	Exposure definition	Outcomes	Subgroup	Main data sources for exposure	Exposure estimation method	Theoretical-minimum-risk exposure distribution	Source of relative risks
(Continued from previous page)							
6. Alcohol and drug use							
6.1. Alcohol use	Average consumption of pure alcohol (measure in g/day) and proportion of the population reporting binge consumption of 0·06 kg or more of pure alcohol on a single occasion	Tuberculosis; lower respiratory infections; oesophageal cancer; the aggregate of mouth cancer, nasopharynx cancer, cancer of other part of pharynx and oropharynx; liver cancer; larynx cancer; breast cancer; colon and rectum cancers; diabetes mellitus; IHD; ischaemic stroke; haemorrhagic and other non-ischaemic stroke; HHD; atrial fibrillation and flutter; cirrhosis of the liver; pancreatitis; epilepsy; transport injuries; the aggregate of falls, drowning, fire, heat, and hot substances, poisonings, exposure to mechanical forces, intentional self-harm, and interpersonal violence; alcohol use disorders	All ages for alcohol use disorders, transport injuries, and interpersonal violence; ≥15 years for all others	Population surveys, alcohol sales, production, and other economic statistics	Mixed effect regression[45]	No alcohol consumption	Published studies[46–59]
6.2. Drug use	Proportion of the population reporting use of cannabis, opioids, and amphetamines, proportion of the population reporting use of injecting drugs	Drug use disorders; schizophrenia; HIV/AIDS; the aggregate of acute hepatitis B, liver cancer secondary to hepatitis B, and cirrhosis of the liver secondary to hepatitis B; the aggregate of acute hepatitis C, liver cancer secondary to hepatitis C, and cirrhosis of the liver secondary to hepatitis C; intentional self-harm	All ages	Population surveys, registries, and indirect measures	DisMod 3	No use of cannabis, opioid, or amphetamines, no use of injecting drugs	New meta-analyses, published studies[60,61]
7. Physiological risk factors							
7.1. High fasting plasma glucose	Fasting plasma glucose, measured in mmol/L	Diabetes mellitus; IHD; cerebrovascular disease; CKD; tuberculosis	Age ≥25 years	Examination surveys and epidemiological studies	Bayesian hierarchical regression[62]	Mean 4·9–5·3 mmol/L (SD 0·3 mmol/L)	Meta-regression of pooled prospective studies[63–66]
7.2. High total cholesterol	Total cholesterol, measured in mmol/L	IHD; ischaemic stroke	Age ≥25 years	Examination surveys and epidemiological studies	Bayesian hierarchical regression[67]	Mean 3·8–4·0 mmol/L (SD 0·9 mmol/L)	Meta-regression of pooled prospective studies[68,69]
7.3. High blood pressure	Systolic blood pressure, measured in mm Hg	RHD; IHD; ischaemic stroke, haemorrhagic and other non-ischaemic stroke; HHD; the aggregate of cardiomyopathy and myocarditis and endocarditis; the aggregate of atrial fibrillation and flutter, PVD, and other CVD; aortic aneurysm; CKD	Age ≥25 years	Examination surveys and epidemiological studies	Bayesian hierarchical regression[70]	Mean 110–115 mm Hg (SD 6 mm Hg)	Meta-regression of pooled prospective studies[71–73]
7.4. High body-mass index	Body-mass index, measured in kg/m²	Oesophageal cancer; gallbladder and biliary tract cancer; pancreatic cancer; kidney and other urinary organ cancers; breast cancer; uterine cancer; colon and rectum cancers; diabetes mellitus; IHD; ischaemic stroke; HHD; the aggregate of cardiomyopathy and myocarditis and endocarditis; the aggregate of atrial fibrillation and flutter, PVD, and other CVD; CKD; osteoarthritis; low back pain	Age ≥25 years	Examination surveys and epidemiological studies	Bayesian hierarchical regression[74]	Mean 21·0–23·0 kg/m² (SD 1 kg/m²)	Meta-regression of pooled prospective studies[75–78]

