Global, regional, and national burden of chronic kidney disease, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017

GBD Chronic Kidney Disease Collaboration*

Summary
Background Health system planning requires careful assessment of chronic kidney disease (CKD) epidemiology, but data for morbidity and mortality of this disease are scarce or non-existent in many countries. We estimated the global, regional, and national burden of CKD, as well as the burden of cardiovascular disease and gout attributable to impaired kidney function, for the Global Burden of Diseases, Injuries, and Risk Factors Study 2017. We use the term CKD to refer to the morbidity and mortality that can be directly attributed to all stages of CKD, and we use the term impaired kidney function to refer to the additional risk of CKD from cardiovascular disease and gout.

Methods The main data sources we used were published literature, vital registration systems, end-stage kidney disease registries, and household surveys. Estimates of CKD burden were produced using a Cause of Death Ensemble model and a Bayesian meta-regression analytical tool, and included incidence, prevalence, years lived with disability, mortality, years of life lost, and disability-adjusted life-years (DALYs). A comparative risk assessment approach was used to estimate the proportion of cardiovascular diseases and gout burden attributable to impaired kidney function.

Findings Globally, in 2017, 1·2 million (95% uncertainty interval [UI] 1·2 to 1·3) people died from CKD. The global all-age mortality rate from CKD increased 41·5% (95% UI 35·2 to 46·5) between 1990 and 2017, although there was no significant change in the age-standardised mortality rate (2·8%, –1·1 to 6·3). In 2017, 697·5 million (95% UI 649·2 to 752·0) cases of all-stage CKD were recorded, for a global prevalence of 9·1% (8·5 to 9·8). The global all-age prevalence of CKD increased 29·3% (95% UI 26·4 to 32·6) since 1990, whereas the age-standardised prevalence remained stable (1·2%, –1·1 to 3·5). CKD resulted in 35·8 million (95% UI 33·7 to 38·0) DALYs in 2017, with diabetic nephropathy accounting for almost a third of DALYs. Most of the burden of CKD was concentrated in the three lowest quintiles of Socio-demographic Index (SDI). In several regions, particularly Oceania, sub-Saharan Africa, and Latin America, the burden of CKD was much higher than expected for the level of development, whereas the disease burden in western, eastern, and central sub-Saharan Africa, east Asia, south Asia, central and eastern Europe, Australasia, and western Europe was lower than expected. 1·4 million (95% UI 1·2 to 1·6) cardiovascular disease-related deaths and 25·3 million (22·2 to 28·9) cardiovascular disease DALYs were attributable to impaired kidney function.

Interpretation Kidney disease has a major effect on global health, both as a direct cause of global morbidity and mortality and as an important risk factor for cardiovascular disease. CKD is largely preventable and treatable and deserves greater attention in global health policy decision making, particularly in locations with low and middle SDI.

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Introduction Chronic kidney disease (CKD) is an important contributor to morbidity and mortality from non-communicable diseases, and this disease should be actively addressed to meet the UN’s Sustainable Development Goal target to reduce premature mortality from non-communicable diseases by a third by 2030. Treatment costs for CKD rose after the 1960s, with availability of renal replacement techniques making possible the long-term application of life-saving but costly treatment for patients with end-stage kidney disease (ESKD). The number of people receiving renal replacement therapy exceeds 2·5 million and is projected to double to 5·4 million by 2030, however, in many countries, there is a shortage of renal replacement services, and an estimated 2·3–7·1 million adults have died prematurely from lack of access to this treatment. The effect of CKD also expands well beyond the provision of renal replacement services. Large-scale, nationally representative screening programmes undertaken in the 2000s in Australia, Norway, and the USA showed that more than 10% of the adult population have markers for kidney disease. Different research groups have reviewed the prevalence of and mortality from CKD in Africa.
The burden of chronic kidney disease (CKD) is studied predominantly in high-income countries, mainly in terms of prevalence, quality of life, mortality, and kidney and cardiovascular complications. Even where results of large-scale national CKD screening programmes are available, many data sources report CKD estimates only for selected populations (limited by age group, geography, occupation, etc), and for many countries there are no data for CKD epidemiology. The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) is a major effort to collect and incorporate into one system all available data for 354 diseases and 84 risk factors from the published literature, registries, vital registration systems, verbal autopsies, hospital records data, etc. GBD applies comprehensive statistical modelling to produce comparable estimates of the burden at the global, regional, and national levels.

**Evidence before this study**

The primary cause of CKD varies by setting, with hypertension and diabetes being the most common causes, whereas factors such as HIV and exposure to toxins or heavy metals have an additional role in developing countries. In some areas of the world with especially high burdens of CKD, the cause remains unknown.

CKD has also been recognised as a risk factor for cardiovascular disease independent of other conventional risk factors for cardiovascular disease. CKD is associated with an increased risk for cardiovascular disease mortality and is a risk multiplier in patients with hypertension and diabetes. Importantly, early detection and treatment of diabetes, hypertension, and CKD is possible using available data for 354 diseases and 84 risk factors from the published literature, registries, vital registration systems, verbal autopsies, hospital records data, etc. GBD applies comprehensive statistical modelling to produce comparable estimates of the burden at the global, regional, and national levels.

**Added value of this study**

We compiled data for CKD epidemiology by doing several systematic literature reviews in PubMed and Embase, using search queries combining “chronic kidney disease” and “prevalence”, and we retrieved publications from 1980 onwards. Data related to dialysis and kidney transplantation were extracted from annual renal replacement therapy registry reports up to 2017 and including the most recent year of available data. The results are a variety of estimates of morbidity and mortality for CKD as a direct cause of burden, and impaired kidney function as a risk factor for cardiovascular disease and gout. The statistical modelling approach enabled us to produce estimates of kidney disease burden even for countries without primary data. We showed a substantial burden of both CKD and impaired kidney function at the global level. Prevalence of CKD, in particular, is high (9.1% of the global population). Overall, CKD and its effect on cardiovascular disease resulted in 2.6 million (95% uncertainty interval 2.4 to 2.8) deaths and 35.8 million (33.7 to 38.0) disability-adjusted life-years (DALYs), with most DALYs attributable to CKD occurring in middle and low-middle Socio-demographic Index (SDI) quintiles. Importantly, CKD has continued to rise in rank among leading causes of death over the 27-year period studied, because of ageing and an increasing burden of risk factors for CKD (including diabetes and hypertension) that, together, contributed to more than half the deaths from CKD in 2017.

**Implications of all the available evidence**

The results presented here can help stakeholders form a comprehensive action plan to prevent and treat kidney disease. These actions should include increasing the awareness of CKD among the general public and health-care authorities as well as educational programmes for health-care personnel, appropriate treatment of risk factors, management of earlier stages of CKD, and development of facilities for treating patients with end-stage kidney disease. This work could be especially relevant for countries in low and middle SDI quintiles, where there is a large gap between CKD burden and provision of adequate health care.

Asia, Australia, Europe, Latin America, and several geographically dispersed developing countries, and confirmed the high burden of this disease. The primary cause of CKD varies by setting, with hypertension and diabetes being the most common causes, whereas factors such as HIV and exposure to toxins or heavy metals have an additional role in developing countries. In some areas of the world with especially high burdens of CKD, the cause remains unknown.

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The Global Burden of Disease, Injuries, and Risk Factors Study (GBD), with its broad collection of data sources and statistical modelling approaches, can deliver the most comprehensive estimates of CKD burden to date. We aimed to summarise GBD 2017 findings on CKD epidemiology in 195 countries, expressed in terms of incidence, prevalence, years lived with disability (YLDs), mortality, years of life lost (YLLs), and disability-adjusted life-years (DALYs). GBD also quantifies the burden of health loss due to cardiovascular disease and gout that can be attributed to kidney dysfunction. In this Article, we use the term CKD to refer to elevated urinary albumin:creatinine ratio (ACR), decreased estimated glomerular filtration rate (eGFR), dialysis, or kidney transplantation as direct causes of morbidity and mortality, whereas we use the term impaired kidney function to refer to elevated ACR or decreased eGFR without dialysis or kidney transplantation as risk factors for cardiovascular disease and gout in addition to the direct estimates of mortality and morbidity from CKD. Most published work is based on one timepoint to define elevated ACR or decreased eGFR without dialysis or kidney transplantation as risk factors for cardiovascular disease and gout in addition to the direct estimates of mortality and morbidity from CKD. As a result, many countries have underdeveloped nephrology workforces or mainly focus on the provision of treatment for ESKD but not for early stages of CKD.

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includes persistence for at least 3 months. We estimated the burden from CKD and the additional burden from comorbid cardiovascular disease and gout that can be attributed to impaired kidney function. We followed the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER; appendix pp 32–33).19

Methods

In GBD, all appropriate data and statistical methods are used to borrow strength from predictive covariates and geographical proximity to countries with data, so estimates can be obtained for countries and years with few or no primary data sources. Data collected based on different case definitions or study methods are adjusted to the level they would have been at if data were obtained using a reference method or case-definition set, for each disease or risk factor. Similarly, cause-of-death data from vital registrations or verbal autopsy studies are adjusted by reassigning deaths coded to less informative International Classification of Diseases and Injuries (ICD) codes. To account for uncertainty in primary data sources, data manipulations, measurement error, and the choice of model, all entities quantified in GBD are estimated 1000 times over in the ensemble and meta-regression models, to produce final estimates with 95% uncertainty intervals (UIs), which comprise the 2.5th and 97.5th percentiles of the 1000 draws.

