyopathy I42·1–I42·5, I42·7–I42·8, I43·4–I43·9 |
| Atrial fibrillation and flutter I48·1–I48·9 |
| Peripheral artery disease I70·2–I70·7, I73–I73·9 |
| Endocarditis I33·3–I33·9, I38·1–I38·9 |
| Other cardiovascular and circulatory diseases I28–I28·8, I30–I31·1, I31·8–I32·8, I47·1–I47·9, I51·0–I51·3, I56·0, I72–I72·9, I77–I78·9, I86–I86·9, I89·9, I89·9, K75·1 |

Digestive diseases

| ICD-10 | ICD-9 |
|--------|-------|
| Cirrhosis due to non-alcoholic steatohepatitis K75·81 |
| Cirrhosis and other chronic liver diseases due to other causes B18·8–B18·9, K71·7, K73·5–K75·8, K75·89, K75·9, K76·1–K76·2, K76·4–K76·7, K77·8 |
| Gastritis and duodenitis K29·K29· |
| Paralytic ileus and intestinal obstruction K56–K56·9 |
| Inflammatory bowel disease K50–K52·9, M09·1 |
| Vascular intestinal disorders K55–K55·9 |

ICD=International Statistical Classification of Diseases and Related Health Problems.

Table 2 continues on next page
age-standardised YLL per 100 000 population on year.
We configured the model to detect a maximum of five joinpoints and avoid segments comprising only two datapoints. We calculated AAPCs and 95% UIs for 1990–2017 and subperiods (1990–99, 2000–09, and 2010–17), by sex (male, female, and both) at global, regional, and country levels. The AAPC is a summary measure of the trend over a prespecified fixed interval, computed as a weighted average (mean) of the annual percentage change of each time segment from the Joinpoint model, with weights equal to the length of each segment over time. We used the Monte Carlo method30 with 4499 randomly permuted datasets to calculate the 95% UIs of the AAPCs, and the overall asymptotic significance level was maintained through a Bonferroni correction. We assumed constant variance (homoscedasticity) in age-standardised YLL over time. However, these tests also consider situations with non-constant variance, Poisson variation, and possible autocorrelation errors. AAPC is considered significant when it is different from zero at α=0·05. A constant trend was considered when the zero value was within both 95% UI limits for the AAPC, an increasing trend when both 95% UI limits were positive, and a decreasing trend when both 95% UI limits were negative.

ICD=International Statistical Classification of Diseases and Related Health Problems.

Table 2: Causes of non-avertable mortality from non-communicable diseases
Assessment of progress towards SDG target 3.4

We assessed progress towards SDG target 3.4 by estimating AAPC and 95% UI for 2010–17. Countries were considered on track if the upper 95% UI of the AAPC was −2·22% or lower (equivalent to a one-third reduction by 2030 relative to 2015 levels). Countries whose lower and upper 95% UI for AAPC exceeded −2·22% were categorised as progressing with a high chance of reaching the target. Countries with lower and upper 95% UIs of AAPC between −2·22% and 0% were categorised as progressing, but not on track. Countries in which the upper 95% UI of the AAPC was 0 or above were categorised as stagnating or deteriorating.

We did a decomposition analysis of AAPC for premature avertable mortality from NCDs and NCD clusters by location and sex for 2010–17 to determine which causes of death drove overall trends. We calculated the change in premature avertable mortality from NCDs for each disease cluster using counterfactual scenarios: allowing premature avertable mortality from NCDs for each disease cluster to change as they did from 2010 to 2017, while keeping premature mortality constant at 2010 levels for other causes. We then calculated the fraction of change for each disease cluster relative to the sum of change of all nine clusters, and multiplied this fraction by the AAPC for all premature avertable mortality from NCDs—ie, making...
the fraction of change proportional to the rate of the change that would occur if each disease cluster alone had changed. This analysis adheres to the Guidelines for Accurate and Transparent Health Estimates Reporting standards32 developed by WHO and others (appendix 2 p 52).