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	Exposure definition	Outcomes	Subgroup	Main data sources for exposure	Exposure estimation method	Theoretical-minimum-risk exposure distribution	Source of relative risks
(Continued from previous page)							
7.5. Low bone mineral density	Standardised bone mineral density measured at the femoral neck	Hip fracture falls; non-hip fracture falls	Age ≥50 years	Examination surveys and epidemiological studies	DisMod 3	90th percentile of NHANES-III cohort[79] by age	Johnell and colleagues[80]
8. Dietery risk factors and physical inactivity							
8.1. Diet low in fruits	Dietary intake of fruits (fresh, frozen, cooked, canned, or dried but excluding fruit juices and salted or pickled fruits)	The aggregate of oesophageal cancer, mouth cancer, the aggregate of nasopharynx cancer, cancer of other part of pharynx and oropharynx, and larynx cancer; trachea, bronchus, and lung cancers; IHD; ischaemic stroke; haemorrhagic and other non-ischaemic stroke	Age ≥25 years	Nutrition and health surveys	DisMod 3	Mean 300 g/day (SD 30 g/day)	New meta-analysis, published studies[81,82]
8.2. Diet low in vegetables	Dietary intake of vegetables (fresh, frozen, cooked, canned, or dried vegetables including legumes but excluding salted or pickled, juices, nuts and seeds, and starchy vegetables such as potatoes or corn)	The aggregate of mouth cancer, nasopharynx cancer, cancer of other part of pharynx and oropharynx, and larynx cancer; IHD; ischaemic stroke; haemorrhagic and other non-ischaemic stroke	Age ≥25 years	Nutrition and health surveys	DisMod 3	Mean 400 g/day (SD 30 g/day)	New meta-analysis, He and colleagues[81]
8.3. Diet low in whole grains	Dietary intake of whole grains (bran, germ, and endosperm in their natural proportions) from breakfast cereals, bread, rice, pasta, biscuits, muffins, tortillas, pancakes, and others	Diabetes mellitus; IHD; cerebrovascular disease	Age ≥25 year	Nutrition and health surveys	DisMod 3	Mean 125 g/day (SD 12·5 g/day)	Mellen and colleagues,[83] de Munter and colleagues[84]
8.4. Diet low in nuts and seeds	Dietary intake of nut and seed foods including, for example, peanut butter	IHD	Age ≥25 years	Nutrition and health surveys	DisMod 3	Mean 114 g per week (SD 11·4 g per week)	Kelly and colleagues[85]
8.5. Diet low in milk	Dietary intake of milk including non-fat, low-fat, and full-fat milk but excluding soya milk and other plant derivatives	Colon and rectum cancers	Age ≥25 years	Nutrition and health surveys	DisMod 3	Mean 450 g/day (SD 45 g/day)	World Cancer Research Fund and American Institute for Cancer Research[82]
8.6. Diet high in red meat	Dietary intake of red meat (beef, pork, lamb, and goat but excluding poultry, fish, eggs, and all processed meats)	Colon and rectum cancers; diabetes mellitus	Age ≥25 years	Nutrition and health surveys	DisMod 3	Mean 100 g per week (SD 10 g per week)	World Cancer Research Fund and American Institute for Cancer Research,[82] published studies[86,87]
8.7. Diet high in processed meat	Dietary intake of meat preserved by smoking, curing, salting, or addition of chemical preservatives, including bacon, salami, sausages, or deli or luncheon meats like ham, turkey, and pastrami	Colon and rectum cancers; diabetes mellitus; IHD	Age ≥25 years	Nutrition and health surveys	DisMod 3	No dietary intake of processed meat	World Cancer Research Fund and American Institute for Cancer Research,[82] Micha and colleagues[87]
8.8. Diet high in sugar-sweetened beverages	Dietary intake of beverages with ≥50 kcal per 226·8 g serving, including carbonated beverages, sodas, energy drinks, fruit drinks but excluding 100% fruit and vegetable juices	Diabetes mellitus and body-mass index with subsequent effects on: oesophageal cancer; gallbladder and biliary tract cancer; pancreatic cancer; kidney and other urinary organ cancers; breast cancer; uterine cancer; colon and rectum cancers; diabetes mellitus; IHD; ischaemic stroke; HHD; the aggregate of cardiomyopathy and myocarditis and endocarditis; the aggregate of atrial fibrillation and flutter, PVD, and other CVD; CKD; osteoarthritis; low back pain	Age ≥25 years	Nutrition and health surveys	DisMod 3	No dietary intake of sugar-sweetened beverages	New meta-analysis

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	Exposure definition	Outcomes	Subgroup	Main data sources for exposure	Exposure estimation method	Theoretical-minimum-risk exposure distribution	Source of relative risks
(Continued from previous page)							
8.9. Diet low in fibre	Dietary intake of fibre from all sources including fruits, vegetables, grains, legumes, and pulses	Colon and rectum cancers; IHD	Age ≥25 years	Nutrition and health surveys	DisMod 3	Mean of 30 g/day (SD 3 g/day)	World Cancer Research Fund and American Institute for Cancer Research,[82] Pereira and colleagues[88]
8.10. Diet low in calcium	Dietary intake of calcium from all sources, including milk, yogurt, and cheese	Colon and rectum cancers; prostate cancer	Age ≥25 years	Nutrition and health surveys	DisMod 3	Mean of 1200 mg/day (SD 120 mg/day)	World Cancer Research Fund and American Institute for Cancer Research,[82] Cho and colleagues[89]
8.11. Diet low in seafood omega-3 fatty acids	Dietary intake of eicosapentaenoic acid and docosahexaenoic acid, measured in mg/day	Death caused by IHD	Age ≥25 years	Nutrition and health surveys	DisMod 3	250 mg/day	Updated published review of Mozaffarian and colleagues[90]
8.12. Diet low in polyunsaturated fatty acids	Dietary intake of omega-6 fatty acids from all sources, mainly liquid vegetable oils, including soybean oil, corn oil, and safflower oil	IHD	Age ≥25 years	Nutrition and health surveys	DisMod 3	Substitution of present saturated fatty acid intake up to a mean intake of polyunsaturated fatty acids of 12% of energy (SD 1·2%)	Jakobsen and colleagues,[91] Mozaffarian and colleagues[92]
8.13. Diet high in trans fatty acids	Dietary intake of trans fat from all sources, mainly partially hydrogenated vegetable oils and ruminant products	IHD	Age ≥25 years	Nutrition and health surveys	DisMod 3	Mean of 0·5% of energy (SD 0·05%)	Mozaffarian and colleagues[93]
8.14. Diet high in sodium	24 h urinary sodium, measured in mg/day	Stomach cancer; systolic blood pressure which has effects on: RHD; IHD; ischaemic stroke, haemorrhagic and other non-ischaemic stroke; HHD; the aggregate of cardiomyopathy and myocarditis and endocarditis; the aggregate of atrial fibrillation and flutter, PVD, and other CVD; aortic aneurysm; CKD	Age ≥25 years	Nutrition and health surveys	DisMod 3	Mean of 1000 mg/day (SD 100 mg/day)	Re-analysis of observational studies for stomach cancer and randomised studies for blood pressure lowering[82,94]
8.15. Physical inactivity and low physical activity*	Proportion of the population in categories of physical activity: level 0, <600 MET-minutes per week (inactive); level 1, 600–3999 MET-minutes per week (low-active); level 2, 4000–7999 MET-minutes per week (moderately active); and level 3, ≥8000 MET-minutes per week (highly active)	Breast cancer; colon and rectum cancers; diabetes mellitus; IHD; ischaemic stroke	Age ≥25 years	Population surveys	DisMod 3	All individuals are highly active (level 3)	Danaei and colleagues[11]
9. Occupational risk factors							
9.1. Occupational carcinogens							
9.1.1. Occupational exposure to asbestos	Cumulative exposure to asbestos using mesothelioma in a smoking impact ratio analogue	Ovarian cancer; other neoplasms; larynx cancer; trachea, bronchus, and lung cancers	Age ≥15 years	Vital registration mortality data, asbestos production, import, and export statistics	Spatiotemporal Gaussian process regression[19–21]	No exposure to asbestos	Published studies[95–98]