Mortality

General methods for processing, standardisation, and modelling of cause-of-death data in GBD 2017 are described in the appendix (pp 2–5), and are published elsewhere.20 Briefly, we modelled mortality assigned to diagnostic (ICD) codes for CKD using vital registration, verbal autopsy, and surveillance system data for 1980–2017. Cause-of-death data for CKD were mapped to GBD categories based on ICD-9 and ICD-10 codes (appendix p 12). Aggregated data were age–sex split, and intermediate or poorly defined ICD codes were redistributed to a more appropriate GBD cause using regression or proportional redistribution methods.20 Most codes redistributed to CKD belonged to hypertension, unspecified anaemia, and heart failure.

We used the GBD Cause of Death Ensemble model (CODEm) process to produce estimates of mortality due to CKD. CODEm fits mixed-effects and spatiotemporal Gaussian process regression models using predictive covariates to estimate either the fraction of total deaths due to CKD (cause fraction) or mortality rates by location, year, age, and sex from 1980 to 2017. The final model is a weighted average of submodels, with weights assigned based on out-of-sample predictive validity. Cause fractions from CODEm models were multiplied by GBD all-cause mortality estimates to approximate the number of deaths and mortality rate due to CKD. We scaled CODEm results for all causes to be consistent with all-cause mortality estimates by country, year, age, and sex.

Non-fatal estimation

We defined prevalent CKD as an abnormality of kidney function, indicated by low eGFR based on serum creatinine measurement, elevated ACR, or both. We modelled six categories of prevalent CKD, defined by level of eGFR and ACR or renal replacement therapy. The categories defined in GBD are CKD stages 1–2, stage 3, stage 4, and stage 5, ESKD on maintenance dialysis, and kidney transplantation. The GBD definition of CKD differs from that presented in the KDIGO 2012 Clinical Practice Guidelines,22 because the GBD definition uses only one measurement of eGFR and ACR and, thus, does not formally fit the KDIGO duration requirement of abnormalities for more than 3 months. The GBD definition also does not take into account markers of kidney damage other than ACR, since these are often not reported in epidemiological studies used to estimate disease occurrence. The criteria used to define CKD categories in GBD, and how these entities correspond with KDIGO guidelines, are presented in table 1.

Building on past data collection efforts for GBD,23 we updated the systematic review of the literature for cross-sectional or cohort studies reporting population-representative prevalence of each stage of CKD based on serum creatinine measurements or eGFR and ACR values. New data for dialysis and transplantation were largely obtained from national registries for ESKD. We included 216 unique data sources for the prevalence of CKD stages 1–2, stage 3, stage 4, and stage 5 and 193 sources of data for incidence and prevalence of renal replacement therapy. A full list of sources used in the
CKD non-fatal estimation process is available through the Global Health Data Exchange.

We modelled each stage of CKD separately in DisMod-MR 2.1, which is a Bayesian mixed-effects meta-regression tool developed specifically for GBD by the Institute for Health Metrics and Evaluation (Seattle, WA, USA). DisMod uses input data for several epidemiological parameters, including prevalence, incidence, remission rate, and excess mortality rate, to make consistent estimates of each parameter. We also ran a DisMod-MR 2.1 model for the prevalence of CKD stages 3–5 combined and scaled estimates for the prevalence of CKD stage 3, stage 4, and stage 5 to sum to the prevalence of stages 3–5 combined for each country–year–age–sex group.

The Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation was designated as the reference equation for estimating GFR in adults aged 18 years and older.35 We adjusted data reporting eGFR with the Modification of Diet in Renal Disease (MDRD) formula by a fixed ratio to the level of data reporting prevalence with the CKD-EPI equation.36 The CKD stages 1–2 model included fixed-effects to adjust input data using alternate ACR thresholds (17 mg/g, 20 mg/g, or 25 mg/g) to define elevated urinary ACR. Studies using dipstick tests to assess proteinuria were not used.

CKD is one of the causes of anaemia estimated in GBD. Anaemia prevalence was approximated for all causes combined and then attributed to underlying causes. Methods related to the cause-specific attribution of anaemia prevalence have been described elsewhere.26,34

Estimates of CKD by cause

We estimated the burden of CKD for each of five causes: type 1 diabetes, type 2 diabetes, glomerulonephritis, hypertension, and a residual category of other and unspecified causes. For CKD stages 1–2, stage 3, stage 4, and stage 5, we estimated stage-specific distributions of causes. We used available laboratory and ICD-coded diagnosis data from Geisinger Health System,35 a health maintenance organisation in central and northern Pennsylvania, to identify patients with CKD stages 1–2, stage 3, stage 4, or stage 5 not on renal replacement therapy. For every individual with CKD, we used ICD codes for primary renal diseases to map individuals to GBD cause groupings (appendix p 12). Individuals with CKD but no ICD code for a primary renal disease were classified as having CKD of uncertain cause. We ran a multinomial logistic regression including sex and a non-linear term for age to predict the probability of each cause by age and sex for each stage of CKD.

We used data from ESKD registries to model the proportion of ESKD and CKD mortality attributable to each cause. Registry data were extracted to represent the proportion of cases of ESKD attributable to each modelled cause of CKD, excluding cases with unknown or missing cause. We ran a DisMod-MR 2.1 model for each cause. Results from the five cause proportion models were then scaled to sum to 1 for each country–year–age–sex and applied to CKD cause-of-death data and ESKD prevalence and incidence estimates.

DALY estimation

We multiplied estimates of deaths due to CKD by estimates of standard life expectancy by age, to produce estimates of YLLs for CKD.27 Non-fatal CKD estimates were separated into 15 unique sequelae dependent on CKD stage and anaemia severity (appendix pp 6–13). We calculated YLDs for each CKD sequela, multiplying the prevalence of each sequela by its corresponding disability weight.28 We summed YLDs and YLLs for each CKD cause to estimate DALYs. We quantified uncertainty around all estimates by taking 1000 draws from the distributions of sampling error, residual error, and corrections for measurement error. Inherent to the CODEm methods is the additional uncertainty from model choice. Final 95% UIs were calculated.

Socio-demographic Index

Socio-demographic Index (SDI) is a summary measure of development, created as a composite of a country’s total fertility rate for women younger than 25 years, educational attainment, and lag-distributed income per capita. Methods of SDI development and computation are detailed elsewhere.36 The expected relation between SDI and DALY rates was determined by fitting a Gaussian process regression on estimates for all locations from 1980 to 2017.

Risk estimation

We estimated the burden of CKD stages 1–2, stage 3, stage 4, and stage 5 not including renal replacement therapy, termed impaired kidney function (table 1), as a risk factor for ischaemic heart disease, stroke, peripheral vascular disease, and gout. For the estimation of risk factors in GBD we use a counterfactual approach rather than the categorical assignment to causes. One cannot categorically assign a case or death from ischaemic heart disease to impaired kidney function while there is evidence for an elevated risk of ischaemic heart disease to impaired kidney function. In the counterfactual approach we answer the question, what would the number of cases or deaths of ischaemic heart disease have been if no one in the population had impaired kidney function? The difference between the counterfactual and observed levels of ischaemic heart disease is what is being attributed to the risk factor. To capture the full range of health loss resulting from decreased eGFR and elevated ACR, we also attributed 100% of CKD prevalence to impaired kidney function, such that all CKD burden was also considered as burden attributable to impaired kidney function exposure. We set the theoretical minimum risk exposure level (TMREL) at an ACR of 30 mg/g or lower.
## Prevalence (95% UI)

|                      | Count, 2017 | Age-standardised rate per 100,000, 2017 | Percentage change in age-standardised rates between 1990 and 2017 | Count, 2017 | Age-standardised rate per 100,000, 2017 | Percentage change in age-standardised rates between 1990 and 2017 |
|----------------------|-------------|----------------------------------------|--------------------------------------------------------------|-------------|----------------------------------------|--------------------------------------------------------------|
| **Global**           |             |                                        |                                                              |             |                                        |                                                              |
| Low SDI              |             |                                        |                                                              |             |                                        |                                                              |
| Low-middle SDI       |             |                                        |                                                              |             |                                        |                                                              |
| Middle SDI           |             |                                        |                                                              |             |                                        |                                                              |
| High-middle SDI      |             |                                        |                                                              |             |                                        |                                                              |
| High SDI             |             |                                        |                                                              |             |                                        |                                                              |
| **East Asia**        |             |                                        |                                                              |             |                                        |                                                              |
| China                |             |                                        |                                                              |             |                                        |                                                              |
| North Korea          |             |                                        |                                                              |             |                                        |                                                              |
| Taiwan (province of) |             |                                        |                                                              |             |                                        |                                                              |
| **Southeast Asia**   |             |                                        |                                                              |             |                                        |                                                              |
| Cambodia             |             |                                        |                                                              |             |                                        |                                                              |
| Indonesia            |             |                                        |                                                              |             |                                        |                                                              |
| Laos                 |             |                                        |                                                              |             |                                        |                                                              |
| Malaysia             |             |                                        |                                                              |             |                                        |                                                              |
| Maldives             |             |                                        |                                                              |             |                                        |                                                              |
| Mauritius            |             |                                        |                                                              |             |                                        |                                                              |
| Myanmar              |             |                                        |                                                              |             |                                        |                                                              |
| Philippines          |             |                                        |                                                              |             |                                        |                                                              |
| Sri Lanka            |             |                                        |                                                              |             |                                        |                                                              |
| Seychelles           |             |                                        |                                                              |             |                                        |                                                              |
| Thailand             |             |                                        |                                                              |             |                                        |                                                              |
| Timor-Leste          |             |                                        |                                                              |             |                                        |                                                              |
| Vietnam              |             |                                        |                                                              |             |                                        |                                                              |
| **Oceania**          |             |                                        |                                                              |             |                                        |                                                              |
| American Samoa       |             |                                        |                                                              |             |                                        |                                                              |
| Federated States of Micronesia |             |                                        |                                                              |             |                                        |                                                              |
| Fiji                 |             |                                        |                                                              |             |                                        |                                                              |