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

Results
Globally, NCDs accounted for an estimated 41·1 million (95% UI 40·4–41·5) deaths in 2017, representing 73·5% (70·8–75·7) of all deaths. They caused a small proportion of deaths in childhood, but their share of all deaths increased rapidly with age until about 60 years, when the proportion plateaued at over 80% (figure 1A). Avertable NCDs accounted for the largest share of these deaths, 34·5 million (95% UI 33·4–35·6), or 83·9% (80·4–88·1) of all NCD deaths worldwide. In all age groups, more than 50% of NCD deaths are avertable, with the share increasing with age once individuals are older than 5 years (figure 1B).

The number of avertable global NCD deaths increased by 49·3% (95% UI 47·3 to 52·2) from 23·1 million (22·0 to 24·1) deaths in 1990 to 34·5 million (33·4 to 35·6) in 2017. Global age-standardised YLL per 100 000 population due to avertable NCDs declined substantially for both sexes combined, at an average (mean) annual rate of –1·3% (95% UI –1·4 to –1·2) from 12 885 years (95% UI 11 809 to 14 051) in 1990 to 9 008 years (8 329 to 9 756) in 2017 (figure 2). In 2017, premature avertable mortality from NCDs was more than four times the rate for non-avertable NCDs, both globally (–0·5% [95% UI –0·6 to –0·5]) and for every WHO region.

For men, global premature avertable mortality from NCDs declined by –1·2% (95% UI –1·4 to –1·0) per year from 14 092 years (12 981 to 15 375) in 1990 to 10 187 years (9 321 to 11 066) in 2017. It declined slightly faster among women, with an AAPC of –1·4% (95% UI –1·5 to –1·3), from 9 997 years (8 902 to 11 064) in 1990 to 6 811 years (6 186 to 7 510) in 2017. However, this difference between sexes is not significant (appendix 2 pp 27–33).

This decline in global premature avertable mortality from NCDs changed over time in five segments: beginning slowly in 1990–94 (–0·27%), accelerating in 1994–2003 (–1·5%), further accelerating in 2003–07 (–2·26%), but decelerating in 2007–13 (–1·33%) and 2013–17 (–0·72%), when there were significant reductions (appendix 2 p 18). Trends were similar for both sexes.

Between 1990 and 2017, premature avertable mortality from NCDs fell substantially in every WHO region, with...
AAPC ranging from –1·7 (95% UI –2·0 to –1·5) in the Western Pacific region to –0·9% (–1·0 to –0·8) in the Eastern Mediterranean region (figure 2). As with the global picture, these reductions were substantially higher for avertable than for non-avertable mortality from NCDs. In 2017, premature avertable mortality from NCDs was highest in the Eastern Mediterranean, followed by South-East Asia, and African regions with...
levels over those observed globally (figure 2). Since 2013, premature non-avertable mortality from NCDs decreased slightly or stagnated in most regions, and rose in the Region of the Americas.

78 (40%) of 195 countries with high levels of premature avertable mortality from NCDs (over 10 022.9 years per 100 000 population) are low-income and middle-income countries in the South-East Asia, Eastern Mediterranean, and African regions (figure 3A). In 2017, premature avertable mortality from NCDs for both sexes combined was below 6130 years per 100 000 population in 41 countries, mostly high-income economies (36 of 41) (figure 3A). Premature avertable mortality from NCDs by sex in 2017 is shown in appendix 2 (pp 34–39). The ten countries of more than 2 million people with the highest levels of premature avertable mortality from NCDs (all >18 300 years per 100 000 population) were Afghanistan, the Central African Republic, Uzbekistan, Haiti, Mongolia, Turkmenistan, Pakistan, Ukraine, Laos, and Egypt. Singapore, Japan, Switzerland, Italy, and Israel had the lowest levels of premature avertable mortality from NCDs, with values below 4000 years per 100 000 population (appendix 2 pp 37–39).

Premature avertable mortality from NCDs fell in most countries between 1990 and 2017, with 14 exceptions (appendix 2 pp 24–33, pp 40–42). 163 (84%) of 195 countries had significant reductions in the AAPC for premature avertable mortality from NCDs between 2010 and 2017 (AAPC upper 95% UI ±0%). However, only 25 countries had rates of decline significantly lower than –2.22% (ie, the required rate to be on track for achieving SDG target 3.4) for both sexes combined. Sex-disaggregated data are shown in appendix 2 (pp 43–48).