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	Exposure definition	Outcomes	Subgroup	Main data sources for exposure	Exposure estimation method	Theoretical-minimum-risk exposure distribution	Source of relative risks
(Continued from previous page)							
9.1.2. Occupational exposure to arsenic	Proportion of population ever exposed (by taking into account worker turnover)[99,100] based on distribution of the population in nine industries†	Trachea, bronchus, and lung cancers	Age ≥15 years	Labour force surveys, censuses, and International Information System on Occupational Exposure to Carcinogens	Spatiotemporal Gaussian process regression[19–21]	No occupational exposure to carcinogens	Lee-Feldstein[101]
9.1.3. Occupational exposure to benzene	Proportion of population ever exposed (by taking into account worker turnover)[99,100] based on distribution of the population in nine industries†	Leukaemia	Age ≥15 years	Labour force surveys, censuses, and International Information System on Occupational Exposure to Carcinogens	Spatiotemporal Gaussian process regression[19–21]	No occupational exposure to carcinogens	Khalade and colleagues[102]
9.1.4. Occupational exposure to beryllium	Proportion of population ever exposed (by taking into account worker turnover)[99,100] based on distribution of the population in nine industries†	Trachea, bronchus, and lung cancers	Age ≥15 years	Labour force surveys, censuses, and International Information System on Occupational Exposure to Carcinogens	Spatiotemporal Gaussian process regression[19–21]	No occupational exposure to carcinogens	Schubauer-Berigan and colleagues[103]
9.1.5. Occupational exposure to cadmium	Proportion of population ever exposed (by taking into account worker turnover)[99,100] based on distribution of the population in nine industries†	Trachea, bronchus, and lung cancers	Age ≥15 years	Labour force surveys, censuses, and International Information System on Occupational Exposure to Carcinogens	Spatiotemporal Gaussian process regression[19–21]	No occupational exposure to carcinogens	Hutchings and colleagues[95]
9.1.6. Occupational exposure to chromium	Proportion of population ever exposed (by taking into account worker turnover)[99,100] based on distribution of the population in nine industries†	Trachea, bronchus, and lung cancers	Age ≥15 years	Labour force surveys, censuses, and International Information System on Occupational Exposure to Carcinogens	Spatiotemporal Gaussian process regression[19–21]	No occupational exposure to carcinogens	Rosenman and colleagues[104]
9.1.7 Occupational exposure to diesel engine exhaust	Proportion of population ever exposed (by taking into account worker turnover)[99,100] based on distribution of the population in nine industries†	Trachea, bronchus and lung cancers	Age ≥15 years	Labour force surveys, censuses, and International Information System on Occupational Exposure to Carcinogens	Spatiotemporal Gaussian process regression[19–21]	No occupational exposure to carcinogens	Lipsett and colleagues[105]
9.1.8. Occupational exposure to second-hand smoke	Proportion of population ever exposed (by taking into account worker turnover)[99,100] based on distribution of the population in nine industries†	Trachea, bronchus, and lung cancers	Age ≥15 years	Labour force surveys, censuses, and International Information System on Occupational Exposure to Carcinogens	Spatiotemporal Gaussian process regression[19–21]	No occupational exposure to carcinogens	Stayner and colleagues[106]
9.1.9. Occupational exposure to formaldehyde	Proportion of population ever exposed (by taking into account worker turnover)[99,100] based on distribution of the population in nine industries†	Leukaemia; nasopharynx cancer	Age ≥15 years	Labour force surveys, censuses, and International Information System on Occupational Exposure to Carcinogens	Spatiotemporal Gaussian process regression[19–21]	No occupational exposure to carcinogens	Collins and colleagues,[107] Hauptmann and colleagues[108]
9.1.10. Occupational exposure to nickel	Proportion of population ever exposed (by taking into account worker turnover)[99,100] based on distribution of the population in nine industries†	Trachea, bronchus, and lung cancers	Age ≥15 years	Labour force surveys, censuses, and International Information System on Occupational Exposure to Carcinogens	Spatiotemporal Gaussian process regression[19–21]	No occupational exposure to carcinogens	Grimsrud and colleagues[109,110]
9.1.11. Occupational exposure to polycyclic aromatic hydrocarbons	Proportion of population ever exposed (by taking into account worker turnover)[99,100] based on distribution of the population in nine industries†	Trachea, bronchus, and lung cancers	Age ≥15 years	Labour force surveys, censuses, and International Information System on Occupational Exposure to Carcinogens	Spatiotemporal Gaussian process regression[19–21]	No occupational exposure to carcinogens	Armstrong and colleagues[111]
9.1.12. Occupational exposure to silica	Proportion of population ever exposed (by taking into account worker turnover)[99,100] based on distribution of the population in nine industries†	Trachea, bronchus, and lung cancers	Age ≥15 years	Labour force surveys, censuses, and International Information System on Occupational Exposure to Carcinogens	Spatiotemporal Gaussian process regression[19–21]	No occupational exposure to carcinogens	Kurihara and colleagues[112]
9.1.13. Occupational exposure to sulphuric acid	Proportion of population ever exposed (by taking into account worker turnover)[99,100] based on distribution of the population in nine industries†	Larynx cancer	Age ≥15 years	Labour force surveys, censuses, and International Information System on Occupational Exposure to Carcinogens	Spatiotemporal Gaussian process regression[19–21]	No occupational exposure to carcinogens	Soskolne and colleagues[113]