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| Region                     | Prevalence (95% UI) | Deaths (95% UI) |
|---------------------------|---------------------|-----------------|
|                           | Count, 2017         | Age-standardised rate per 100,000, 2017 | Percentage change in age-standardised rates between 1990 and 2017 | Count, 2017 | Age-standardised rate per 100,000, 2017 | Percentage change in age-standardised rates between 1990 and 2017 |
| **Central Europe**        |                     |                 |                           |             |                             |                         |
| Armenia                   | 434 331             | 11 302          | 10.7% (6.3 to 15.9)       | 430         | 10.6 (10.1 to 11.1)          | (5.9 to 87.8)           |
| Azerbaijan                 | 10 625              | 10 577          | 0.9% (6.0 to 12.0)        | 1169        | 14.2 (12.2 to 15.7)         | (5.0 to 108.2)          |
| Georgia                   | 11 010              | 11 013          | 13.2% (7.6 to 18.0)       | 795         | 13.6 (12.7 to 14.4)         | (11.7 to 147.0)         |
| Kazakhstan                 | 10 093              | 10 093          | 12.2% (7.1 to 17.3)       | 1485        | 9.3 (8.7 to 9.9)            | (26.8 to 44.3)          |
| Kyrgyzstan                | 483 340             | 882 102         | 1.2% (6.7 to 9.2)         | 451         | 9.1 (8.6 to 9.8)            | (6.6 to 24.6)           |
| Mongolia                  | 269 339             | 10 050          | 2.4% (8.0 to 14.3)        | 328         | 15.3 (-6.2 to 61.2)        |                           |
| Tajikistan                | 665 377             | 10 093          | 1.8% (17.1 to 5.7)        | 614         | 11.2 (9.8 to 12.3)          | (2.3 to 29.6)           |
| Turkmenistan              | 473 830             | 10 949          | 8.8% (5.1 to 16.9)        | 632         | 16.0 (5.1 to 36.0)          | (7.6 to 48.6)           |
| Uzbekistan                | 2 896 741           | 10 993          | 14.2% (20.4 to 17.5)      | 3584        | 15.9 (14.3 to 17.7)         | (51.2 to 128.4)         |
| **Europe**                | 13 951 402          | 7 659           | -2.7% (-6.2 to 1.4)       | 16 284      | 7.5 (7.3 to 7.7)            | (-23.6 to -18.9)        |
| Albania                   | 272 017             | 7 259           | -1.1% (5.2 to 3.1)        | 363         | 9.2 (7.7 to 11.2)           | (-10.2 to -14.2)        |
| Bosnia and Herzegovina    | 427 229             | 8723            | 5.9% (1.3 to 10.4)        | 604         | 10.5 (9.6 to 11.5)          | (-10.1 to 9.9)          |
| Bulgaria                  | 981 339             | 8000            | 14.7% (9.4 to 10.8)       | 1447        | 10.1 (9.4 to 10.8)          | (25.3 to 57.2)          |
| Croatia                   | 562 778             | 777             | 12.4% (3.1 to 6.2)        | 829         | 8.8 (8.2 to 9.4)            | (35.3 to 46.0)          |
| Czech Republic            | 1 278 622           | 7998            | -2.5% (7.0 to 2.8)        | 1257        | 5.9 (-3.2 to -2.4)          | -28.4%                   |
| Hungary                   | 1 322 316           | 8204            | 1.0% (2.4 to 4.5)         | 1553        | 7.6 (7.2 to 8.1)            | (12.6 to 44.1)          |
| Montenegro                | 71 628              | 8118            | -1.5% (5.0 to 2.4)        | 127         | 13.1 (11.7 to 14.5)         | (-1.2 to 11.0)          |

(Continued from previous page)
### Prevalence (95% UI)  
| Country          | Count, 2017 | Age-standardised rate per 100,000, 2017 | Percentage change in age-standardised rates between 1990 and 2017 | Deaths (95% UI) | Count, 2017 | Age-standardised rate per 100,000, 2017 | Percentage change in age-standardised rates between 1990 and 2017 |
|------------------|-------------|--------------------------------------|----------------------------------------------------------------|----------------|-------------|--------------------------------------|----------------------------------------------------------------|
| (Continued from previous page) |             |                                      |                                                                |                |             |                                      |                                                                |
| North Macedonia  | 253,249     | 8308                                 | 2.4%                                                           | 309            | 9.4         | -11.3%                               | -20.5%                                                          |
| Poland           | 4,325,349   | 7271                                 | -6.0%                                                          | 3442           | 4.8         | -50.1%                               | -53.5%                                                          |
| Romania          | 2,313,736   | 7292                                 | -4.9%                                                          | 3,043          | 8.0         | -34.1%                               | -38.3%                                                          |
| Serbia           | 1,134,512   | 8421                                 | -0.5%                                                          | 2,186          | 14.8        | 18.8%                                 | 17.3%                                                           |
| Slovakia         | 623,048     | 7736                                 | -3.1%                                                          | 731            | 8.1         | -34.9%                               | -41.5%                                                          |
| Slovenia         | 266,527     | 7581                                 | -1.1%                                                          | 213            | 4.4         | -30.2%                               | -36.7%                                                          |
| Eastern Europe   | 38,150,780  | 12,408                               | 3.0%                                                           | 15,734         | 4.8         | -11.2%                               | -13.3%                                                          |
| Belarus          | 1,558,671   | 11,039                               | -1.6%                                                          | 485            | 31.1        | -32.7%                               | -37.4%                                                          |
| Estonia          | 2,58,859    | 12,059                               | 3.6%                                                           | 268            | 9.9         | -15.6%                               | -20.0%                                                          |
| Latvia           | 386,621     | 11,899                               | 5.3%                                                           | 259            | 6.2         | 41.5%                                 | 124.7%                                                          |
| Lithuania        | 533,970     | 11,328                               | 1.1%                                                           | 253            | 4.3         | -6.1%                                 | -13.5%                                                          |
| Moldova          | 587,124     | 11,365                               | 1.2%                                                           | 207            | 3.8         | -3.7%                                 | -9.7%                                                           |
| Russia           | 26,681,655  | 12,832                               | 4.5%                                                           | 11,261         | 51.1        | -34.7%                               | -16.8%                                                          |
| Ukraine          | 7,843,270   | 11,571                               | -1.6%                                                          | 2900           | 41.1        | -4.3%                                 | -9.6%                                                           |
| High-income Asia-Pacific |     | 27,550,513                      | 8,098                                           | 42,468         | 7.6         | -41.1%                               | -43.5%                                                          |
| Brunei           | 40,907      | 10,232                               | -8.7%                                                          | 70             | 26.0        | -13.2%                               | -27.1%                                                          |
| Japan            | 2,141,356   | 8,404                                | -5.9%                                                          | 35,799         | 7.5         | -40.3%                               | -43.0%                                                          |
| South Korea      | 5,451,810   | 7,103                                | -9.2%                                                          | 6095           | 7.7         | -46.0%                               | -45.7%                                                          |
| Singapore        | 6,64,440    | 9,223                                | -8.8%                                                          | 594            | 9.0         | -36.7%                               | -41.5%                                                          |
| Australasia      | 2,919,853   | 6,964                                | -0.7%                                                          | 528            | 9.2         | 8.8%                                  | -0.7%                                                           |
| Australia        | 2,471,845   | 6,962                                | -0.9%                                                          | 4,455          | 9.2         | 6.1%                                  | -4.8%                                                           |
| New Zealand      | 4,86,008    | 6,859                                | -0.2%                                                          | 773            | 9.4         | 21.6%                                 | 13.5%                                                           |
| Western Europe   | 41,976,625  | 5,446                                | -5.0%                                                          | 90,450         | 7.8         | -0.7%                                 | -4.4%                                                           |
| Andorra          | 6,496       | 5,423                                | 0.8%                                                           | 6              | 36.1        | -17.3%                               | -31.8%                                                          |
| Austria          | 8,57,140    | 5,557                                | 5.3%                                                           | 2754           | 12.4        | 128.0%                                | 111.7%                                                          |
| Belgium          | 11,019,945  | 5,642                                | -1.4%                                                          | 2097           | 7.2         | -29.4%                                | -34.9%                                                          |
| Cyprus           | 10,77,44    | 6,108                                | -6.4%                                                          | 256            | 13.2        | -23.5%                                | -34.1%                                                          |

