Burden of non-communicable diseases in sub-Saharan Africa, 1990–2017: results from the Global Burden of Disease Study 2017

Hebe N Gouda, Fiona Charlson, Katherine Sorsdahl, Sanam Ahmadzada, Alize J Ferrari, Holly Erskine, Janini Leung, Damian Santamauro, Crick Lund, Leopold Ndemnge Aminde, Bongani M Mayosi1, Andre Pascal Kengne, Meredith Harris, Tom Achoki, Charles S Wiysonge, Dan J Stein, Harvey Whiteford

Summary

Background Although the burden of disease in sub-Saharan Africa continues to be dominated by infectious diseases, countries in this region are undergoing a demographic transition leading to increasing prevalence of non-communicable diseases (NCDs). To inform health system responses to these changing patterns of disease, we aimed to assess changes in the burden of NCDs in sub-Saharan Africa from 1990 to 2017.

Methods We used data from the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2017 to analyse the burden of NCDs in sub-Saharan Africa in terms of disability-adjusted life-years (DALYs)—with crude counts as well as all-age and age-standardised rates per 100 000 population—with 95% uncertainty intervals (UIs). We examined changes in burden between 1990 and 2017, and differences across age, sex, and regions. We also compared the observed NCD burden across countries with the expected values based on a country’s Socio-demographic Index.

Findings All-age total DALYs due to NCDs increased by 67·0% between 1990 (90·6 million [95% UI 81·0–101·9]) and 2017 (151·3 million [133·4–171·8]), reflecting an increase in the proportion of total DALYs attributable to NCDs (from 18·6% [95% UI 17·1–20·4] to 29·8% [27·6–32·0] of the total burden). Although most of this increase can be explained by population growth and ageing, the age-standardised DALY rate (per 100 000 population) due to NCDs in 2017 (21757·7 DALYs [95% UI 19377·1–24 380·7]) was almost equivalent to that of communicable, maternal, neonatal, and nutritional diseases (26 491·6 DALYs [25 165·2–28 129·8]). Cardiovascular diseases were the second leading cause of NCD burden in 2017, resulting in 22·9 million (21·5–24·3) DALYs (15·1% of the total NCD burden), after the group of disorders categorised as other NCDs (28·8 million [25·1–33·0] DALYs, 19·1%). These categories were followed by neoplasms, mental disorders, and digestive diseases. Although crude DALY rates for all NCDs have decreased slightly across sub-Saharan Africa, age-standardised rates are on the rise in some countries (particularly those in southern sub-Saharan Africa) and for some NCDs (such as diabetes and some cancers, including breast and prostate cancer).

Interpretation NCDs in sub-Saharan Africa are posing an increasing challenge for health systems, which have to date largely focused on tackling infectious diseases and maternal, neonatal, and child deaths. To effectively address these changing needs, countries in sub-Saharan Africa require detailed epidemiological data on NCDs.

Funding Bill & Melinda Gates Foundation, National Health and Medical Research Centre (Australia).

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

Introduction In sub-Saharan Africa, communicable diseases such as malaria, tuberculosis, and HIV have long been among the most prominent contributors to disease burden.1 However, like most low-income and middle-income countries across the globe, countries in sub-Saharan Africa are undergoing a rapid epidemiological transition characterised by a shift from disease-burden profiles dominated by communicable diseases and childhood illnesses to profiles featuring an increasing predominance of chronic, non-communicable diseases (NCDs). Our understanding of the epidemiology of NCDs in sub-Saharan Africa is limited by the lack of established vital statistics systems and reliable population-level data for most countries in the region.2 Nonetheless, research indicates growing burdens of diabetes,3 chronic respiratory diseases,4 chronic kidney disease,5 cardiovascular diseases,6 cancers,7 and mental and substance use disorders8,9,10 in numerous countries in sub-Saharan Africa. Furthermore, sub-Saharan Africa is expected to see one of the largest increases in mortality due to NCDs globally.11 NCD risk factor surveillance in sub-Saharan Africa over the past decade indicates that most adults are exposed to at least one risk factor for NCDs, including tobacco consumption, harmful alcohol use, unhealthy diet, physical inactivity, obesity, or high blood pressure.12 Global recognition of the growing challenges posed by NCDs is reflected in the UN Sustainable Development Goals, which include a target to reduce premature deaths...
due to major NCDs by 30% by 2030 and promote mental health and general wellbeing.13-14 The WHO Global NCD Action Plan 2013–2020 also outlines global targets to reduce mortality due to major NCDs.15 To achieve these targets, health systems will need to be equipped to address the changing patterns of disease burden; however, according to the NCD policy indicators outlined in the action plan, countries across sub-Saharan Africa do not have the appropriate measures in place to aid with reaching the targets. In many sub-Saharan African countries, health systems remain fragile, fragmented, under-resourced, and limited in terms of infrastructure and capacity to address the increasing burden of NCDs.16,17 As NCDs increase in prevalence, existing barriers to treatment will become more apparent.16,18 Determining which NCDs should be prioritised, both now and in the future, is necessary for local health service planning and ongoing global health efforts in sub-Saharan Africa.19

In this study, we used estimates from the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2017—which uses methods that allow for the estimation of burden in countries or regions with scarce data—to provide a comprehensive and in-depth examination of the burden of NCDs in sub-Saharan Africa and to analyse the change in NCD burden from 1990 to 2017 at the regional and country levels. We aimed to investigate the role of NCDs in the epidemiological transition in sub-Saharan Africa; the burden of NCDs by cause, and how this changed between 1990 and 2017; the burden of NCDs by region, age, and sex; and the variations in NCD burden across countries according to the social, economic, and demographic variation between countries, as measured by the Socio-demographic Index (SDI).

Methods

Overview
All GBD 2017 estimates were generated and are reported here in accordance with the Guidelines for Accurate and Transparent Health Estimates Reporting (appendix p 1). The methods used by GBD 2017 are described in detail elsewhere.20 The estimation process for NCDs in GBD 2017 is briefly summarised below.