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	Exposure definition	Outcomes	Subgroup	Main data sources for exposure	Exposure estimation method	Theoretical-minimum-risk exposure distribution	Source of relative risks
(Continued from previous page)							
9.2. Occupational asthmagens	Proportion of population exposed based on distribution of the population in eight occupational groups (professional, technical, and related workers; administrative and managerial workers; clerical and related workers; sales workers; service workers; agriculture, animal husbandry, and forestry workers, fishermen and hunters; production and related workers; and transport equipment operators and labourers)	Asthma	Age ≥15 years	Labour force surveys and censuses	Spatiotemporal Gaussian process regression[19–21]	Background asthmagen exposures	Published studies[114–116]
9.3. Occupational particulate matter, gases, and fumes	Proportion of population exposed based on distribution of the population in nine industries†	COPD	Age ≥15 years	Labour force surveys and censuses	Spatiotemporal Gaussian process regression[19–21]	No occupational exposure to particulates, gases, or fumes	New meta-analysis
9.4. Occupational noise	Proportion of population exposed based on distribution of the population in nine industries†	Hearing loss	Age ≥15 years	Labour force surveys and censuses	Spatiotemporal Gaussian process regression[19–21]	Background noise exposure	New meta-analysis
9.5. Occupational risk factors for injuries	Fatal occupational injury	..	Age ≥15 years	International Labour Organization injury database	Spatiotemporal Gaussian process regression[19–21]	Five injury deaths per 1 000 000 person-years	..
9.6. Occupational low back pain	Proportion of population exposed based on distribution of the population in eight occupational groups (professional, technical, and related workers; administrative and managerial workers; clerical and related workers; sales workers; service workers; agriculture, animal husbandry, and forestry workers, fishermen and hunters; production and related workers; and transport equipment operators and labourers)	Low back pain	Age ≥15 years	Labour force surveys and censuses	Spatiotemporal Gaussian process regression[19–21]	All individuals have the ergonomic factors of clerical and related workers	New meta-analysis
10. Sexual abuse and violence							
10.1. Childhood sexual abuse*	Proportion of the population who have ever experienced childhood sexual abuse, defined as the experience with an older person of unwanted non-contact, contact abuse, or intercourse, when aged 15 years or younger	Alcohol use disorders, unipolar depressive disorders, intentional self-harm	All ages	Population surveys and epidemiological studies	DisMod 3	No childhood sexual abuse	New meta-analysis
10.2. Intimate partner violence*	Proportion of the population who have ever experienced one or more acts of physical or sexual violence by a present or former partner since age 15 years	Abortion, unipolar depressive disorders, intentional self-harm, interpersonal violence	Age 15–49 years for abortion, ≥15 years for all others	Population surveys and epidemiological studies	DisMod 3	No intimate partner violence	New meta-analysis, Beydoun and colleagues[117]

IHD=ischaemic heart disease. COPD=chronic obstructive pulmonary disease. CVD=cardiovascular and circulatory diseases. RHD=rheumatic heart disease. PVD=peripheral vascular disease. CKD=chronic kidney disease. HHD=hypertensive heart disease *Not assessed for 1990 because of absence of exposure data. †Agriculture, hunting, forestry, and fishing; mining and quarrying; wholesale and retail trade and restaurants and hotels; manufacturing; electricity, gas, and water; transport, storage, and communication; construction; financing, insurance, real estate, and business services; and community, social, and personal services.

Table 1: **Risk factors included, exposure variables, theoretical-minimum-risk exposure distributions, and outcomes affected**

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diameter ($PM_{2\cdot5}$) in ambient air: TM5 estimates—based on a nested three-dimensional global atmospheric chemistry transport model—which simulates both particulate matter and ozone at a high spatial resolution;[22,23,121] and satellite-based estimates, which are based on satellite observations of aerosol optical depth, a measure of light extinction by aerosols in the total atmospheric column.[25] TM5 and satellite-based estimates of $PM_{2\cdot5}$, measured in μg/m³, were averaged at a 0·1°×0·1° grid cell resolution (equivalent to roughly 11 km×11 km at the equator) and linked to available measures of $PM_{2\cdot5}$ from ground-based monitors. We used a regression model with the average of TM5 and satellite-based estimates as the predictor to estimate ground-based $PM_{2\cdot5}$ for all grid cells.[26] For ozone, we relied solely on the TM5 model.

Few population-based surveys have measured zinc deficiency based on serum zinc concentration;[122] however, intervention trials show a benefit of zinc supplementation for reduction of diarrhoea and lower respiratory infections in populations that have high zinc deficiency.[10] Because of the paucity of data for serum zinc concentrations, we measured zinc deficiency at the population level on the basis of dietary sources of zinc, expanding on previous work of the International Zinc Nutrition Consultative Group.[123] This approach uses national food balance sheets produced by the UN Food and Agriculture Organization to estimate a country-specific mean fractional absorption of zinc. The estimated mean daily per person amount of absorbable zinc in the food supply was compared with the mean physiological requirements of the population to calculate the percentage of the population with inadequate zinc intake.

Panel: The World Cancer Research Fund grading system[118]

Convincing evidence

Evidence based on epidemiological studies showing consistent associations between exposure and disease, with little or no evidence to the contrary. The available evidence is based on a substantial number of studies including prospective observational studies and where relevant, randomised controlled trials of sufficient size, duration, and quality showing consistent effects. The association should be biologically plausible.