(Table 2 continues on next page)
| Country        | Prevalence (95% UI) | Deaths (95% UI) |
|---------------|---------------------|-----------------|
|              | Count, 2017         | Age-standardised rate per 100,000, 2017 | Percentage change in age-standardised rates between 1990 and 2017 | Count, 2017 | Age-standardised rate per 100,000, 2017 | Percentage change in age-standardised rates between 1990 and 2017 |
| Denmark       | 552 944             | 5816            | 4.9% (1.8 to 8.1) | 968 | 7.7 (7 to 8.3) | 117.1% (101.1 to 135.2) |
| Finland       | 561 542             | 5761            | -4.5% (-8.6 to -0.2) | 569 | 4.0 (3.7 to 4.3) | -18.5% (8.9 to 28.5) |
| France        | 6077 964            | 5242            | -1.7% (-6.0 to 2.5) | 9279 | 4.9 (4.6 to 5.3) | -25.8% (-31.8 to -18.7) |
| Germany       | 9046 875            | 5687            | -4.7% (-7.7 to -1.4) | 26754 | 11.3 (10.2 to 12.4) | 45.0% (30.3 to 61.3) |
| Greece        | 1097 180            | 5432            | -5.3% (-9.1 to -1.1) | 3582 | 12.0 (11.2 to 12.9) | -30.0% (-35.3 to -24.1) |
| Iceland       | 25 067              | 2535            | 0.4% (-4.8 to 6.0) | 25 (25 to 29) | 4.3 (4.0 to 4.6) | -1.2% (-1.0 to 0.8) |
| Ireland       | 394 543             | 5985            | -4.0% (-8.4 to 0.7) | 579 | 7.5 (6.9 to 8.3) | -24.8% (-30.6 to -18.1) |
| Israel        | 654 367             | 6246            | 0.6% (2.1 to 3.3) | 2242 | 17.7 (16.5 to 19.0) | -20.9% (-26.6 to -14.2) |
| Italy         | 616 048             | 5156            | -9.2% (-12.8 to -6.1) | 14292 | 7.3 (6.8 to 7.9) | -19.5% (-25.3 to -12.9) |
| Luxembourg    | 52 621              | 6011            | -3.3% (-7.3 to 0.7) | 85 | 7.7 (6.9 to 8.6) | -3.7% (-14.1 to 7.7) |
| Malta         | 45 196              | 6053            | -5.3% (-8.6 to 1.7) | 94 | 10.2 (9.5 to 11.0) | -20.7% (-27.6 to -13.6) |
| Netherlands   | 1714 351            | 6142            | 1.3% (3.1 to 6.1) | 2683 | 7.1 (6.7 to 7.6) | 6.9% (0.5 to 15.8) |
| Norway        | 463 455             | 5677            | 10.1% (7.2 to 12.8) | 590 | 5.3 (5.1 to 5.5) | 34.5% (29.1 to 39.8) |
| Portugal      | 1168 749            | 5817            | -3.8% (7.6 to 12.4) | 5309 | 10.6 (9.8 to 11.4) | -7.6% (-14.7 to 0.3) |
| Spain         | 233 657             | 5014            | -5.9% (10.2 to 1.6) | 10605 | 8.0 (7.5 to 8.6) | -3.2% (-37.5 to -26.5) |
| Sweden        | 1128 448            | 6839            | 3.0% (0.3 to 5.7) | 1461 | 5.7 (5.3 to 6.1) | 57.5% (46.9 to 68.8) |
| Switzerland   | 841 113             | 5734            | -1.2% (0.3 to 3.5) | 1558 | 7.1 (6.6 to 7.6) | 103.9% (87.2 to 122.7) |
| UK            | 5636 676            | 5167            | -11.4% (0.6 to 12.0) | 6766 | 4.5 (4.4 to 4.6) | -14.4% (-16.3 to -12.6) |
| Southern Latin America | 5750 645 | 7402 | 3.9% (5 to 8.0) | 15 847 | 18.8 (17.5 to 20.2) | -7.5% (14.5 to 0.5) |
| Argentina     | 3841 099            | 7547            | 4.1% (0.0 to 8.0) | 10 834 | 19.7 (12.8 to 21.8) | -14.4% (23.0 to 4.7) |
| Chile         | 1569 089            | 7129            | 3.6% (0.0 to 8.7) | 9779 | 18.1 (16.4 to 20.0) | 26.5% (35.3 to 13.9) |
| Uruguay       | 340 293             | 7112            | 4.5% (0.6 to 12.0) | 787 | 12.9 (11.6 to 14.2) | -4.2% (-14.1 to 6.6) |
| High-income North America | 42 289 233 | 7919 | 0.2% (-3.5 to 3.9) | 91 038 | 13.8 (13.5 to 14.1) | 57.3% (53.4 to 61.1) |
| Canada        | 3 467 822           | 6033            | 5.9% (0.2 to 12.5) | 6087 | 7.9 (7.4 to 8.5) | 4.6% (-3.5 to 13.6) |
| Greenland     | 3965                | 6282            | -1.8% (-5.7 to 2.9) | 4 | 8.3 (6.0 to 9.2) | 12.2% (-10.9 to 28.7) |
| USA           | 3818 706            | 8144            | 0.1% (-3.6 to 3.8) | 84 944 | 14.6 (14.3 to 14.9) | 63.0% (58.8 to 66.9) |

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| Caribbean          | 4 304 951 (4 009 520 to 4 639 975) | 8591 (8000 to 9263) | 3.5% (0.1 to 7.6) | 11 023 (10 366 to 11 697) | 21.8 (20.5 to 23.1) | 17.2% (9.1 to 25.1) |
|--------------------|-------------------------------------|---------------------|-------------------|----------------------------|---------------------|---------------------|
| Antigua and Barbuda| 9207 (8632 to 10 029)               | 9007                | 2.2%              | 93                         | 25.9                | 4.0%                |
| Barbados           | 38 943 (33 248 to 38 503)           | 9135                | 3.2%              | 89                         | 18.9                | 5.1%                |
| Belize             | 28 612 (26 661 to 30 823)           | 9372                | 8.8%              | 84                         | 31.9                | 41.5%               |
| Bermuda            | 8 824 (8 193 to 9 609)              | 8 728               | 0.8%              | 16                         | 12.9                | 20.7%               |
| Cuba               | 788 (1 215 120 to 1 429 705)        | 7 314                | 1.9%              | 2 340                       | 12.6                | 32.1%               |
| Dominica           | 8 350 (7 753 to 8 987)              | 9 774               | 5.1%              | 33                         | 35.7                | 26.3%               |
| Dominican Republic | 814 154 (7 568 845 to 8 800 729)    | 8 394               | 7.9%              | 2 308                       | 74.4%               |
| Grenada            | 13 726 (12 800 to 14 781)           | 9 768               | 4.5%              | 51                         | 32.6                | 0.5%                |
| Guyana             | 61 209 (58 819 to 68 364)           | 9 689               | 8.7%              | 181                        | 30.1                | 39.6%               |
| Haiti              | 728 043 (675 837 to 766 398)        | 8 904               | 1.9%              | 2 083                       | 31.5                | 6.3%                |
| Jamaica            | 286 664 (266 400 to 308 671)        | 9 775               | 10.6%             | 810                        | 27.4                | 19.4%               |
| Puerto Rico        | 5 443 395 (5 049 959 to 5 883 309)  | 9 378               | 3.2%              | 1 691                       | 23.1                | 12.8%               |
| Saint Lucia        | 19 023 (17 767 to 20 445)           | 9 292               | 0.7%              | 55                         | 26.8                | 5.6%                |
| Saint Vincent and the Grenadines | 11 964 (11 64 to 13 872) | 9 775 | 6.6% | 37 | 27.0 | 17.4% |
| Suriname           | 55 279 (51 366 to 59 805)           | 9 464               | 7.8%              | 209                        | 37.7                | 37.8%               |
| Trinidad and Tobago| 152 776 (141 560 to 165 562)        | 8 317               | 3.3%              | 473                        | 27.0                | 19.9%               |
| Virgin Islands     | 14 527 (13 404 to 15 773)           | 9 250               | 5.1%              | 48                         | 27.3                | 30.1%               |

| Andean Latin America | 4 202 601 (3 920 607 to 4 538 911) | 7 473 (6 965 to 8 086) | 5.1% (1.4 to 9.7) | 14 191 (13 149 to 15 259) | 26.5 (24.5 to 28.4) | 9.1% (-0.2 to 19.8) |
|---------------------|--------------------------------------|-----------------------|-------------------|----------------------------|---------------------|---------------------|
| Bolivia             | 713 795 (665 086 to 723 378)         | 7 663                 | 0.9%              | 3 165                      | 39.7                | 3.7%                |
| Ecuador             | 1 207 828 (1 123 429 to 1 301 635)   | 7 875                 | 11.3%             | 5 739                      | 40.2                | 95.5%               |
| Peru                | 2 280 798 (2 123 558 to 2 472 702)   | 7 221                 | 3.3%              | 5 287                      | 16.9                | -24.0%              |

| Central Latin America | 26 908 399 (25 096 588 to 28 953 310) | 11 116 (10 358 to 11 979) | 7.2% (6.6 to 10.3) | 96 362 (93 272 to 99 062) | 42.1 (40.8 to 43.3) | 60.9% (52.7 to 66.2) |
|---------------------|----------------------------------------|------------------------|---------------------|----------------------------|---------------------|---------------------|
| Colombia            | 5 150 794 (4 775 434 to 5 611 276)     | 9 698                 | 1.1%              | 8 902                      | 15.7                | -34.1%              |
| Costa Rica          | 505 459 (468 201 to 546 223)           | 10 173                | 5.7%              | 1 265                      | 25.6                | 37.5%               |
| El Salvador         | 618 749 (575 374 to 669 028)           | 10 650                | 12.4%             | 4 174                      | 41.7                | 199.0%              |