The GBD 2017 cause list was made up of a four-level hierarchy. Causes reported within each level are mutually exclusive and collectively exhaustive (appendix p 7). Level 2 NCDs featured in GBD 2017 were cardiovascular diseases; neoplasms (cancers); chronic respiratory diseases; diabetes, urogenital, blood, and endocrine disorders; neurological disorders; cirrhosis; digestive diseases; mental disorders; substance use disorders; musculoskeletal disorders; and other non-communicable diseases (including congenital anomalies, sense organ diseases, skin and subcutaneous diseases, and oral disorders). GBD 2017 uses the disability-adjusted life-year (DALY) to measure disease burden at the population level. DALYs are calculated by summing years of life lost (YLLs) due to premature mortality and years of life lived with disability (YLDs), thereby incorporating both fatal and non-fatal burden.20 All estimates generated in GBD 2017 were accompanied by 95% uncertainty intervals (UIs). DALYs, YLDs, and YLLs were estimated for each NCD by sex, age (20 age groups spanning the entire lifespan), year
YLLs because of premature mortality

For direct causes of death, YLLs were calculated by multiplying the number of deaths for a given age group, sex, year, and location by the reference life expectancy. GBD 2017 estimated cause-specific deaths using data from vital registries, verbal autopsies, and other mortality surveillance databases. The International Classification of Diseases (ICD) coding system (ICD-9 and ICD-10) was used to assign each death to its direct physical cause. Deaths allocated to ambiguous or incorrect cause codes were redistributed with redistribution algorithms developed specifically for GBD purposes. For most GBD causes, death estimates were analysed with the Cause of Death Ensemble Modelling (CODEm) tool. Normative lifetables were calculated using the lowest death rates for each age group in locations with populations greater than 5 million. The reference life expectancy estimated was 86·6 years at birth and 23·8 years at 65 years. The cause of death data and model specifications are further detailed elsewhere.1

YLDs

For each cause, YLDs were calculated by multiplying estimates of prevalence for each age group, sex, year, and location by a corresponding disability weight. The epidemiological modelling, disability weights and comorbidity adjustments are described briefly here and in detail elsewhere.22

Systematic literature reviews were done to capture epidemiological data from health surveys, surveillance systems, disease registries, and hospital and claims databases. For most causes, epidemiological data were modelled with use of DisMod-MR 2.1, a Bayesian meta-regression tool designed specifically for GBD purposes. DisMod-MR 2.1 was used to estimate the prevalence of diseases, including for countries or regions that were lacking data, as well as to provide an assessment of internal consistency and UIs. Details of data input sources are available online.

Following the estimation of disease prevalence, additional steps were taken to estimate prevalent cases of each cause by severity. For some causes (eg, chronic obstructive pulmonary disease), severity was modelled via DisMod using data gathered in different locations around the world. Other causes use severity proportions from meta-analyses. For the remaining causes, individual-level survey data from the Medical Expenditure Panel Survey, the National Epidemiologic Survey on Alcohol and Related Conditions, and the 1997 Australian National Survey of Mental Health and Wellbeing were used to estimate the proportion of cases with each cause that were within each level of severity.23 Each level of severity for each cause has an associated health state with a disability weight. These disability weights were derived from responses of more than 60000 participants in an online internet survey and population surveys in Bangladesh, Indonesia, Peru, Tanzania, the USA, Hungary, Italy, Sweden, and the Netherlands. In the surveys, participants were presented with pairs of non-clinical descriptions of sequelae and asked which was the healthier of the two. Responses were converted into disability weights, anchored on a scale from 0 (perfect health) to 1 (death), using questions comparing the benefits of life-saving and disease-prevention programmes.21

The burden associated with each non-fatal sequela was first estimated independently to other sequelae; however, individuals often live with multiple sequelae at a time.
| Age-standardised DALYs per 100 000 population | All-age DALYs per 100 000 population | All-age total DALYs (thousands) | Percentage change, 1990-2017 |
|---------------------------------------------|---------------------------------------|---------------------------------|-----------------------------|
| 1990                                       | 2017                                  | 2010-2017                       |                              |
| Lip and oral cavity cancer                 | -4.6%                                 | -5.2%                           | -28.6% 245.7                |
| Nasopharynx cancer                         | -21.2%                                | -21.5%                          | -22.6% 48.7                 |
| Other pharynx cancer                       | -6.0%                                 | -6.4%                           | -35.9% 245.7                |
| Oesophageal cancer                         | -18.6%                                | -21.7%                          | -22.6% 48.7                 |
| Stomach cancer                             | -33.2%                                | -35.4%                          | -35.9% 245.7                |
| Colon and rectum cancer                    | -3.7%                                 | -3.7%                           | -35.9% 245.7                |
| Liver cancer                               | -27.4%                                | -28.4%                          | -35.9% 245.7                |
| Gallbladder and biliary tract cancer       | -11.6%                                | -16.0%                          | -35.9% 245.7                |
| Pancreatic cancer                          | 25.4%                                 | 21.5%                           | -22.6% 48.7                 |
| Larynx cancer                              | -23.7%                                | -25.3%                          | -35.9% 245.7                |
| Tracheal, bronchus, and lung cancer         | -12.2%                                | -15.6%                          | -35.9% 245.7                |
| Malignant skin melanoma                    | -4.0%                                 | -2.6%                           | -35.9% 245.7                |
| Non-melanoma skin cancer                   | -5.4%                                 | -4.2%                           | -35.9% 245.7                |
| Breast cancer                              | 9.4%                                  | 11.9%                           | -35.9% 245.7                |
| Cervical cancer                            | -29.7%                                | -29.0%                          | -35.9% 245.7                |
| Uterine cancer                             | -12.2%                                | -15.9%                          | -35.9% 245.7                |
| Ovarian cancer                             | 9.9%                                  | 9.3%                            | -35.9% 245.7                |
| Prostate cancer                            | -4.7%                                 | -8.8%                           | -35.9% 245.7                |
| Testicular cancer                          | -28.6%                                | -27.3%                          | -35.9% 245.7                |
| Kidney cancer                              | -8.9%                                 | -6.7%                           | -35.9% 245.7                |
| Bladder cancer                             | -11.7%                                | -15.3%                          | -35.9% 245.7                |
| Brain and nervous system cancer            | -5.9%                                 | -4.6%                           | -35.9% 245.7                |
| Thyroid cancer                             | -20.4%                                | -22.6%                          | -35.9% 245.7                |
| Mesothelioma                               | -23.8%                                | -26.1%                          | -35.9% 245.7                |
| Hodgkin lymphoma                           | -35.1%                                | -35.9%                          | -35.9% 245.7                |
### Cardiovascular diseases