Probable evidence

Evidence based on epidemiological studies showing fairly consistent associations between exposure and disease, but for which there are perceived shortcomings in the available evidence or some evidence to the contrary, which precludes a more definite judgment. Shortcomings in the evidence may be any of the following: insufficient duration of trials (or studies); insufficient trials (or studies) available; inadequate sample sizes; or incomplete follow-up. Laboratory evidence is usually supportive. The association should be biologically plausible.

Possible evidence

Evidence based mainly on findings from case-control and cross-sectional studies. Insufficient randomised controlled trials, observational studies, or non-randomised controlled trials are available. Evidence based on non-epidemiological studies, such as clinical and laboratory investigations, is supportive. More trials are needed to support the tentative associations, which should be biologically plausible.

Insufficient evidence

Evidence based on findings of a few studies which are suggestive, but insufficient to establish an association between exposure and disease. Little or no evidence is available from randomised controlled trials. More well-designed research is needed to support the tentative associations.

Effects of risk factors on disease outcomes

Table 1 shows the sources of effect sizes per unit of exposure for each risk factor. Some effect sizes were based on meta-analyses of epidemiological studies. For several risk factors without recent systematic reviews or for which evidence had not recently been synthesised, new meta-analyses were done as part of GBD 2010. We used effect sizes that had been adjusted for measured confounders but not for factors along the causal pathway. For example, effect sizes for body-mass index were not adjusted for blood pressure. For some risk–outcome pairs, evidence is only available for the relative risk (RR) of morbidity or mortality. In these cases, we assumed that the reported RR would apply equally to morbidity or mortality, unless evidence suggested a differential effect. For example, studies of ambient particulate matter pollution suggest a smaller effect on incidence of cardiovascular and respiratory disease than on mortality;[124–126] the published work on consumption of seafood omega-3 fatty acids suggests an effect on ischaemic heart disease mortality but not on incidence of ischaemic heart disease.[90]

Evidence for the RR of diarrhoea from unimproved water and sanitation is complicated by the complexity of available epidemiological studies, since the comparison groups varied greatly between studies. The comparison group used varied widely. For example, some studies compare an improved water source (eg, piped water) with an unimproved water source (eg, river water); in other studies the comparison is between two different types of improved water source (eg, piped water *vs* a protected well). Furthermore, studies often examine a combination of water, sanitation, and hygiene interventions. Previous reviews have yielded conflicting results about the magnitude of the effect sizes.[127–131]

We re-examined the epidemiological evidence for the effects of water and sanitation by reviewing the relation between water, sanitation and hygiene, and diarrhoea, starting with previous reviews.[128–131] We did a meta-regression of 119 studies that was designed to adjust for intervention and baseline group characteristics. First, we compared indicator variables for each of the intervention components (improved sanitation, hygiene, point-of-use water treatment, source water treatment, and piped water) with a reference category (improved water source). Second, we also included indicator variables for the baseline characteristics—ie, whether the baseline was an unimproved or improved water source or sanitation—as covariates to account for the heterogeneous control groups. Our analysis showed a significant effect of both improved water and improved sanitation compared with unimproved water and sanitation; we did not note a significantly greater effect of piped water or point-of-use or source water treatment compared with improved water.

Particulate matter smaller than 2·5 μm is a common useful indicator of the risk associated with exposure to a mixture of pollutants from diverse sources and in different environments, including ambient particulate matter pollution from transportation, wind-blown dust, burning of biomass, and industrial sources; second-hand smoke; burning of biomass and coal for household energy; and active smoking.[132,133] However, existing studies cover only small concentration ranges—for example, ambient particulate matter pollution studies have been restricted to yearly average concentrations of particulate matter smaller than 2·5 μm of roughly 5 μg/m^3 to 30 μg/m^3[3,134–137] but much higher concentrations of ambient particulate matter have been recorded in polluted cities in Asia and elsewhere. The relation between concentration of small particulate matter and risk of disease is probably non-linear.[132,133]

To inform estimates of risk across the full range of concentrations, we used the approach of Pope and colleagues[132] and integrated epidemiological evidence for the hazardous effects of particulate matter at different concentrations from different sources and environments. Methods for estimation of the integrated exposure–response curves for each cause are described elsewhere.[138] Briefly, we compiled study-level estimates of the RR of mortality associated with any or all of ambient air pollution, second-hand smoke, household air pollution, and active smoking for the following outcomes: ischaemic heart disease, stroke, lung cancer, chronic obstructive pulmonary disease, and acute lower respiratory tract infection in children. We evaluated several non-linear functions with up to three parameters for fitting the integrated exposure–response relation and assessed them by calculation of the root mean squared error. An exponential decay with a power of concentration was the functional form that provided the best fit for all five outcomes. The integrated exposure–response curve was then used to generate effect sizes specific to the amount of ambient particulate matter smaller than 2·5 μm for each population. For ischaemic heart disease and stroke, evidence shows that household air pollution affects intermediate outcomes, such as blood pressure,[139] but not clinical events. For acute lower respiratory tract infection, the integrated exposure–response curve enabled us to extrapolate beyond the partial exposure–response measured in the RESPIRE trial.[140] For effects of household air pollution on chronic obstructive pulmonary disease and lung cancer we use the effect size based on new systematic reviews and meta-analyses.

Several dietary factors affect ischaemic heart disease and stroke, including consumption of fruits, vegetables, nuts and seeds, whole grains, processed meat, polyunsaturated fats, and seafood omega-3 fatty acids.[81,83,85,87,90–92,141,142] We updated earlier systematic reviews and meta-analyses for fruits, vegetables, and seafood omega-3 fatty acids, which included both observational and intervention studies if available. A systematic review[143] of randomised clinical trials of supplementation with seafood omega-3 fatty acids reported non-significant effects on several outcomes, and a significant effect for mortality from ischaemic heart disease—the primary outcome in GBD 2010. In view of this finding, we tested whether a significant difference exists between the randomised clinical trials of seafood omega-3 fatty acid supplementation and observational studies of seafood-omega 3 fatty acid intake. The effect of seafood omega-3 fatty acids tended to be lower in randomised controlled trials than in observational studies, however, this difference was not statistically significant (p=0·057). Therefore, we used the effect size based on the combination of randomised clinical trials and observational studies but also did a sensitivity analysis with the effect size based on randomised clinical trials.