(Table 2 continues on next page)
| Country       | Prevalence (95% UI) | Deaths (95% UI) |
|---------------|---------------------|----------------|
|               | Count, 2017         | Age-standardised rate per 100 000, 2017 | Percentage change in age-standardised rates between 1990 and 2017 |
|               |                     | Age-standardised rate per 100 000, 2017 | Percentage change in age-standardised rates between 1990 and 2017 |
| Guatemala     | 1 346 702           | 10 843 | 11.9% (7.9 to 16.4) |
| (1 251 012 to 1 449 662) | (10 059 to 11 704) | (7.9 to 16.4) |
| Honduras      | 682 978             | 9 510 | 10.4% (4.4 to 16.3) |
| (635 265 to 738 666) | (9 920 to 10 852) | (4.4 to 16.3) |
| Mexico        | 14 596 534          | 12 107 | 10.2% (7.7 to 13.0) |
| (13 572 422 to 15 614 239) | (11 292 to 13 009) | (7.7 to 13.0) |
| Nicaragua     | 559 208             | 10 989 | 2.4% (-0.1 to 6.1) |
| (518 841 to 600 857) | (10 170 to 11 804) | (-0.1 to 6.1) |
| Panama        | 396 230             | 9 979 | 7.0% (2.0 to 12.4) |
| (367 921 to 428 061) | (9 264 to 10 775) | (2.0 to 12.4) |
| Venezuela     | 3 090 745           | 10 502 | 3.5% (-4.0 to 7.7) |
| (2 860 732 to 3 350 686) | (9 733 to 11 384) | (-4.0 to 7.7) |
| Tropical Latin America | 17 263 386 | 7 365 | 0.1% (-2.5 to 3.1) |
| (16 844 242 to 18 629 836) | (6 852 to 7 949) | (-2.5 to 3.1) |
| Brazil        | 16 477 277          | 7 227 | -0.2% (-2.8 to 2.8) |
| (15 577 858 to 18 170 349) | (6 810 to 7 918) | (-2.8 to 2.8) |
| Paraguay      | 485 053             | 8 445 | 11.6% (6.7 to 17.0) |
| (453 016 to 524 486) | (7 828 to 9 144) | (6.7 to 17.0) |
| North Africa and Middle East | 48 796 617 | 10 361 | 1.9% (-1.8 to 5.7) |
| (45 311 656 to 52 988 276) | (9 616 to 11 247) | (-1.8 to 5.7) |
| Afghanistan  | 1 386 966           | 10 913 | -0.9% (-5.3 to 3.3) |
| (1 466 363 to 17 30 232) | (10 087 to 11 878) | (-5.3 to 3.3) |
| Algeria      | 3 479 207           | 9 813 | 0.9% (-3.5 to 5.8) |
| (3 232 001 to 3 812 516) | (9 074 to 10 998) | (-3.5 to 5.8) |
| Bahrain      | 120 057             | 10 427 | -1.7% (-6.6 to 3.5) |
| (120 764 to 143 901) | (9 660 to 11 291) | (-6.6 to 3.5) |
| Egypt        | 7 101 539           | 10 572 | 5.3% (4.1 to 9.6) |
| (6 552 681 to 7 720 210) | (9 754 to 11 521) | (4.1 to 9.6) |
| Iran         | 8 339 849           | 10 924 | 11.3% (8.2 to 15.0) |
| (7 708 434 to 9 705 743) | (10 112 to 11 895) | (8.2 to 15.0) |
| Iraq         | 3 044 399           | 10 991 | -9.3% (8.2 to 0.5) |
| (2 826 656 to 3 295 432) | (10 186 to 11 946) | (-8.2 to 0.5) |
| Jordan       | 745 402             | 10 378 | -5.0% (8.5 to 11.1) |
| (691 588 to 808 791) | (9 665 to 11 727) | (-8.5 to 11.1) |
| Kuwait       | 339 577             | 9 716 | -0.2% (-6.6 to 3.5) |
| (313 380 to 369 112) | (8 988 to 10 559) | (-6.6 to 3.5) |
| Lebanon      | 668 003             | 10 029 | -0.3% (-5.5 to 5.6) |
| (618 913 to 718 649) | (9 284 to 10 928) | (-5.5 to 5.6) |
| Libya        | 594 010             | 10 963 | 6.8% (2.1 to 11.5) |
| (548 524 to 644 171) | (10 142 to 11 905) | (2.1 to 11.5) |
| Morocco      | 3 289 444           | 9924 | 1.5% (5.8 to 1.7) |
| (3 046 873 to 3 568 865) | (9 931 to 11 333) | (5.8 to 1.7) |
| Palestine    | 307 284             | 10 423 | -2.2% (3.0 to 6.6) |
| (283 987 to 333 626) | (9 590 to 11 333) | (3.0 to 6.6) |
| Oman         | 324 195             | 10 611 | 9.2% (4.2 to 14.9) |
| (297 665 to 352 901) | (9 380 to 11 554) | (4.2 to 14.9) |
| Qatar        | 188 206             | 9 920 | -8.9% (13.1 to 3.6) |
| (170 629 to 205 354) | (9 919 to 10 757) | (13.1 to 3.6) |
| Saudi Arabia | 2 387 872           | 9 882 | 2.4% (0.4 to 4.4) |
| (2 010 128 to 2 595 630) | (9 193 to 10 812) | (0.4 to 4.4) |
| Sudan        | 2 747 010           | 10 107 | 1.9% (3.2 to 7.3) |
| (2 106 225 to 3 145 285) | (9 337 to 11 001) | (3.2 to 7.3) |
| Syria        | 1 384 897           | 9 881 | -4.8% (8.8 to 0.1) |
| (1 271 191 to 1 505 808) | (9 099 to 10 748) | (8.8 to 0.1) |

(Continued from previous page)
## Prevalence (95% UI) and Deaths (95% UI)

| Country                    | Prevalence (95% UI) | Age-standardised rate per 100,000, 2017 | Percentage change in age-standardised rates between 1990 and 2017 | Deaths (95% UI) | Age-standardised rate per 100,000, 2017 | Percentage change in age-standardised rates between 1990 and 2017 |
|----------------------------|---------------------|----------------------------------------|---------------------------------------------------------------|----------------|----------------------------------------|---------------------------------------------------------------|
| (Continued from previous page) |                     |                                        |                                                                |                |                                        |                                                                |
| Tunisia                    | 4532                | (125 849 to 1 331 895)                 |                                                                | 153            | (12 780 to 18 207)                    |                                                                |
| Turkey                     | 3091                | (9 042 506)                            | 5.1% (-6 to 11.9)                                              | 153            | (12 780 to 18 207)                    |                                                                |
| United Arab Emirates       | 274 351             | (655 751 to 795 089)                   | 2.5% (-7.4 to 2.6)                                             | 153            | (12 780 to 18 207)                    |                                                                |
| South Asia                 | 143 173 973         | (132 967 984 to 154 589 580)           | 535 (-3.6 to 9.0)                                              | 22 8           | (21 2 to 23 9)                       | 2.6% (-12.1 to 6.0)                                             |
| Bangladesh                 | 11 579              | (11 196 657)                           | 2.0% (-10 to 8.9)                                              | 16 783         | (14 590 to 18 866)                    | 1.4% (-7.8 to 6.0)                                              |
| Bhutan                     | 69 290              | (64 157 74 597)                        | 2.0% (-14 to 6.5)                                              | 136            | (110 to 162)                         | 2.3% (-4.0 to 4.7)                                              |
| India                      | 115 605 914         | (106 818 767 to 124 130 281)           | 5.6% (3.3 to 8.2)                                              | 223 811        | (207 938 to 235 529)                  | 22.3 (-14.1 to 27)                                              |
| Nepal                      | 21 741              | (21 593 410 to 2 351 912)              | 7.9% (3.9 to 12.0)                                             | 47 897         | (42 587 to 58 019)                    | 24.7 (-21.0 to 15.0)                                             |
| Pakistan                   | 14 663              | (13 591 220 to 15 834 707)             | 14.3% (10.2 to 18.7)                                           | 36 844         | (31 938 to 41 322)                    | 24.3 (12.4 to 15.9)                                              |
| Central sub-Saharan Africa | 6 969 028           | (6 467 179 to 7 451 973)               | 0.0% (-3.6 to 3.7)                                             | 12 587         | (11 086 to 14 204)                    | 28.0 (24.9 to 31.0)                                              |
| Angola                     | 1 499 668           | (1 389 646 to 1 622 666)               | 3.2% (-0.7 to 7.6)                                             | 28 090         | (23 955 to 32 275)                    | 19.7 (33.0 to 0.1)                                              |
| Central African Republic   | 285 293             | (263 420 to 309 434)                   | 2.1% (-1.6 to 6.5)                                             | 655            | (53 587 to 789)                      | 13.9 (-7.5 to 4.6)                                              |
| Congo (Brazzaville)        | 347 706             | (322 213 to 37 356)                    | 2.9% (-6.7 to 8.0)                                             | 617            | (55 279 to 795)                      | 13.2 (-3.5 to 7.5)                                              |
| Democratic Republic of the | 4 623 446           | (4 286 990 to 5 002 633)               | 0.7% (-4.5 to 3.4)                                             | 802 27         | (677 2 to 929 0)                     | 17.3 (-30.5 to 0.3)                                             |
| Equatorial Guinea          | 74 843              | (69 512 to 80 983)                     | 0.5% (-3.5 to 4.5)                                             | 324            | (23 3 to 43 3)                       | 30.3 (-4.8 to 6.1)                                              |
| Gabon                      | 1 138 082           | (1 123 236 to 1 149 087)               | 9.8% (-2.3 to 8.4)                                             | 296            | (25 3 to 37 0)                       | -6.6 (-22.9 to 5.8)                                             |
| Eastern sub-Saharan Africa | 20 223 557          | (18 793 079 to 21 887 248)             | 1.6% (-1.7 to 5.2)                                             | 27 322         | (24 2 to 28 2)                       | -27.0 (-33.4 to -19.0)                                           |