| Condition                         | 1990 (DALYs) | 2017 (DALYs) | Percentage change, 1990-2017 | 1990 (DALYs) | 2017 (DALYs) | Percentage change, 1990-2017 | 1990 (total DALYs) | 2017 (total DALYs) | Percentage change, 1990-2017 |
|-----------------------------------|-------------|-------------|--------------------------------|-------------|-------------|--------------------------------|------------------|------------------|--------------------------------|
| Non-Hodgkin lymphoma              | 144·3       | 325·6       | -12·9%                         | 126·4       | 301·9       | -19·4%                         | 621·0            | 1045·8           | 68·4%                          |
| Multiple myeloma                  | 31·3        | 34·0        | 8·4%                           | 15·0        | 15·9        | 6·5%                           | 73·5             | 163·6            | 122·5%                         |
| Leukaemia                         | 137·7       | 128·8       | -6·4%                          | 135·4       | 119·1       | -12·1%                         | 665·2            | 1221·6           | 83·7%                          |
| Other malignant cancers           | 240·1       | 227·3       | -5·3%                          | 229·7       | 205·1       | -10·7%                         | 1128·4           | 2104·4           | 86·5%                          |
| Other neoplasms                   | 16·2        | 21·0        | 29·6%                          | 189·4       | 198·6       | 4·8%                           | 191·9            | 1946·8           | 111·8%                         |
| Rheumatic heart disease           | 246·3       | 130·9       | -46·9%                         | 198·1       | 101·0       | -49·0%                         | 973·2            | 1063·7           | 6·5%                           |
| Ischaemic heart disease           | 226·4       | 190·5       | -15·9%                         | 1003·2      | 823·5       | -17·9%                         | 4928·7           | 8449·7           | 71·4%                          |
| Stroke                            | 245·9       | 173·2       | -29·6%                         | 1201·8      | 794·2       | -34%                           | 5904·4           | 8129·9           | 37·7%                          |
| Hypertensive heart disease        | 472·3       | 364·8       | -23·0%                         | 215·3       | 155·7       | -27·7%                         | 1057·5           | 1597·5           | 51·1%                          |
| Non-rheumatic valvular heart disease | 36·5     | 29·5        | -19·2%                         | 20·2        | 15·8        | -21·6%                         | 99·2             | 162·2           | 38·9%                          |
| Cardiomyopathy and myocarditis    | 200·3       | 140·8       | -29·7%                         | 166·6       | 96·9        | -41·9%                         | 818·6            | 994·0            | 21·4%                          |
| Atrial fibrillation and flutter    | 68·3        | 69·0        | 1·0%                           | 23·2        | 22·9        | -1·2%                          | 113·8            | 234·8            | 106·4%                         |
| Aortic aneurysm                   | 58·9        | 39·2        | -33·4%                         | 27·8        | 18·0        | -35·4%                         | 136·6            | 184·4            | 35·0%                          |
| Peripheral vascular disease       | 13·8        | 17·4        | 27·4%                          | 5·2         | 6·4         | 21·6%                          | 25·8             | 65·5            | 154·0%                         |
| Endocarditis                      | 75·0        | 47·4        | -36·8%                         | 81·7        | 43·5        | -46·8%                         | 401·6            | 446·2           | 11·1%                          |
| Other cardiovascular and circulatory diseases | 337·8 | 253·7       | -24·9%                         | 225·1       | 152·0       | -32·5%                         | 1105·8           | 1555·9           | 41·1%                          |

### Chronic respiratory diseases

| Condition                        | 1990 (DALYs) | 2017 (DALYs) | Percentage change, 1990-2017 | 1990 (DALYs) | 2017 (DALYs) | Percentage change, 1990-2017 | 1990 (total DALYs) | 2017 (total DALYs) | Percentage change, 1990-2017 |
|----------------------------------|-------------|-------------|--------------------------------|-------------|-------------|--------------------------------|------------------|------------------|--------------------------------|
| Chronic obstructive pulmonary disease | 1127·9    | 882·0       | -21·8%                         | 534·1       | 410·5       | -23·1%                         | 2624·2           | 4213·2           | 60·5%                          |
| Pneumococcal pneumonia           | 70          | 48          | -30·6%                         | 3·3         | 2·2         | -32·0%                         | 162              | 230              | 41·9%                          |
| Asthma                            | 65·5        | 39·6        | -39·8%                         | 594·4       | 307·4       | -39·1%                         | 2478·4           | 3154·2           | 27·3%                          |
| Intestinal lung disease and pulmonary sarcoidosis | 30·3    | 26·9        | -11·3%                         | 14·6         | 12·4        | -19·4%                         | 71·5             | 121·7           | 77·7%                          |
| Other chronic respiratory diseases | 75·4       | 71·2        | -5·6%                          | 600         | 604         | 0·7%                           | 294·9            | 620              | 110·2%                         |

### Digestive diseases

| Condition                        | 1990 (DALYs) | 2017 (DALYs) | Percentage change, 1990-2017 | 1990 (DALYs) | 2017 (DALYs) | Percentage change, 1990-2017 | 1990 (total DALYs) | 2017 (total DALYs) | Percentage change, 1990-2017 |
|----------------------------------|-------------|-------------|--------------------------------|-------------|-------------|--------------------------------|------------------|------------------|--------------------------------|
| Cirrhosis and other chronic liver diseases | 1284·0    | 897·8       | -30·1%                         | 757·2       | 593·9       | -28·7%                         | 3720·1           | 997·6            | 48·8%                          |
| Upper digestive system diseases  | 522·1       | 415·2       | -20·5%                         | 349·7       | 284·2       | -18·7%                         | 1718·3           | 2916·0           | 41·0%                          |