Estimates of the RR associated with dietary risk factors are based largely on observational studies that control for age, sex, and other cardiovascular risk factors. However, some early observational studies do not fully control for other dietary components. Protective dietary risk factors such as consumption of fruits, vegetables, and whole grains, tend to be positively correlated with each other and negatively correlated with harmful dietary risk factors such as consumption of processed meat. Therefore, RRs estimated for single risk factors in observational studies could overestimate the protective or harmful effect of that risk factor. In effect, the partially adjusted RR will include some of the effects associated with other correlated diet components, particularly since the exposure measure for dietary risk factors is energy adjusted to a standard calorie intake.

To examine this issue, we did further empirical assessments using studies of dietary patterns and randomised controlled feeding studies. Studies of dietary patterns[144–148] have estimated the effects of beneficial diets (prudent or Mediterranean diets) and harmful diets (western diets); these studies capture the overall effects of differences in dietary components. For example, a prudent diet has lots of fruits, vegetables, fish, and whole grains. For each of the dietary pattern studies we computed the estimated RR for dietary pattern groups with the RRs from the meta-analyses of single dietary risk factors, the reported differences in dietary intake, and assuming a multiplicative relation between RRs for individual components. Results of this internal validation study show that overall, estimation of the effect of dietary pattern based on the RRs reported for single risk factors was much the same as the effect reported in the study; across four large cohort studies of seven dietary patterns the average ratio for the estimated RR reduction compared with the measured RR reduction was 0·98.

In addition to the dietary pattern studies, we also investigated the evidence for the effects of dietary risk factors from randomised controlled feeding studies, such as DASH[149] and OmniHeart,[150] which measured the effect of dietary changes on blood pressure and LDL cholesterol. We used meta-regression to estimate the pooled effect of

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fruits, vegetables, nuts and seeds, whole grains, fish, and dietary fibre on systolic blood pressure and LDL cholesterol, based on all randomised controlled feeding studies (six treatment groups from three studies for blood pressure and six treatment groups from two studies for cholesterol). When translated into an effect using the RRs of blood pressure and cholesterol for ischaemic heart disease, the average ratio of the estimated to measured RR reduction was 1·07 for all components and 0·85 when excluding fish, which has mechanisms additional to lowering blood pressure and cholesterol.[151] These two supplementary analyses suggest that the RRs estimated in the meta-analyses of single dietary risk factors are unlikely to be significantly biased because of residual confounding due to other diet components.

Pooled epidemiological studies of cardiovascular disease risks show that the RR decreases with age, and that the inverse age association is roughly log-linear. Based on a pooled analysis of several risk factors (high blood pressure, high fasting plasma glucose, high total cholesterol, and tobacco smoking), the age at which the RR reaches 1 is often between 100 and 120 years. We therefore estimated age-specific RRs for all cardiovascular risk factors by meta-regression of available data with logRR as the dependent variable and median age at event as the independent variable with an age intercept (RR=1) at age 110 years. Uncertainty in the RR was generated by simulation analyses.[152]

	Disability-adjusted life-years (%)
Physiological risk factors	
High blood pressure	53%
High total cholesterol	29%
High body-mass index	23%
High fasting plasma glucose	16%
Alcohol use	33%
Tobacco smoking, including second-hand smoke	31%
Dietary risk factors and physical inactivity	
Diet low in nuts and seeds	40%
Physical inactivity and low physical activity	31%
Diet low in fruits	30%
Diet low in seafood omega-3 fatty acids	22%
Diet low in whole grains	17%
Diet high in sodium	17%
Diet high in processed meat	13%
Diet low in vegetables	12%
Diet low in fibre	11%
Diet low in polyunsaturated fatty acids	9%
Diet high in trans fatty acids	9%
Diet high in sugar-sweetened beverages	2%
Air pollution	
Ambient particulate matter pollution	22%
Household air pollution from solid fuels	18%
Other environmental risks	
Lead exposure	4%

Table 2: **Proportion of ischaemic heart disease disability-adjusted life-years attributable to individual risk factors, worldwide, 2010**

The causal association between a risk factor and a disease outcome is often informed by a wider body of evidence than epidemiological studies of RRs for specific measures of exposure, especially when disease-specific and age-specific RRs are needed. For example, although smoking is an established cause of cardiovascular diseases, when cohorts are analysed in fine age groups, the 95% CI for the effect of smoking on stroke spans 1·0 in several age groups.[38] Similarly, randomised trials of zinc supplementation were designed to detect effects on total mortality.[36,153] Re-analysis of the same trials for disease-specific outcomes, which is necessary to extrapolate effects to populations with different causes of death, reduced their statistical power and gave 95% CIs that spanned 1·0. To use the broad evidence while accounting for the uncertainty of the subgroup RRs, we included in the uncertainty analysis all draws of the RR distribution, including those that show a protective effect as long as the overall relation for the risk factor across all ages is significant. In other cases, if there are different degrees of exposure for a risk factor, in some exposure categories the RR might not be significant. We have included draws from these posterior distributions if the mean values show a dose–response relation. To fairly represent the extent of our epidemiological knowledge, we have included in the uncertainty analysis draws from the posterior distribution for those exposure categories that show a protective effect.