Figure 4 compares premature avertable mortality from NCDs in 2017 with the AAPC for 1990–2017 (figure 4A) and 2010–17 (figure 4B). Countries with fast declines in age-standardised YLL between 1990 and 2017 had low premature avertable mortality from NCDs by sex in 2017 (figure 4A). In countries with high premature avertable mortality from NCDs in 2017 (>67th percentile) the pace of reduction accelerated between 2010 and 2017 in both sexes combined and in each sex (figure 4B). However, Ukraine, Libya, and Nepal are the top three countries with both high rates of premature avertable mortality from NCDs in 2017 and an increasing trend in 2010–17 in both sexes combined (figure 4B).

Figure 5 shows the contributions of NCD clusters to overall trends in premature avertable mortality from NCDs between 2010 and 2017 by sex and region. Data by sex and country are given in appendix 2 (pp 49–51). Globally, for both sexes combined, all clusters (except diabetes and substance use disorders) contributed to the reduction in premature avertable mortality from NCDs (figure 5). Cardiovascular diseases, cancer, chronic respiratory disorders, congenital birth defects, and digestive diseases are the largest contributors, accounting for more than 80% of the overall decline. By contrast, substance use disorders slightly offset the decline in most of the regions, except the Americas. In the Americas, substance abuse disorders accounted for a 6% increase in the annual rate of change. The Western Pacific and European regions are the only two regions that are on track for reaching SDG target 3.4, assuming sustained progress until 2030.

A comprehensive set of estimates and interactive visualisations from this study are available online via the premature avertable mortality NCD Results Tool.

**Discussion**

To our knowledge, this is the first study that thoroughly assesses NCD mortality without arbitrary restrictions by age or disease category. Premature avertable mortality from NCDs shows the YLLs that could be averted if NCD risk factor exposures of populations were reduced to a theoretical minimum level and good quality health care was universally available. The high variation in premature avertable mortality from NCDs across countries in 2017 (range: 3421–28 490) indicates that levels in many countries can be considered excessively high. As such, we consider premature avertable mortality from NCDs to be a robust, comprehensive,
and actionable indicator for assessing performance in reducing NCD mortality and a powerful concept for informing public health and policy. For these reasons, and in the light of known concerns about the existing indicator set out by the *Lancet* NCD Countdown 2030 Collaborators and others, we argue that it should be adopted as the gold standard.

Our study includes two important innovations. First, we review, update, and apply a new list of avertable burden conditions, which is exhaustive, comprehensive, and globally applicable. Second, we decompose overall changes in premature avertable mortality from NCDs by NCD clusters, going beyond the four NCD clusters (cancer, cardiovascular diseases, respiratory disease, and all other NCDs) used by the NCD Countdown 2030 report to include eight clusters that account for avertable mortality. This approach allows for the identification of causes contributing to change in premature avertable mortality from NCDs.

WHO regions represent a heterogeneous set of countries and their overall epidemiological profiles are strongly shaped by the most populous countries. For example, the reduction in premature avertable mortality from NCDs in the Western Pacific region is largely due to the rapid decline achieved by China. Similarly, the early 1990s spike in such mortality in the European region is mainly driven by trends in formerly socialist economies in eastern Europe. The deceleration in the decline and subsequent reversal in this measure in the Americas in eastern Europe. The deceleration in the decline and subsequent reversal in this measure in the Americas since 2013 is explained by the notable increase in premature mortality from substance use disorders in the USA (appendix 2 pp 49–51). Notably, the Eastern Mediterranean region—the worst performing region in terms of premature avertable mortality from NCDs—is facing numerous health challenges related to armed conflicts and political crises. However, this is a descriptive study, which is not intended to assess the effects of specific public policies, interventions, or changing national circumstances. Interpretation of these trends in premature avertable mortality from NCDs should be done with great caution. For example, it is important to assess the relative contributions of NCD incidence and survival rates. Mortality attributable to premature avertable mortality from NCDs will be affected by competition from deaths from non-NCD causes, especially those at young ages, which is a particular concern in conflict situations. There might also be time lags between the reduction of amenable mortality and the introduction of interventions and policies. There is a need for more nuanced analysis of these effects in future studies of premature avertable mortality from NCDs.