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(For all countries not mentioned, see original article for detailed data.)
### Prevalence (95% UI)

| Country          | Count, 2017 | Age-standardised rate per 100 000, 2017 | Percentage change in age-standardised rates between 1990 and 2017 | Count, 2017 | Age-standardised rate per 100 000, 2017 | Percentage change in age-standardised rates between 1990 and 2017 |
|------------------|-------------|----------------------------------------|---------------------------------------------------------------|-------------|----------------------------------------|---------------------------------------------------------------|
| **Southern sub-Saharan Africa** |             |                                        |                                                               |             |                                        |                                                               |
| Botswana         | 196 440     | (182 104 to 211 968)                   |                                                               | 116 155     | (110 808 to 125 512)                   | 10.7% to 8.3%                                                   |
| eSwatini         | 88 896      | (82 455 to 95 944)                     |                                                               | 58 739      | (52 457 to 67 121)                     |                                                               |
| Lesotho          | 166 622     | (154 774 to 180 465)                   |                                                               | 140 322     | (134 086 to 148 576)                   |                                                               |
| Namibia          | 11 762      | (10 740 to 12 819)                     |                                                               | 11 217      | (10 672 to 12 742)                     |                                                               |
| South Africa     | 568 137     | (520 490 to 612 9994)                  |                                                               | 32 189      | (28 109 to 36 279)                     |                                                               |
| Zimbabwe         | 944 836     | (877 212 to 1 022 937)                 |                                                               | 25 663      | (22 124 to 29 217)                     |                                                               |
| **Western sub-Saharan Africa** |             |                                        |                                                               |             |                                        |                                                               |
| Benin            | 689 440     | (640 678 to 745 414)                   |                                                               | 26 286      | (21 240 to 31 332)                     |                                                               |
| Burkina Faso     | 1 281 101   | (1 185 130 to 1 383 412)               |                                                               | 12 707      | (12 050 to 13 360)                     |                                                               |
| Cameroon         | 1 741 850   | (1 622 811 to 1 889 103)               |                                                               | 30 641      | (27 809 to 33 493)                     |                                                               |
| Cape Verde       | 55 825      | (51 817 to 60 741)                     |                                                               | 46 696      | (41 891 to 51 500)                     |                                                               |
| Chad             | 779 014     | (723 905 to 844 703)                   |                                                               | 6 102       | (5 787 to 6 417)                       |                                                               |
| Côte d'Ivoire    | 1 642 666   | (1 519 379 to 1 784 152)               |                                                               | 24 611      | (21 371 to 28 051)                     |                                                               |
| The Gambia       | 135 988     | (126 031 to 147 163)                   |                                                               | 8 487       | (7 500 to 9 474)                       |                                                               |
| Ghana            | 2 252 649   | (2 096 610 to 2 441 403)               |                                                               | 24 482      | (21 065 to 28 059)                     |                                                               |
| Guinea           | 747 095     | (693 302 to 807 476)                   |                                                               | 21 715      | (19 024 to 24 406)                     |                                                               |
| Guinea-Bissau    | 116 129     | (107 475 to 126 088)                   |                                                               | 3 570       | (2 950 to 4 250)                       |                                                               |
| Nicaragua        | 308 102     | (285 351 to 333 730)                   |                                                               | 14 720      | (12 280 to 17 160)                     |                                                               |
| Mali             | 1 127 953   | (1 044 615 to 1 219 025)               |                                                               | 24 131      | (20 550 to 27 712)                     |                                                               |

(Continued from previous page)
and eGFR of 60 mL/min per 1·73 m² or higher, given that this population is at the lowest risk for cardiovascular disease events.19,21,37–45

Relative risk values for cardiovascular disease outcomes were calculated by the Chronic Kidney Disease Prognosis Consortium, a research consortium composed of investigators representing several cohorts, including population-level cohorts with prospective data.21–25 Relative risk was first calculated within each cohort, then a pooled analysis of cohort-level relative risks was done using a random-effects meta-analysis. Gout relative risk was calculated by a random-effects meta-analysis of four studies,56–59 considering only CKD stages 3–5 indicating increased risk of gout.

Exposure, relative risk, and TMREL were used to calculate the fraction of fatal and non-fatal burden attributable to exposure to impaired kidney function (appendix pp 14–15).

Role of the funding source
The funder had no role in study design, data collection, data analysis, data interpretation, or writing of the report. All authors had full access to all data in the study and had final responsibility for the decision to submit for publication.

Results
Global prevalence
Globally in 2017, there were 679·7 million (95% UI 649·2 to 752·1) cases of CKD (table 2). Almost a third of patients with CKD lived in two countries, China (132·3 million [95% UI 121·8 to 143·7] cases) and India (115·1 million [106·8 to 124·1] cases). Bangladesh, Brazil, Indonesia, Japan, Mexico, Nigeria, Pakistan, Russia, the USA, and Vietnam had more than 10 million cases of CKD each. 79 of 195 countries included in GBD had more than 1 million prevalent cases of CKD in 2017.

In 2017, the prevalence of CKD was estimated as 9·1% (95% UI 8·5 to 9·8) in the world’s population, with CKD stages 1–2 accounting for 5·0% (4·5 to 5·5), stage 3 for 3·9% (3·5 to 4·3), stage 4 for 0·16% (0·13 to 0·19), stage 5 for 0·07% (0·06 to 0·08), dialysis for 0·041% (0·037 to 0·044), and kidney transplantation for 0·011% (0·010 to 0·012). The age-standardised prevalence of CKD was 1·29 (95% UI 1·28 to 1·30) times higher in females (9·5% [8·8 to 10·2]) than in males (7·3% [6·8 to 7·9]). The global age-standardised incidence of CKD was 1·29 (95% UI 1·28 to 1·30) times higher in females (9·5% [8·8 to 10·2]) than in males (7·3% [6·8 to 7·9]). The global age-standardised incidence of dialysis and kidney transplantation increased by 1·47 (95% UI 1·46 to 1·48) times greater among males (13·7 [12·6 to 14·9]) than among females (8·6 [7·9 to 9·3]) per 100,000 population.

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Results
Global prevalence
Globally in 2017, there were 697·5 million (95% UI 649·2 to 752·1) cases of CKD (table 2). Almost a third of patients with CKD lived in two countries, China (132·3 million [95% UI 121·8 to 143·7] cases) and India (115·1 million [106·8 to 124·1] cases). Bangladesh, Brazil, Indonesia, Japan, Mexico, Nigeria, Pakistan, Russia, the USA, and Vietnam had more than 10 million cases of CKD each. 79 of 195 countries included in GBD had more than 1 million prevalent cases of CKD in 2017.

In 2017, the prevalence of CKD was estimated as 9·1% (95% UI 8·5 to 9·8) in the world’s population, with CKD stages 1–2 accounting for 5·0% (4·5 to 5·5), stage 3 for 3·9% (3·5 to 4·3), stage 4 for 0·16% (0·13 to 0·19), stage 5 for 0·07% (0·06 to 0·08), dialysis for 0·041% (0·037 to 0·044), and kidney transplantation for 0·011% (0·010 to 0·012). The age-standardised prevalence of CKD was 1·29 (95% UI 1·28 to 1·30) times higher in females (9·5% [8·8 to 10·2]) than in males (7·3% [6·8 to 7·9]). The global age-standardised incidence of dialysis and kidney transplantation increased by 1·47 (95% UI 1·46 to 1·48) times greater among males (13·7 [12·6 to 14·9]) than among females (8·6 [7·9 to 9·3]) per 100,000 population. The global age-standardised CKD mortality rate was 1·39 (1·30 to 1·45) times greater among males (13·7 [12·6 to 14·9]) per 100,000 population than among females (8·6 [7·9 to 9·3]) per 100,000 population. The country median prevalence of CKD was 8·9% (IQR 7·1 to 10·8).

The global age-standardised prevalence of CKD has remained stable between 1990 and 2017, with a 1·2% (95% UI –1·1 to 3·5) change, although the all-age prevalence of CKD has increased by 29·3% (26·4 to 32·6) from 1990 to 2017. The availability of renal replacement therapy from 1990 to 2017 has grown; global all-age incidence of dialysis and kidney transplantation increased by 43·1% (95% UI 40·5 to 45·8) and 34·4% (29·7 to 38·9), respectively, while global age-standardised incidence rose by 10·7% (9·1 to 12·3) and 12·8% (10·2 to 15·3), respectively, with larger increases in all-age incidence of

| Country | Count, 2017 | Age-standardised rate per 100,000, 2017 | Percentage change in age-standardised rates between 1990 and 2017 | Count, 2017 | Age-standardised rate per 100,000, 2017 | Percentage change in age-standardised rates between 1990 and 2017 |
|---------|-------------|--------------------------------------|---------------------------------------------------------------|-------------|--------------------------------------|---------------------------------------------------------------|
| Mauritania | 271,447 | (251,721 to 291,400) | 6·6 | (5·5 to 7·7) | 11,281 | (10,440 to 12,231) | –4·2% | (–7·9 to 0·1) | 460 | (385 to 549) | 23·8 | (20·0 to 28·4) | –38·8% | (–49·5 to –26·8) |
| Niger | 104,009 | (97,398 to 113,392) | 7·7 | (6·8 to 8·7) | 10,774 | (9,978 to 11,713) | –1·7% | (–2·8 to 2·9) | 1,777 | (1,433 to 2,203) | 21·8 | (17·7 to 27·3) | –3·5% | (–4·6 to –21·8) |
| Nigeria | 12,681,837 | (11,655,780 to 13,853,971) | 7·8 | (6·9 to 8·8) | 11,387 | (10,498 to 12,386) | 0·5% | (–1·9 to 1·4) | 13,740 | (10,420 to 18,751) | 15·0 | (11·3 to 20·6) | –3·4% | (–5·0 to –1·1) |
| São Tomé and Príncipe | 15,734 | (14,575 to 17,056) | 0·8% | (–3·3 to 5·2) | 12,188 | (11,288 to 13,210) | 45 | (39·0 to 52·7) | 44·1 | (38·1 to 50·5) | 15·9% | (12·5 to 19·8) |
| Senegal | 996,438 | (924,922 to 1,079,051) | 0·6% | (–0·6 to 1·6) | 11,262 | (10,423 to 11,276) | 1930 | (1668 to 2282) | 27·0 | (23·2 to 32·0) | –27·2% | (–37·6 to –14·9) |
| Sierra Leone | 510,214 | (472,533 to 552,280) | 2·0% | (–2·0 to 2·0) | 11,412 | (10,580 to 12,389) | 396 | (375 to 415) | 23·0 | (20·9 to 28·2) | –32·7% | (–36·8 to –5·9) |
| Togo | 517,758 | (472,213 to 554,594) | 2·3% | (–2·0 to 2·7) | 11,396 | (10,547 to 12,341) | 759 | (629 to 907) | 22·4 | (18·9 to 26·2) | –24·5% | (–37·6 to –10·2) |

UI=uncertainty interval. SDI=Socio-demographic Index. Table 2: Prevalence and deaths for chronic kidney disease in 2017, and percentage change of age-standardised rates by location, 1990–2017
renal replacement therapy resulting from population ageing. Despite such increases, availability of renal replacement therapy is still limited in many world regions with a high burden of CKD.