Theoretical-minimum-risk exposure distributions for counterfactual comparison

In the comparative risk assessment framework, disease burden attributable to risk factors is calculated with reference to an alternative (counterfactual) distribution of exposure; in GBD 2010, we used an optimal exposure distribution (in terms of effect on population health), termed the theoretical-minimum-risk exposure distribution. For several risk factors, such as tobacco smoking, the choice of theoretical-minimum-risk exposure distribution is clear—ie, 100% of the population being lifelong non-smokers. However, for many of the other risk factors zero exposure is not possible (eg, blood pressure), or the lowest amount of exposure that is still beneficial is not yet established. In these cases the theoretical-minimum-risk exposure distribution was informed by two considerations: the availability of convincing evidence from epidemiological studies that support a continuous reduction in risk of disease to the chosen distribution; and a distribution that is theoretically possible at the population level (table 1).

For some risk factors, new evidence has resulted in a revision of the theoretical-minimum-risk exposure distribution compared to the previous comparative risk assessment. For example, the previous distribution for systolic blood pressure was a mean of 115 mm Hg (SD 6).[6] However, subsequent randomised trials[154] of blood pressure-lowering medication suggest that the benefits of lowering blood pressure could continue to 110 mm Hg or lower. On this basis, we changed the theoretical-minimum-risk exposure distribution to a mean of 110–115 mm Hg (SD 6). For other exposures, the distribution was increased because of data from new epidemiological studies[75]—eg, for mean body-mass index we used 21–23 kg/m², compared with 21 kg/m² used previously.

For ambient particulate matter pollution, we did a sensitivity analysis with an alternative theoretical-minimum-risk exposure distribution that included the effect of regional dust particulate matter. We did so because although particulate exposure from dust could theoretically be reduced, it would probably be prohibitively expensive and could only be done over a very long period. This factor is particularly relevant in areas with high amounts of dust—eg, deserts. Dusty grid cells were identified as those with an ambient air concentration of $PM_{2·5}$ of 36 μg/m³ or more and where the dust fraction from the TM5 chemical transport model was 50% or more.

Mortality and disease burden attributable to individual and clusters of risk factors

We calculated the burden attributable to risk factors with continuous exposure by comparing the present distribution of exposure to the theoretical-minimum-risk exposure distribution for each age group, sex, year (1990 and 2010), and cause according to the following formula:

$$PAF=\frac{\int_{x=0}^{m}RR(x)P1(x)dx-\int_{x=0}^{m}RR(x)P2(x)dx}{\int_{x=0}^{m}RR(x)P1(x)dx}$$

Where PAF is the population attributable fraction (burden attributable to risk factor), RR(x) is the RR at exposure level x, P1(x) is the (measured or estimated) population distribution of exposure, P2(x) is the counterfactual distribution of exposure (ie, the theoretical-minimum-risk exposure distribution), and m the maximum exposure level.[4]

Burden attributable to categorical exposures was calculated by comparing exposure categories to a reference category for each age, sex, year, and cause according to the following formula:

$$PAF=\frac{\sum_{i=1}^{n}P_i(RR_i-1)}{\sum_{i=1}^{n}P_i(RR_i-1)+1}$$

Where RR_i is the RR for exposure category i, P_i is the fraction of the population in exposure category i, and n is the number of exposure categories.[4]

We calculated the burden attributable to clusters of risk factors by computing the combined population attributable fraction for risk factors for each age, sex, year, and cause according to the following formula:

$$PAF=1-\prod_{r=1}^{R}(1-PAF_r)$$

Where r is each individual risk factor, and R is the number of risk factors. This approach assumes that risk factors are independent—ie, it does not account for mediation, exposure correlation, or effect size modification that might exist between risk factors in a cluster.[155]

To represent uncertainty in the estimates we used simulation analysis to take 1000 draws from the posterior distribution of exposure, RR, and each relevant outcome for each age, sex, country, year. We accounted for the correlation structure of uncertainty (ie, whether exposure in a country, age group, and sex is high or low might be related to whether it is high or low in other subgroups) by use of the same draw of exposure across different outcomes and the same draw of RR across country, age, and sex subgroups when the RR does not vary by country, age, or sex. We otherwise assumed that the uncertainties in exposure, RR, and underlying burden attributable to the outcome were independent.

We computed the mean deaths and DALYs attributable to each risk factor and risk factor cluster from the 1000 draws. The 95% uncertainty intervals (95% UI) were calculated as the 2·5th and 97·5th percentiles of the 1000 draws. We also computed the mean rank and 95% UI for the 43 risk factors included in the ranking list. The mean of the ranks for a risk factor was not necessarily equivalent to the rank of the mean deaths or mean DALYs attributable to the risk factor.

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Results

Quantification of risk factors in this analysis represents the effects of each individual risk factor, holding all other independent factors constant. The effects of multiple risk factors are not a simple addition of the individual effects and are often smaller than their sums,[156] especially for cardiovascular diseases, which are affected by several risk factors (eg, table 2). The sum of the individual effects of just the metabolic risk factors at the global level is 121% and the summation of all the risks is greater than 400%.