(The table continues on next page)
### Articles

| Mental Disorders | 1990 | 2017 | Percentage change, 1990-2017 | All-age DALYs per 100,000 population | 1990 | 2017 | Percentage change, 1990-2017 | All-age DALYs per 100,000 population | 1990 | 2017 | Percentage change, 1990-2017 | All-age total DALYs (thousands) | 1990 | 2017 | Percentage change, 1990-2017 | All-age total DALYs (thousands) |
|------------------|------|------|-----------------------------|--------------------------------------|------|------|-----------------------------|--------------------------------------|------|------|-----------------------------|---------------------------------|------|------|-----------------------------|---------------------------------|
| Appendicitis     | 65.1 | 50.3 | -20.3%                      | 59.6                                 | 43.4 | -27.2% | 292.9                       | (210-2-418.8)                      | 445.4 | 52.1% |                             |                                  |      |      |                             |                                  |
| Paralytic ileus and intestinal obstruction | 244.3 | 237.1 | -2.9%                      | 219.8                                 | 184.0 | -16.3% | 1079.8                      | (939-7-1267.0)                      | 1887.4 | 74.8% |                             |                                  |      |      |                             |                                  |
| Inguinal, femoral, and abdominal hernia | 52.0 | 45.6 | -12.3%                      | 35.7                                 | 30.7 | -13.9% | 175.4                       | (138-2-217.8)                      | 315.4 | 79.9% |                             |                                  |      |      |                             |                                  |
| Neurological disorders (1418.8–2117.6) | 174.3 | 1674.5 | -4.0%                      | 1263.7                                | 1199.7 | -5.1% | 6208.7                      | (4905-4-7772.6)                      | 12309.9 | 98.3% |                             |                                  |      |      |                             |                                  |
| Alzheimer’s disease and other dementias | 456.7 | 450.4 | -1.4%                      | 127.5                                 | 124.0 | -2.5% | 626.6                       | (564-1-697.1)                      | 1276.1 | 10.3% |                             |                                  |      |      |                             |                                  |
| Parkinson’s disease | 69.9 | 68.9 | -1.4%                      | 23.8                                 | 22.5 | -5.4% | 117.1                       | (99-5-129.0)                      | 231.2 | 97.5% |                             |                                  |      |      |                             |                                  |
| Epilepsy | 453.7 | 380.0 | -16.3%                      | 467.8                                 | 378.0 | -19.2% | 239.2                       | (1759-1-2988.8)                    | 2913.3 | 68.8% |                             |                                  |      |      |                             |                                  |
| Multiple sclerosis | 5.0 | 5.1 | 0.4%                      | 3.0                                 | 3.2 | 4.5% | 15.0                       | (10-8-26.3)                      | 37.2 | 118.3% |                             |                                  |      |      |                             |                                  |
| Motor neuron disease | 1.2 | 1.1 | -6.1%                      | 0.8                                 | 0.7 | -12.7% | 3.7                       | (3-0-6.0)                      | 6.8 | 69.7% |                             |                                  |      |      |                             |                                  |
| Headache disorders | 683.8 | 689.1 | 1.5%                      | 556.3                                 | 591.7 | 6.4% | 2733.3                      | (1799-2-3835.7)                   | 3395.5 | 55.0% |                             |                                  |      |      |                             |                                  |
| Other neurological disorders | 69.5 | 70.8 | 1.8%                      | 84.4                                 | 79.2 | -6.2% | 414.8                       | (234-5-583.6)                    | 583.0 | 96.0% |                             |                                  |      |      |                             |                                  |
| Mental disorders | 1552.0 | 1538.8 | -0.8%                      | 1290.2                                | 1215.1 | 2.4% | 6338.9                      | (4651-3-8265.7)                   | 13559.2 | 113.9% |                             |                                  |      |      |                             |                                  |
| Schizophrenia | 102.5 | 105.2 | 2.6%                      | 71.9                                 | 78.3 | 8.8% | 353.3                       | (262-1-439.3)                    | 803.1 | 127.3% |                             |                                  |      |      |                             |                                  |
| Depressive disorders | 649.7 | 636.6 | -2.0%                      | 470.6                                 | 478.5 | 1.7% | 2312.2                      | (1633-9-3156.5)                   | 4099.5 | 112.3% |                             |                                  |      |      |                             |                                  |
| Bipolar disorder | 124.5 | 125.5 | 0.8%                      | 102.8                                 | 108.3 | 5.4% | 505.0                       | (317-2-748.8)                    | 1111.5 | 120.1% |                             |                                  |      |      |                             |                                  |
| Anxiety disorders | 307.0 | 309.5 | 0.8%                      | 272.2                                 | 282.6 | 3.8% | 1372.2                      | (942-1-1747.0)                    | 2899.8 | 116.9% |                             |                                  |      |      |                             |                                  |
| Eating disorders | 24.9 | 27.7 | 12.1%                      | 21.7                                 | 27.9 | 17.7% | 116.4                       | (73-2-116.6)                    | 186.1 | 145.9% |                             |                                  |      |      |                             |                                  |
| Autism spectrum disorders | 64.6 | 64.7 | 0.1%                      | 68.9                                 | 68.8 | 0.0% | 338.4                       | (231-9-464.5)                    | 706.4 | 108.7% |                             |                                  |      |      |                             |                                  |
| Attention-deficit/ hyperactivity disorder | 16.1 | 16.2 | 0.5%                      | 18.4                                 | 18.8 | 2.5% | 90.3                       | (54-6-144.2)                    | 119.4 | 114.1% |                             |                                  |      |      |                             |                                  |
| Conduct disorder | 92.9 | 94.0 | 1.2%                      | 126.7                                 | 129.1 | 1.9% | 622.7                       | (379-7-996.6)                    | 1324.7 | 112.7% |                             |                                  |      |      |                             |                                  |
| Idiopathic developmental intellectual disability | 32.8 | 22.9 | -30.1%                      | 37.8                                 | 26.2 | -30.7% | 185.7                       | (66-1-345.2)                    | 268.9 | 44.8% |                             |                                  |      |      |                             |                                  |
| Other mental disorders | 126.5 | 126.9 | 0.3%                      | 97.2                                 | 102.9 | 5.8% | 477.7                       | (315-5-661.0)                    | 1056.0 | 121.1% |                             |                                  |      |      |                             |                                  |