Global mortality

CKD resulted in 1·2 million (95% UI 1·2 to 1·3) deaths in 2017 (table 2). An additional 1·4 million (1·2 to 1·6) deaths from cardiovascular disease were attributable to impaired kidney function, representing 7·6% (6·5 to 8·8) of deaths due to cardiovascular disease in 2017. Deaths due to CKD, and cardiovascular disease deaths attributable to impaired kidney function, represented 4·6% (95% UI 4·3 to 5·0) of total mortality. Ranked as the 17th leading cause of death in 1990, CKD has increased in importance, ranking as the 12th leading cause of death in 2017. The rank of CKD among all causes of death was especially prominent in Central and Andean Latin America, ranking second and fifth, respectively. The global all-age CKD mortality rate increased by 41·5% (95% UI 35·2 to 46·5) from 1990 to 2017. The age-standardised mortality rate remained stable, with a 2·8% change (–1·5 to 6·3) from 1990 to 2017. The age-standardised CKD mortality rate, however, has increased by 60·9% (95% UI 53·2 to 65·8) in central Latin America, 60·9% (53·2 to 66·1) in ascending Latin America, 60·9% (53·2 to 66·5) in central Asia, and 57·3% (53·2 to 61·1) in high-income North America.

YLDs, YLLs, and DALYs

In 2017, CKD resulted in 7·3 million (95% UI 5·4 to 9·2) YLDs, 28·5 million (27·6–29·3) YLLs, and 35·8 million
Although most prevalent cases of CKD are stages 1–2 or stage 3, YLDs are largest for CKD stage 5 and dialysis, which accounted for 40% and 22% of YLDs for CKD, respectively, in 2017. Considerable global variation was noted in CKD burden, with age-standardised CKD DALY rates varying more than 15-fold between countries (figure 1). American Samoa, El Salvador, Federated States of Micronesia, Marshall Islands, and Mauritius had the highest estimated rates of age-standardised CKD DALYs in 2017, with more than 1500 DALYs per 100000 population, whereas Andorra, Finland, Iceland, and Slovenia had the lowest burden, with age-standardised DALYs for CKD of less than 120 per 100000 population. Despite the relatively high prevalence of non-fatal CKD, YLDs accounted for only 20·3% (95% UI 15·9 to 24·6) of total CKD DALYs in 2017, with more than 1500 DALYs per 100000 population, whereas Andorra, Finland, Iceland, and Slovenia had the lowest burden, with age-standardised DALYs for CKD of less than 120 per 100000 population. Despite the relatively high prevalence of non-fatal CKD, YLDs accounted for only 20·3% (95% UI 15·9 to 24·6) of total CKD DALYs in 2017, because most of the prevalence of CKD was contributed by disease stages 1–2 and stage 3, which confer little to no functional health loss. While slight increases were estimated in CKD prevalence and mortality from 1990 to 2017, global age-standardised rates of YLLs and YLDs due to CKD decreased over this period by 9·6% (95% UI 5·8 to 13·1) and 4·3% (0·4 to 9·0), respectively, thereby resulting in an 8·6% (5·4 to 11·8) decrease in the global age-standardised rate of DALYs due to CKD.

**Burden by SDI**

The age-standardised DALY rate due to CKD was highest in the low-middle SDI quintile, and was lower in the high and high-middle SDI quintiles than in the other quintiles in 2017 (appendix pp 26–31). The low SDI quintile saw the largest change in age-standardised DALY rates, changing by –23·6% (95% UI –29·2 to –16·2) between 1990 and 2017. The high and middle SDI quintiles saw the smallest changes, with age-standardised DALY rates changing by –4·0% (–6·5 to –1·8) and –5·5% (–9·3 to –2·3), respectively, since 1990 (figure 2). Despite declining age-standardised DALY rates, all SDI quintiles showed a net increase in the absolute number of DALYs attributable to CKD from 1990 to 2017, attributable to population growth and ageing.

The estimated relation between SDI and expected age-standardised rate of CKD DALYs is generally negative, with the slope steepening as SDI increases (figure 3). Oceania had much higher age-standardised DALY rates due to CKD than expected based on SDI for all years between 1990 and 2017. Despite gains in SDI over time, central Latin America, high-income North America, and the Caribbean also saw increasing rates of CKD DALYs, by contrast with other world regions. Western, eastern, and central sub-Saharan Africa, east Asia, south Asia, central and eastern Europe, Australasia, and western Europe all had a lower age-standardised CKD DALY rate than expected, based on their SDI values.

**Causal attribution**

CKD due to diabetes accounted for 30·7% (95% UI 27·8 to 34·0) of CKD DALYs, the largest contribution in terms of absolute number of DALYs of any cause in 2017, with CKD due to type 1 and type 2 diabetes resulting in 2·9 million (2·4 to 3·5) DALYs and
8.1 million (7.1 to 9.2) DALYs, respectively (figure 4A). CKD due to other and unspecified causes resulted in a substantial number of DALYs across all age groups and was estimated to have the highest age-standardised rate of DALYs (138.8 [95% UI 123.7 to 155.9] per 100 000 population) among all causes of CKD. Type 2 diabetes was the only cause of CKD to show a significant increase in the age-standardised DALY rate, which changed by 9.5% (95% UI 4.3 to 13.7) from 1990 to 2017 (figure 4B).

**Risk factors for CKD**

Impaired fasting plasma glucose, high blood pressure, high body-mass index, a diet high in sodium, and lead were risk factors for CKD quantified in GBD, accounting for 57.6% (95% UI 50.5 to 63.8), 43.2% (42.3 to 54.1), 26.6% (17.0 to 37.7), 9.5% (3.7 to 18.0), and 3.6% (2.3 to 5.1), respectively, of the age-standardised rate of CKD DALYs in 2017. High blood pressure accounted for the largest proportion of CKD burden in east Asia, eastern Europe, tropical Latin America, and western sub-Saharan Africa, whereas high fasting plasma glucose was the leading risk factor for CKD in all other regions.

**Impaired kidney function as a risk factor**

In 2017, impaired kidney function resulted in 61.3 million (95% UI 56.9 to 66.1) DALYs, of which 58.4% (55.4 to 61.4) were directly contributed by CKD whereas 41.6% (38.2 to 44.4) were cardiovascular disease DALYs and less than 1% (0.003% [95% UI 0.002 to 0.004]) were gout DALYs attributable to impaired kidney function, although the composition was different by world region (figure 5). Of 25.3 million (95% UI 22.2 to 28.9) DALYs resulting from cardiovascular disease attributable to impaired kidney function, 58.8% (54.0 to 63.7) came from ischaemic heart disease, 40.2% (35.4 to 45.0) from stroke, and the remaining 1.0% (0.6 to 1.5) from peripheral artery disease. The global age-standardised rate of cardiovascular disease DALYs attributable to impaired kidney function in 2017 was 318.3 (278.9 to 363.2) DALYs per 100 000 population. With an age-standardised rate of 1028.4 (866.0 to 1218.8) DALYs per 100 000 population, Oceania had the largest age-standardised rate of cardiovascular disease DALYs attributable to impaired kidney function, followed by central Asia, eastern Europe, and north Africa and the Middle East, which all had age-standardised DALY rates.
above 500 per 100000 population. Since 1990, the age-standardised rate of cardiovascular disease DALYs due to impaired kidney function has decreased globally by 29·4% (95% UI 26·4 to 32·2), although central Asia saw a rise of 10·5% (4·9 to 16·3).

Information on input data sources for cause of death, non-fatal, and risk factor models can be downloaded from the Global Health Data Exchange. Complete GBD 2017 results are available online for visualisation and can be downloaded from the Global Health Data Exchange.

Discussion
The number of individuals with all-stage CKD reached almost 700 million in 2017, which is more people than those with diabetes, osteoarthritis, chronic obstructive pulmonary disease (COPD), asthma, or depressive disorders. CKD diagnoses resulted in 1·2 million deaths in 2017, a number that has been projected to rise by 2040 to 2·2 million in a best-case scenario and up to 4·0 million in a worst-case scenario. GBD ranks CKD as the 12th leading cause of death out of 133 conditions. Globally in 2017, CKD resulted in more deaths than did tuberculosis or HIV, and the number of CKD deaths was almost equal to the number of deaths due to road injuries. The decrease in the global age-standardised DALY rate for CKD from 1990 to 2017 was not accompanied by corresponding decreases in age-standardised rates of CKD mortality or prevalence, indicating a shift to mortality due to CKD occurring at an older age and lower average severity of non-fatal CKD. However, these declines are slower than for cardiovascular disease and stroke. A handful of locations deviated from this global trend and had a greater than 50% increase in the age-standardised CKD DALY rate from 1990 to 2017, including American Samoa, Ecuador, El Salvador, Georgia, Guam, Mexico, Paraguay, and Philippines. The increases in CKD burden in these locations have been largely driven by substantial increases in the CKD mortality rate. Although there is still uncertainty about the cause of CKD in some populations with high CKD mortality, studies from American Samoa, Guam, and Mexico suggest that limited access to renal replacement therapy combined with increases in the prevalence of diabetes and hypertension have contributed to rising CKD burden in these regions. We found a higher prevalence of CKD stages 1–3 in females and higher mortality in males, which suggests that males progress to ESKD more rapidly. There is evidence of substantial gender disparities in access to CKD treatment, and actions are needed to provide equal access to kidney health care. These results highlight the importance of improved management of risk factors for CKD at primary care level and the need for expanded access to affordable renal replacement services for those with ESKD.