Despite the global reduction in premature avertable mortality from NCDs, our analysis showed that only the Western Pacific and European regions and 25 countries (mostly high-income economies) are on track to achieve SDG target 3.4. This finding is consistent with values reported by NCD Countdown 2030, and raises concerns about the global community’s ability to meet the SDG commitments. Worldwide in 2017, 9008 years of life per 100 000 population were lost due to conditions amenable to effective public policies, health interventions, and health care. This global level is almost three times the best performing countries (3421 YLLs per 100 000 population), showing what can theoretically be achieved. 65 countries had what can be considered high levels of premature avertable mortality from NCDs in 2017 (over the upper tercile of the distribution by country, equivalent to 10712 YLL per 100 000 population), the most populous examples being Afghanistan, the Central African Republic, Uzbekistan, Haiti, Mongolia, Turkmenistan, Pakistan, Ukraine, Laos, and Egypt. Some countries, including Ukraine, Libya, and Nepal, present both high rates of premature avertable mortality from NCDs and an increasing trend since 2010.

Most NCD clusters have contributed to the overall reduction in premature avertable mortality from NCDs,
but substance use disorders, chronic kidney disease and acute glomerulonephritis, and diabetes counteract this reduction in many countries and regions. Of these diseases, only diabetes is included as one of the four major NCDs promoted by global targets. Substance use disorders is an emerging and complex public health issue, now referred to as one of the so-called diseases of despair, which is especially marked in parts of the USA and is an emerging concern for other countries, such as the UK.

Our approach has limitations associated with the use of GBD data,\textsuperscript{13,24,26} especially when high-quality vital registration systems are lacking, in terms of completeness, coverage, and medical certification, or complete absence of vital registration, and estimates are mostly based on modelling. Although the method used by the GBD study to estimate deaths and death rates by cause, the Cause of Death Ensemble model (CODEm), outperforms previous approaches, it is inevitably subject to problems in capturing data on the covariates used in CODEm, the treatment of outliers, and the rules used for redistribution of garbage codes.\textsuperscript{7} Nevertheless, the concept of YLL due to premature avertable mortality from NCDs offers a comprehensive and robust measure for monitoring NCD mortality. We used an alternative method to assess uncertainty to that applied by GBD. Although the point estimates of our comparison are identical to those derived from GBD methods, indicating that our comparison is valid, our method of assessing uncertainty is much more conservative than GBD (appendix 2 p 12). This difference is not surprising as the GBD method uses considerably more data. Our inferences based on the significance of differences between groups are also conservative, so we might have missed some significant findings (type 1 error) that are detectable by GBD methods. Re-running our analyses using GBD methods for assessing uncertainty would not result in any changes to the significant differences we have described, but might reveal further, smaller, differences that we would have rejected as non-significant.

A one-third reduction of premature avertable mortality from NCDs by 2030 relative to its level in 2015 is a very ambitious goal, since it includes all preventable and treatable NCDs, and deaths at all ages. Measuring premature avertable mortality from NCDs allows for comparison of how countries succeed (or not) in preventing and delaying deaths from conditions amenable to public health interventions and health care. This goal and measure should spur countries that are currently off track to re-evaluate and strengthen their action plans, including those for universal health care. Our study sounds an alarm about the global slowdown of the reduction in premature avertable mortality from NCDs since 2007—calling for more robust, politically committed responses to the social determinants of NCDs, effective public health interventions, and universal good quality health care for all.

Contributors
RM, PS, SE, PO, and MM conceived the idea for the study and designed it. RM, PS, and PO created the list of avertable causes. RM and PO analysed the data and drafted the manuscript. All authors interpreted the findings and prepared the manuscript.

Declaration of interests
We declare no competing interests.

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