(Continued from previous page)
| Substance use disorders | Age-standardised DALYs per 100 000 population 1990 | All-age DALYs per 100 000 population 1990 | Percentage change, 1990–2017 | All-age total DALYS (thousands) 1990 | Percentage change, 1990–2017 |
|--------------------------|-----------------------------------------------|------------------------------------------|---------------------------------|-----------------------------------------|-------------------------------|
| Alcohol use disorders    | 198 (325–499)                                 | 186 (34–354)                              | -5.7%                           | 141 (107–185)                           | 0.4%                          |
| Drug use disorders       | 217 (153–454)                                 | 202 (135–221)                             | -4.5%                           | 176 (128–219)                           | -2.1%                         |
| Diabetes and kidney      | 197 (1764–2127)                               | 184 (154–2181)                           | -4.5%                           | 1160 (1004–1218)                        | -12.3%                        |
| Diabetes mellitus        | 112 (988–1219)                                | 129 (1062–1458)                          | 10.7%                           | 574 (499–668)                           | 8.4%                          |
| Chronic kidney disease   | 83 (764–999)                                  | 62 (584–638)                              | -24.5%                          | 57 (13–419)                             | -32.0%                        |
| Acute glomerulonephritis | 8 (4–12)                                     | 3.2 (1–4)                                | -62.1%                          | 9.7 (3–15)                              | -69.2%                        |
| Skin and subcutaneous    | 612 (417–901)                                 | 607 (416–885)                             | -0.7%                           | 658 (441–966)                           | -4.2%                         |
| Dermatitis               | 166 (94–267)                                  | 164 (92–264)                              | -1.3%                           | 200 (110–327)                           | -3.5%                         |
| Psoriasis                | 46 (33–61)                                    | 49.4 (34–69)                              | 5.7%                            | 36 (25–47)                              | 7.9%                          |
| Bacterial skin diseases  | 58 (39–94)                                    | 63 (46–105)                               | 8.9%                            | 55 (33–93)                              | -7.4%                         |
| Scabies                  | 54 (30–187)                                   | 52 (28–84)                                | -3.4%                           | 60 (31–98)                               | -3.5%                         |
| Fungal skin diseases     | 99 (39–206)                                   | 83 (33–172)                               | -15.4%                          | 100 (39–210)                            | -29.2%                        |
| Viral skin diseases      | 49 (31–72)                                    | 49 (31–67)                                | 0.1%                            | 67 (43–100)                             | -3.3%                         |
| Acne vulgaris            | 17 (10–28)                                    | 23 (13–36)                                | 34.7%                           | 19.5 (11.5–31)                          | 28.9%                         |
| Alopecia areata          | 5 (3–7)                                      | 5 (3–7)                                   | 0.6%                            | 4.9 (3–7)                               | 4.5%                          |
| Pruritus                 | 9 (4–7)                                      | 9 (3–8)                                   | 2.0%                            | 7.3 (3–14)                              | 3.2%                          |
| Urticaria                | 65 (43–91)                                    | 65 (43–92)                                | 0.6%                            | 77 (50–110)                             | -2.2%                         |
| Decubitus ulcer          | 9 (6)                                        | 9 (6)                                     | -6.5%                           | 4.6 (3–6)                               | -10.4%                        |
| Other skin and subcutaneous diseases | 31 (15–65) | 32 (16–58)                              | 4.3%                            | 23 (11–44)                              | 3.8%                          |
| Blindness and vision impairment | 55 (385–292) | 52 (359–751)                              | -5.8%                           | 302 (204–444)                           | -5.2%                         |
| Age-related and other hearing loss | 50 (357–1690) | 45 (351–693)                              | -0.8%                           | 296 (208–412)                           | 0.2%                          |
| Other sense organ diseases | 29 (18–24) | 29 (17–27)                              | 2.8%                            | 18 (11–22)                              | 2.3%                          |
| Musculoskeletal disorders | 144 (1059–1907) | 147 (1094–1970)                           | 2.5%                            | 891 (658–1179)                          | 6.7%                          |
| Rheumatoid arthritis     | 46.1 (36–57)                                 | 37 (29–49)                                | -17.7%                          | 24 (19–31)                              | -19.1%                        |
| Osteoarthritis           | 78.5 (39–153)                                | 84.8 (42–172)                             | 8.1%                            | 35 (19–47)                              | 8.0%                          |
| Low back pain            | 846 (604–1128)                                | 878 (627–1275)                            | 3.8%                            | 543 (389–735)                           | 8.7%                          |

(Table continues on next page)
A microsimulation method was used to create hypothetical populations (by age, sex, year, and location) and adjust for the independent probability of experiencing more than one disease sequela. The difference in disability weights for individuals experiencing one sequela and the multiplicatively combined disability weight in those experiencing two or more sequelae was the comorbidity correction. The average comorbidity correction for each sequela was applied to the corresponding location-specific, age-specific, sex-specific, and year-specific YLD.

**SDI**

The SDI is a composite measure of development made up of the geometric mean of three common indicators:
income per capita, average years of schooling among people aged 15 years or older, and the total fertility rate. The SDI metric was scaled to values ranging from 0 to 1, where 0 indicates the lowest income, lowest level of schooling, and highest fertility rate. Spline regressions were used to estimate the relationships between burden measures (DALYs, YLLs, and YLDs) and SDI and to estimate the expected values at each level of SDI.

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

Results
Between 1990 and 2017, the total number of DALYs due to NCDs for all ages increased rapidly in sub-Saharan Africa, from around 90·6 million (95% UI 81·0–101·9) to 151·3 million (133·4–171·8), representing a 67·0% increase (figure 1, table). Of the total burden of disease across sub-Saharan Africa from 1990 (486·0 million [469·6–503·3] DALYs) to 2017 (507·6 million [477·7–543·7] DALYs), the proportion of NCDs increased from 18·6% (95% UI 17·1–20·4) to 29·8% (27·6–32·0). Meanwhile, communicable, maternal, neonatal, and nutritional (CMNN) diseases declined, particularly from 2005 onwards, despite a notable increase in the burden of HIV/AIDS between 1995 and 2005 (figure 1). The growth in population size was the key driver of NCD burden over this period and, accounting for changes in population age-structure, the age-standardised DALY rate due to NCDs (21775·7 DALYs per 100 000 population [95% UI 19377·1–24380·7]) is now almost equivalent to that for CMNN diseases (26491·6 DALYs per 100 000 population [25165·2–28129·8]; figure 1).

Apart from the group categorised as other NCDs, which includes congenital anomalies and accounted for around 28·8 million (25·1–33·0) DALYs (19·1% of the total NCD burden), cardiovascular diseases were the leading level 2 causes of NCD burden across sub-Saharan Africa in 2017, contributing more than 22·9 million (95% UI 21·5–24·3) DALYs, or 15·1% of the total NCD burden (table). The next most prominent level 2 causes were neoplasms (contributing 16·9 million [15·7–18·3] DALYs, 11·2%) and mental disorders (13·6 million [9·9–17·7] DALYs, 9·0%). Although uncertainties around these estimates were large, total DALYs due to mental disorders increased by 113·9% between 1990 and 2017, while DALYs associated with neoplasms increased by 79·5%. Within neoplasms, all-age and age-standardised DALY rates per 100 000 population declined across sub-Saharan Africa between 1990 and 2017; however, rates of several cancers (including pancreatic, prostate, and breast) increased (table).

Diabetes also contributes a large disease burden. Total DALYs due to diabetes increased by 126·4% between 1990 and 2017—the tenth largest change observed across all level 3 causes of NCD burden. Diabetes in sub-Saharan Africa has not only increased in terms of total DALYs, but also in terms of crude and age-standardised DALY rates, as well as YLL and YLD rates (appendix p 19).

Although the total number of DALYs due to NCDs has been increasing rapidly in sub-Saharan Africa, crude DALY rates due to NCDs overall declined by 20·50% during the 1990–2017 period, from 18 442·4 DALYs (16 489·4–20 742·2) to 14 746·3 DALYs (12 998·6–16 739·2).
per 100,000 population. The increase in total DALYs due to NCDs can be largely explained by the population growth over this period and, to a lesser extent, by population ageing (appendix p 27). Only in southern sub-Saharan Africa were changes substantially explained by an ageing population. Notably, several countries in this region, including Zimbabwe and Lesotho, have seen rapid increases in NCD burden in terms of both absolute DALYs and DALY rates, in contrast to other countries in sub-Saharan Africa, where age-standardised DALY rates have decreased (appendix p 28).