We have not seen the same degree of progress in prevention of CKD mortality as we have for many other important non-communicable diseases. From 1990 to 2017, the global age-standardised mortality rate declined...
by 30·4% for cardiovascular disease, 14·9% for cancer, and 41·3% for COPD,2 but a similar decline was not seen for CKD (2·8% change [95% UI –1·5 to 6·3]). Disparities in CKD mortality by world region highlight the importance of access to renal replacement therapy, both to initiate treatment and to maintain access to dialysis. For instance, in sub-Saharan Africa, even if individuals requiring renal replacement initiate treatment, retention is low because of an inability to pay for ongoing dialysis, and up to 85% of incident patients are forced to withdraw from this life-saving treatment.29 Public health policy also has a role in slowing the incidence rate of ESKD through education of health personnel, early kidney disease detection programmes and implementation of nephroprotective treatment, and appropriate treatment of CKD risk factors such as high systolic blood pressure and elevated glucose levels.31 This action could be especially important in low SDI regions where primary care health systems are focused on child and maternal health and are less equipped to adequately prevent and treat chronic diseases.27 In view of the detrimental interplay between diabetes, hypertension, CKD, and development of cardiovascular disease, one alternative could be to integrate screening of CKD in ongoing efforts to reduce the occurrence of cardiovascular disease. Studies suggest that screening for CKD in high-risk and elderly populations is a cost-effective approach to reduce progression to ESKD and CKD mortality.27–29 The effect of kidney disease on the burden of non-communicable diseases is not limited to ESKD or CKD itself but extends to cardiovascular diseases for which impaired kidney function is an independent risk factor.19,22 According to our analysis, almost 7% of the total cardiovascular disease burden can be attributed to impaired kidney function. Of all the global risk factors in 2017, the DALY rate for impaired kidney function was higher than that for drug use, unsafe sanitation, low physical activity, second-hand smoke, and several dietary risk factors.29 However, kidney health is given far less attention than the aforementioned risk factors, both by public health authorities and the general population. Fewer than 10% of patients with CKD are aware of their disease, both in developing32 and developed46 countries. According to the Global Kidney Health Atlas 2017, CKD is recognised as a health-care priority in 36% of countries, a national strategy for combating all stages of CKD is available in 17% of countries, and awareness and adoption of CKD guidelines among primary and secondary care specialists is estimated to be below average in 49% of countries.

Kidney care is closely related to global health challenges. The gap between age-standardised CKD DALY rates in low, low-middle, and middle SDI quintiles compared with high and high-middle SDI quintiles reflects inequities in access to preventive care and renal replacement therapy across levels of development. The low SDI quintile saw the largest decrease in age-standardised CKD DALY rates from 1990 to 2017, primarily as a result of substantial decreases in the age-standardised mortality rate in many countries in the low SDI quintile, including Ethiopia, Niger, and Rwanda. Nevertheless, the fraction of all deaths in these countries attributable to CKD has steadily increased over the past 20 years, indicating that differences in CKD burden observed between low-middle and low SDI quintiles might diminish when overall declines in all-cause mortality rate slow, particularly as exposures to risk factors for CKD, including diabetes, hypertension, and high body-mass index, continue to amplify in the low SDI quintile. For these countries at the lower end of the development spectrum, the situation has been aggravated by insufficient access to laboratory diagnostic services,7 a shortage of medical personnel,9 scarce medication, and the absence of universal health coverage.29 Disparities in access to CKD care also exist within countries for different populations, some of which are at higher risk of late referral to nephrology services,20 resulting in greater rates of complications and mortality.21

The prevalence of CKD reported in GBD 2017 (9·1% [95% UI 8·5 to 9·8]) is lower than the global prevalence estimate from a meta-analysis published in 2016 (13·4%).26 This difference is attributable to variations in methodological approach and data inclusion criteria. For the estimation of CKD prevalence, GBD excluded studies reporting on clinic-based or laboratory-based populations, because patients with creatinine samples for CKD in these instances tend to belong to high-risk groups, leading to overestimation of CKD prevalence. Moreover, GBD also accounted for differences in age and sex distributions across input data sources, thus ensuring that data affected prevalence estimates only for the demographic subset from which they were gathered. Estimates of CKD prevalence in GBD 2017 are higher than those reported in previous iterations of GBD, primarily because of inclusion of CKD stages 1–2 as part of the GBD definition of CKD for GBD 2017.

Several limitations applicable to GBD have been discussed in detail elsewhere.26–29 Limitations specific to CKD apply to the current analysis. First, many countries do not have high-quality population-based studies on the occurrence of CKD. Some regions with the highest burden of CKD (eg, Central America, Latin America, and Oceania) have little to no available data for CKD incidence or prevalence within the population (appendix p 7); as such, GBD must rely on statistical methods and predictive covariate values to estimate CKD burden in these regions. Additionally, despite the standardised definition of CKD presented by the KDIGO guidelines,19 sources of information on non-fatal CKD vary in terms of sampling, laboratory methods, and the equation used to calculate eGFR. Several studies have noted systematic differences in estimated CKD prevalence resulting from the use of different equations.30–32 To account for these differences and standardise data across studies, we adjusted data.
sources to represent prevalence as calculated according to our reference definition of eGFR, estimated using the CKD-EPI equation. This correction increases the uncertainty of input data and was derived from a limited number of sources, which might not accurately characterise bias within different demographic subsets of the population. Future iterations of GBD should expand the number of sources used for this analysis to evaluate if these adjustment factors vary by sex, age, ethnicity, or geographical location.

Second, most data sources reporting the prevalence of non-fatal CKD are cross-sectional and do not repeat serum creatinine and urine ACR measurements over 3 months, as suggested by KDIGO guidelines, to confirm the chronicity of abnormalities. Studies suggest that use of one measurement of decreased eGFR to characterise CKD might overestimate prevalence by 25–50%. Therefore, it is possible that the results of our analysis represent an overestimate of CKD prevalence. Future analyses of the global burden of CKD should investigate developing a methodology to correct prevalence estimates based on one eGFR measurement, as done to correct for differences in prevalence estimates resulting from use of alternate estimating equations.

Third, ascertainment of the cause of CKD is difficult. Biopsy is the gold-standard method for assigning the underlying cause of CKD, but this procedure is only advised when confirmation of cause is necessary and the benefits of confirmation outweigh risks of the procedure. Additionally, CKD often arises from comorbid conditions, contributing to a large degree of uncertainty about the true underlying cause of CKD. To capture this uncertainty and better reflect clinical realities of causal attribution, we used data from the Geisinger Health System to identify patients with various stages of CKD, relying on ICD codes for primary renal diseases to map individuals to GBD cause groupings and assigning individuals with CKD but no ICD code for a primary renal disease as having CKD of unknown cause. This method marks an improvement over previous iterations of GBD in which the distribution of CKD by cause was generated using data solely from renal replacement therapy registries and was assumed to be the same across all stages. However, the generalisability of Geisinger data to CKD populations worldwide is limited, because there is considerable geographical variation in the distribution of primary renal diseases. Use of clinical data also probably represents a skewed causal distribution in early-stage CKD, because many cases of mild kidney function decline are asymptomatic, so there could be differential case-ascertainment based on primary renal disease.

Fourth, impaired kidney function as defined for GBD risk factor estimation does not explicitly quantify the risk of elevated ACR and decreased eGFR separately, despite evidence that elevated ACR leads to increased risk for cardiovascular outcomes independent of decreased eGFR. Estimation of attributable burden separately by ACR and eGFR would provide additional insights for treatment and prevention of cardiovascular disease outcomes among individuals with impaired kidney function. We also only quantified the burden of cardiovascular disease and gout attributable to impaired kidney function; however, impaired kidney function might also put individuals at risk for other outcomes that we have not yet accounted for. Additional outcomes for impaired kidney function could be added to future GBD iterations if evidence can establish a causal link.

Finally, the GBD estimation framework for CKD does not currently estimate anaemia impairment for cases of ESKD on dialysis or ESKD after transplant. Patients on dialysis have a high prevalence of anaemia, the severity of which could affect the level of disability they experience. The disability weight associated with dialysis is relatively high; however, the lay description associated with this health state also includes symptoms associated with anaemia. Nevertheless, this might have resulted in an underestimate of the disability associated with dialysis.

In conclusion, CKD is a highly prevalent condition that contributes a substantial proportion of disease burden globally, yet over the past 27 years the burden of CKD has not declined to the same extent as many other important non-communicable diseases. The age-standardised effect of CKD is more prominent in countries in low and middle SDI quintiles, where there is a large gap between CKD burden and provision of adequate health care. Importantly, slowing CKD progression at early stages provides economic benefits and prevents the development of ESKD and cardiovascular complications. A comprehensive action plan should include effective management of risk factors for CKD at the primary care level, improved case-detection among at-risk populations, and development of facilities for treating patients with documented disease. By jointly implementing CKD prevention, assessment, and treatment, we could achieve better health for many populations with a high burden of CKD and related outcomes. The UN Sustainable Development Goals aim to reduce premature mortality from non-communicable diseases by a third by 2030. Our estimates suggest that targeting CKD could be an important step in reaching these goals.

GBD Chronic Kidney Disease Collaboration

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