Compared with global estimates, age-standardised DALY rates by sex in each sub-Saharan African region show that sub-Saharan Africa had a high burden of NCDs overall in 2017 (figure 2). Males and females in all regions of sub-Saharan Africa had higher DALY rates for NCDs collectively compared with the global averages for both sexes. This excess burden can in part be attributed to the higher age-standardised DALY rates for cardiovascular diseases among females and diabetes and kidney diseases among males. Diabetes and kidney diseases are especially burdensome in southern sub-Saharan Africa, where the crude DALY rate (1927.2 DALYs [1693.8–2191.9] per 100,000 population) is more than double that found in other regions of sub-Saharan Africa (1233.3 [1047.6–1432.8] in central, 887.4 [771.0–1016.7] in western, and 915.2 [811.3–1029.2] in eastern sub-Saharan Africa). Ischaemic heart disease was the leading cause of cardiovascular disease burden among males (4857.246.3 DALYs [4417.087.3–5429.459.4]), whereas cerebrovascular disease was most prominent among females (4034.703.6 DALYs [3699.338.3–4378.417.9]).

Age-specific DALYs for NCDs by sex in 2017 show a large NCD burden throughout the life course in males and females (figure 3). The leading causes of NCD burden in children under 5 years of age were those in the other NCDs category, including congenital anomalies (9856.63 DALYs [8721.99–11841.03] per 100,000 population) and sickle cell disorders (769.37 DALYs per 100,000 [432.88–1076.41]), while mental disorders constituted a large burden among people aged 14–39 years. The total burden of cardiovascular disease was similar between males and females.

In 2017, all-age DALY rates (per 100,000 population) varied across sub-Saharan Africa (figure 4), ranging from about 12,000 DALYs (in Ethiopia) to almost 22,000 DALYs (in Central African Republic).

The ratio of observed to expected disease burden (based on SDI) of NCDs by country in 2017 is shown in figure 4. The countries with the lowest ratios (ie, those with a lower NCD burden than would be expected on the basis of SDI) were Ethiopia, Niger, Nigeria, Uganda, and Equatorial Guinea. By contrast, age-standardised DALY rates due to NCDs in several other countries, such as Lesotho, Swaziland, Congo (Brazzaville), and Central African Republic, exceeded what would be expected of countries with a similar SDI.

Discussion
This study comprehensively describes the burden of disease caused by NCDs in sub-Saharan Africa and allows a direct comparison of NCDs over time and across countries and populations for the first time. NCDs impose a formidable burden in sub-Saharan Africa and,
although this increasing burden is largely due to a growing population, age-standardised DALY rates are also rapidly increasing in some countries, and YLDs are on the rise across this super-region. Furthermore, the burden of NCDs in all four sub-Saharan African regions is higher than the global average, and is now almost equivalent to the total burden associated with CMNN diseases. Thus, NCDs can no longer be neglected in sub-Saharan Africa and must be prioritised on health and development agendas. Our findings also show that a large amount of the NCD burden in sub-Saharan Africa is caused by five groups of diseases: cardiovascular diseases; mental disorders; neoplasms; diabetes; and urogenital, blood, and endocrine diseases.

There is a growing concern that cardiovascular disease burden, driven by increasing risk factors such as smoking and unhealthy diets, is likely to increase and pose challenges on health systems in sub-Saharan Africa. The epidemiology of cardiovascular disease in these regions is unique. Historically, the burden of cardiovascular disease due to rheumatic disease arising from infectious origins has been large, while other forms of cardiovascular disease were thought to be relatively rare. Our current findings, however, indicate that strokes are a leading cause of cardiovascular disease burden, particularly among women, and this is consistent with the current literature. These high rates of stroke are typically explained by high rates of hypertension and a lack of effective treatment and control in sub-Saharan Africa, as well as low awareness among the population of the disease and its risk factors. Furthermore, a 2018 systematic review revealed that the prevalence of dyslipidaemia (a leading contributor to cardiovascular disease) is high in Africa, affecting at least one in five adults in the region.

Increasing mortality and morbidity rates from diabetes have also been reported previously. Late diagnosis and poor blood-glucose control exacerbate the impact of diabetes on the sub-Saharan African population and often lead to related complications. Chronic kidney disease burden (which is driven by both NCD risk factors and communicable diseases) is also likely to be high in southern sub-Saharan Africa, but efforts to understand the epidemiology of chronic kidney disease in Africa have been hampered by data quality issues. The key messages of the Lancet Diabetes & Endocrinology Commission on Diabetes in sub-Saharan Africa are that the true burden of diabetes in sub-Saharan Africa is unknown and that more evidence on how to effectively use limited resources to screen and manage diabetes is desperately needed.

Given the large treatment gaps for serious mental health conditions, such as schizophrenia, and emerging substance use epidemics, mental health and substance use disorders are predicted to lead to 45 million YLDs by the year 2050 in sub-Saharan Africa. Calls to integrate evidence-based mental health services into primary health-care services, as well as early interventions in the life course for mental and substance use disorders, warrant further attention. Exploring upstream prevention and health promotion strategies that address some of the social and economic risk factors—including violence, poverty, forced migration and income inequality—will be necessary to tackle this burden effectively.

Our findings point to a large NCD burden during infancy and childhood due to congenital anomalies and sickle cell disorders. An estimated 50–80% of children born with sickle cell disorder die before 5 years of age, and those who survive are at heightened risk of infections and life-threatening anaemia, but are also susceptible to comorbidity with stroke, kidney disease, hypertension, and chronic lung disease.

NCD burden varies across sub-Saharan African regions and age groups. Our findings show a clear urgent need to prepare health services in southern sub-Saharan Africa, which has the highest rates of diabetes, cardiovascular disease, and substance use disorders within sub-Saharan Africa. Countries in southern sub-Saharan Africa, except Namibia, have the highest rates of NCDs across the entire super-region, and these rates are rising. These countries also have higher DALYs than would be expected on the basis of their SDI. The excess NCD burden observed in southern sub-Saharan Africa is likely to be associated with the rate of urbanisation and the unhealthy lifestyles associated with poverty and inequality in the area.

NCDs in sub-Saharan Africa must be considered in regard to the epidemiological contexts of each country. First, in many sub-Saharan African countries, as CMNN diseases decrease and access to treatments such as antiretroviral therapy increases, life expectancy in sub-Saharan Africa is expected to continue rising and, therefore, the burden of NCDs is also likely to increase. Second, comorbidity is likely to be an important aspect of NCD epidemiology in sub-Saharan Africa. For example, antiretroviral therapy might be linked to increased cardiovascular risk, diabetes is associated with increased risk of tuberculosis and pneumonia, and more than a third of cancer cases in Africa are associated with infectious conditions. Some of the decline in cancer burden could therefore be attributed to the decrease in infectious disease epidemics.

The GBD 2017 study has some key limitations, which have been described in detail elsewhere. High-quality data for causes of death remains absent across many countries in sub-Saharan Africa, and caution is needed with use of epidemiological models and the interpretation of results presented here. Furthermore, in some countries in the region, the data that are available pose substantial challenges for cause-of-death analysis. For example, the analysis of all-cause mortality in countries without vital registration systems depends on the validity of sibling history data for measuring adult mortality. Although sibling history data have been shown to be...
unbiased when compared with vital registration data, such comparisons are not available for sub-Saharan Africa, where sibling history data are of key importance. Without sufficient local evidence, another uncertainty arises from the reliance on evidence from high-income countries on the distribution of disease severity. These patterns could potentially reflect the effects of health care, or lack thereof. Based on an assessment of the quality of global vital registration data, only three countries in all of sub-Saharan Africa achieved a score of more than one out of five possible stars, and vital registration and verbal autopsy data were not available for 17 countries in sub-Saharan Africa.1 Where data are available, there is substantial risk of over-interpreting verbal autopsy data, which are subject to limitations; for example, misclassification across broad categories of cause of death by verbal autopsy might be likely for causes such as cardiovascular diseases.

Large uncertainties surround the estimates of disease burden in sub-Saharan Africa, and varying data availability between countries can make comparisons difficult to interpret. Additionally, not all sources of uncertainty could be routinely captured in either the epidemiological or cause-of-death modelling processes. However, despite these limitations, this study provides the most comprehensive perspective on the burden of disease in sub-Saharan Africa to date.

NCDs are costly to health systems. The large burden of disability and the premature mortality caused by NCDs in the most productive ages of a person’s life means that individuals, families, and communities suffer.46 Many countries in sub-Saharan Africa need to invest in prevention and treatment to sustain development despite the costs of NCDs. There is growing evidence of the efficacy and cost-efficiency of integrated chronic-disease management models based on person-centred care. The rapid expansion of HIV services in sub-Saharan African countries provides learning experiences and potential models for a range of NCDs,47 which could be modified for the planning and development of effective and cost-efficient NCD services. However, countries across sub-Saharan Africa vary widely in terms of social and economic development and have had a range of historical trajectories, each with their own specific health challenges and outcomes.9 Recent advocacy efforts push for people-centred health systems that can foster home-grown initiatives to address country-specific needs.9 NCDs continue to be severely underfunded relative to other health priorities in Africa.9 To ensure cost-effective approaches, therefore, better understanding of the patterns of NCD burden is essential. Efforts to support the strengthening of NCD surveillance and routine data collection must be bolstered.

Contributors
HNG, FC, KS, and AJF drafted the manuscript. SA, AJF, HE, DS, JL, HNG, FC, and KS provided the analysis and helped in the interpretation of results. CI, LNA, BMM, APK, MH, TA, CSW, DJS, and HW contributed to reviewing and finalising the manuscript. DJS and HW conceptualised the study. All authors (with the exception of BMM, who died during the preparation of the paper) approved the final version of the manuscript.

Declaration of interests
We declare no competing interests.

Acknowledgments
This study was funded by the Bill & Melinda Gates Foundation. FC, AJF, and HE were supported by Early Career Fellowships from the National Health and Medical Research Council of Australia.

References
1. GBD 2017 Causes of Death Collaborators. Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980–2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 2018; 392: 1736–88.
2. Dalal S, Beunza J, Volmink J, et al. Non-communicable diseases in sub-Saharan Africa: what we know now. Int J Epidemiol 2011; 40: 885–901.
3. Hall V, Thomsen R, Henriksen O, Lohse N. Diabetes in Sub-Saharan Africa 1999–2011: epidemiology and public health implications. A systematic review. BMC Public Health 2011; 11: 564.
4. NCD Risk Factor Collaboration (NCD-RisC)–Africa Working Group. Trends in obesity and diabetes across Africa from 1980 to 2014: an analysis of pooled population-based studies. Int J Epidemiol 2017; 46: 1421–32.
5. Meghji J, Nadeau G, Davis KJ, et al. Noncommunicable lung disease in sub-Saharan Africa. A community-based cross-sectional study of adults in urban Malawi. Am J Resp Crit Care Med 2016; 194: 67–76.
6. Stanifer J, Jing B, Tolan S, et al. The epidemiology of chronic kidney disease in sub-Saharan Africa: a systematic review and meta-analysis. Lancer Glob Health 2016; 2: e774–81.
7. Mensah GA, Roth GA, Sampson UK, et al. Mortality from cardiovascular diseases in sub-Saharan Africa, 1990–2013: a systematic analysis of data from the Global Burden of Disease Study 2013. Cardiovasc J Afr 2015; 26: 56–10.
8. Moran A, Forouzanfar M, Sampson U, Chugh S, Feigin V, Mensah G. The epidemiology of cardiovascular diseases in sub-Saharan Africa: the Global Burden of Diseases, Injuries and Risk Factors 2010 Study. Prog Cardiovasc Dis 2013; 56: 234–39.
9. Parkin DM, Bray F, Ferlay J, Jemal A. Cancer in Africa 2012. Cancer Epidemiol Biomarkers Prev 2014; 23: 953–66.
10. Murray CJ, Barber RM, Foreman KJ, et al. Global, regional, and national disability-adjusted life years (DALYs) for 336 diseases and injuries and healthy life expectancy (HALE) for 188 countries, 1990–2013: quantifying the epidemiological transition. Lancet 2015; 386: 2145–91.
11. Stein DJ, Seedat S, Herman A, et al. Lifetime prevalence of psychiatric disorders in South Africa. Br J Psychiatry 2008; 192: 112–17.
12. WHO. Report on the status of major health risk factors for noncommunicable diseases: WHO Africa Region, 2015. World Health Organization, 2015. https://www.afro.who.int/publications/report-status-major-health-risk-factors-noncommunicable-diseases-who-african-region (accessed 14 March 2016).
13. UN. Sustainable Development Goal 3. Sustainable Development Goals Knowledge Platform. https://sustainabledevelopment.un.org/sdg3 (accessed Feb 7, 2019).
14. Izutsu T, Truitsumi A, Minas H, Thoricroft G, Patel V, Ito A. Mental health and wellbeing in the Sustainable Development Goals. Lancet Psychiatry 2015; 2: 1052–54.
15. Nyaaba GN, Stronsk K, de-Graft Aikins A, Kengne AP, Agemang C. Tracing Africa’s progress towards implementing the Non-Communicable Diseases Global action plan 2013–2020: a synthesis of WHO country profile reports. BMC Public Health 2017; 17: 297.
16. Peck R, Mghamba J, Vanobberghen F, et al. Preparedness of Tanzanian health facilities for outpatient primary care of hypertension and diabetes: a cross-sectional survey. Lancet Glob Health 2014; 2: e285–92.
17. Saraceno B, van Ommeren M, Batuji R, et al. Barriers to improvement of mental health services in low-income and middle-income countries. Lancet 2007; 370: 1164–74.
18 Beran D, Yudkin JS. Diabetes care in sub-Saharan Africa. *Lancet* 2006; 368: 1689–95.

19 Schwartz J, Gwatuudde D, Nugent R, Mondro C. Looking at non-communicable diseases in Uganda through a local lens: an analysis using locally derived data. *Global Health* 2014; 10: 77.

20 GBD 2017 DALYs and HALE Collaborators. Global, regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet* 2018; 392: 1859–922.

21 GBD 2017 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet* 2018; 392: 1789–838.

22 Burstein R, Fleming T, Haagsma J, Salomon JA, Vos T, Murray CJ. Estimating distributions of health state severity for the global burden of disease study. *Popul Health Metr* 2015; 13: 11.

23 Salomon JA, Haagsma JA, Davis A, et al. Disability weights for the Global Burden of Disease 2013 study. *Lancet Glob Health* 2015; 3: e712–23.

24 Keates AK, Mecumbi AO, Ntsekhe M, Siwa K, Stewart S. Cardiovascular disease in Africa: epidemiological profile and challenges. *Nat Rev Cardiol* 2017; 14: 273–93.

25 Siddharthan T, Ramaiya K, Yonga G, et al. Noncommunicable diseases in East Africa: assessing the gaps in care and identifying opportunities for improvement. *Health Aff (Millwood)* 2015; 34: 1506–13.

26 Connor MD, Walker R, Modi G, Warlow CP. Burden of stroke in black populations in sub-Saharan Africa. *Lancet Neurol* 2007; 6: 269–78.

27 Dzudie A, Kengne AP, Muna WF, et al. Prevalence, awareness, treatment and control of hypertension in a self-selected sub-Saharan African urban population: a cross-sectional study. *BMJ Open* 2012; 2: e001217.

28 Noubiap JJ, Bigna JJ, Nansseu JR, et al. Prevalence of dyslipidaemia among adults in Africa: a systematic review and meta-analysis. *Lancet Glob Health* 2018; 6: e998–1007.

29 Pillay-van Wyk V, Meembru W, Laubscher R, et al. Mortality trends and differentials in South Africa from 1997 to 2012: second National Burden of Disease Study. *Lancet Glob Health* 2016; 4: e642–53.

30 Atun R, Davies J, Gale E, et al. Diabetes in sub-Saharan Africa: from clinical care to health policy. *Lancet Diabetes Endocrinol* 2017; 5: 622–67.

31 Charlton FJ, Diminic S, Lund C, Degenhardt L, Whiteford HA. Mental and substance use disorders in sub-Saharan Africa: predictions of epidemiological changes and mental health workforce requirements for the next 40 years. *PLoS One* 2014; 9: e10208.

32 Lund C, Tomlinson M, Patel V. Integration of mental health into primary care in low- and middle-income countries: the PRIME mental healthcare plans. *Br J Psychiatry* 2016; 208 (suppl 56): s1–3.

33 WHO, Calouste Gulbenkian Foundation. Social determinants of mental health. Geneva: World Health Organization, 2014. https://apps.who.int/iris/bitstream/handle/10665/112828/9789241506809_eng.pdf;jsessionid=CGG03B5F832A8A19EB20562C7488B12F?sequence=1 (accessed Feb 7, 2019).

34 Aygun B, Odame I. A global perspective on sickle cell disease. *Palliat Blood Cancer* 2012; 59: 386–90.

35 Hall V, Thomsen RW, Henriksen O, Lehne N. Diabetes in Sub-Saharan Africa 1999–2011: epidemiology and public health implications. A systematic review. *BMC Public Health* 2011; 11: 564.

36 Zungu NP, Mabaso ML, Kumalo F, et al. Prevalence of non-communicable diseases (NCDs) and associated factors among HIV positive educators: findings from the 2015/6 survey of health of educators in public schools in South Africa. *PLoS One* 2019; 14: e0209736.

37 Oni T, youngblood E, Boulle A, McGrath N, Wilkinson RJ, Levitt NS. Patterns of HIV, TB, and non-communicable disease multi-morbidity in peri-urban South Africa—a cross sectional study. *BMC Infect Dis* 2015; 15: 20.

38 Levitt NS, Steyn K, Dave J, Bradshaw D. Chronic noncommunicable diseases and HIV-AIDS on a collision course: relevance for health care delivery, particularly in low-resource settings—insights from South Africa. *Am J Clin Nutr* 2011; 94: 1690S–965.

39 Young F, Critchley J, Johnstone I, Urwin N. A review of co-morbidity between infectious and chronic disease in sub-Saharan Africa: TB and non-communicable diseases and impact of globalization. *Global Health* 2009; 5: 9.

40 Baker JV, Lundgren JD. Cardiovascular implications from untreated human immunodeficiency virus infection. *Eur Heart J* 2011; 32: 945–51.

41 Wang H, Naghavi M, Allen C, et al. Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016; 388: 1545–544.

42 Kengne AP, June-Rose McHiza Z, Amonah AG, Mbuya JC. Cardiovascular diseases and diabetes as economic and developmental challenges in Africa. *Prog Cardiovasc Dis* 2013; 56: 302–13.

43 Schwartz J, Dunkle A, Akinteg AR, et al. Towards reframing health service delivery in Uganda: the Uganda Initiative for Integrated Management of Non-Communicable Diseases. *Glob Health Action* 2015; 8: 26537.

44 Leung C, Aris E, Mhala A, et al. Preparedness of HIV care and treatment clinics for the management of comorbid non-communicable diseases: a cross-sectional survey. *BMC Public Health* 2016; 16: 1002.

45 Kuze Defo B. Demographic, epidemiological and health transitions: are they relevant to population health patterns in Africa? *Glob Health Action* 2014; 7: 22443.

46 Agyepon IA, Sewankambo N, Binagwaho A, et al. The path to longer and healthier lives for all Africans by 2030: the Lancet Commission on the future of health in sub-Saharan Africa. *Lancet* 2018; 390: 2803–59.

47 Lemoine M, Girard PM, Thursz M, Raber J, Verger I, Yon AP, et al. Noncommunicable diseases and HIV-AIDS on a collision course: relevance for health care delivery, particularly in low-resource settings—insights from South Africa. *Am J Clin Nutr* 2011; 94: 1690S–965.