We estimated global attributable mortality and DALYs with uncertainty for 1990, and 2010, for each of the 67 risk factors and clusters of risk factors (table 3, 4). The appendix shows full results by region, year, age, and sex for attributable deaths and DALYs. Because of the interest in

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	Men		Women		Both sexes	
	1990	2010	1990	2010	1990	2010
Unimproved water and sanitation	365 244 (18 940–662 551)	171 097 (6841–326 262)	350 629 (17 531–638 433)	166 379 (6690–326 989)	715 873 (36 817–1 279 220)	337 476 (13 150–648 205)
Unimproved water source	147 857 (10 566–282 890)	59 463 (3880–120 264)	140 150 (10 042–271 546)	56 663 (3604–115 704)	288 007 (20 641–553 293)	116 126 (7518–233 136)
Unimproved sanitation	252 779 (8032–480 822)	123 255 (2924–242 588)	244 207 (7348–460 913)	120 851 (3104–242 452)	496 986 (15 380–927 845)	244 106 (6027–478 186)
Air pollution	..	..	..	..	..	..
Ambient particulate matter pollution	1 549 448 (1 345 894–1 752 880)	1 850 428 (1 614 010–2 082 474)	1 360 712 (1 166 992–1 559 747)	1 373 113 (1 187 639–1 563 793)	2 910 161 (2 546 184–3 286 508)	3 223 540 (2 828 854–3 619 148)
Household air pollution from solid fuels	2 309 166 (1 720 246–2 824 893)	1 900 443 (1 378 832–2 518 572)	2 270 549 (1 889 651–2 655 411)	1 645 956 (1 265 509–2 089 785)	4 579 715 (3 717 711–5 365 013)	3 546 399 (2 679 627–4 516 722)
Ambient ozone pollution	77 087 (25 256–134 021)	86 335 (30 551–153 776)	66 274 (22 424–116 663)	66 100 (21 362–115 225)	143 362 (47 539–251 885)	152 434 (52 272–267 431)
Other environmental risks	109 224 (91 805–131 511)	426 280 (341 744–541 465)	100 699 (82 720–119 745)	346 751 (281 555–413 370)	209 923 (177 673–243 565)	773 030 (640 893–929 935)
Residential radon	..	70 014 (9140–154 460)	..	28 978 (4098–64 387)	..	98 992 (13 133–215 237)
Lead exposure	109 224 (91 805–131 511)	356 266 (292 587–435 046)	100 699 (82 720–119 745)	317 772 (265 722–376 431)	209 923 (177 673–243 565)	674 038 (575 858–779 314)
Child and maternal undernutrition	1 805 224 (1 479 043–2 219 888)	739 863 (570 560–909 248)	1 668 365 (1 396 689–1 986 532)	698 442 (569 013–832 012)	3 473 589 (2 906 896–4 175 138)	1 438 305 (1 175 257–1 713 103)
Suboptimal breastfeeding	693 103 (427 028–972 440)	293 449 (175 623–429 772)	581 921 (370 598–814 551)	251 368 (155 884–359 651)	1 275 024 (802 142–1 772 745)	544 817 (338 453–775 077)
Non-exclusive breastfeeding	612 059 (354 236–875 230)	257 771 (143 116–382 459)	505 849 (302 585–720 858)	218 117 (126 383–319 470)	1 117 908 (663 274–1 576 633)	475 888 (272 493–684 422)
Discontinued breastfeeding	81 044 (8643–178 237)	35 678 (3475–79 940)	76 073 (7809–165 395)	33 251 (3091–73 804)	157 117 (16 188–341 702)	68 929 (6445–153 290)
Childhood underweight	1 198 178 (997 627–1 484 105)	458 639 (366 866–561 352)	1 065 774 (898 859–1 299 715)	401 478 (325 516–484 452)	2 263 952 (1 927 356–2 735 821)	860 117 (715 742–1 033 573)
Iron deficiency	39 409 (30 677–47 108)	32 287 (21 925–37 449)	128 675 (92 036–156 884)	87 321 (62 505–107 021)	168 084 (130 444–197 085)	119 608 (93 261–139 985)
Vitamin A deficiency	181 151 (85 775–341 439)	63 291 (32 070–104 030)	168 203 (80 696–298 163)	56 472 (28 192–91 464)	349 354 (170 504–632 149)	119 762 (61 723–191 846)
Zinc deficiency	143 518 (27 797–276 850)	52 390 (9382–105 728)	132 071 (23 716–253 841)	44 940 (7696–87 711)	275 590 (51 274–529 451)	97 330 (17 575–190 527)
Tobacco smoking (including second-hand smoke)	3 680 571 (3 213 427–4 229 530)	4 507 059 (3 757 779–5 092 460)	1 649 238 (1 380 504–2 144 408)	1 790 228 (1 278 666–2 094 260)	5 329 808 (4 778 526–6 049 296)	6 297 287 (5 395 769–7 006 942)
Tobacco smoking	3 332 192 (2 871 957–3 840 033)	4 251 424 (3 503 674–4 850 554)	1 244 106 (961 356–1 781 819)	1 443 924 (920 763–1 743 849)	4 576 298 (4 068 753–5 312 438)	5 695 349 (4 755 779–6 421 611)
Second-hand smoke	348 378 (273 555–425 310)	255 634 (191 587–314 541)	405 132 (310 224–500 100)	346 304 (252 702–439 439)	753 510 (585 131–912 313)	601 938 (447 705–745 328)
Alcohol and drug use	2 367 579 (2 201 233–2 555 818)	3 249 978 (3 004 655–3 488 393)	1 394 778 (1 245 021–1 545 612)	1 768 073 (1 588 197–1 935 072)	3 762 356 (3 508 021–4 030 022)	5 018 051 (4 680 954–5 321 362)
Alcohol use	2 325 747 (2 153 733–2 512 207)	3 140 109 (2 902 204–3 376 483)	1 374 578 (1 223 155–1 522 080)	1 720 059 (1 541 469–1 886 125)	3 700 324 (3 451 511–3 967 436)	4 860 168 (4 533 106–5 153 283)
Drug use	46 682 (33 063–78 398)	109 420 (82 297–152 421)	21 895 (15 984–31 023)	48 385 (36 780–64 303)	68 577 (50 706–102 395)	157 805 (124 639–209 873)
Physiological risk factors						
High fasting plasma glucose	1 051 401 (865 949–1 250 550)	1 749 058 (1 455 169–2 039 206)	1 052 773 (881 704–1 230 327)	1 607 214 (1 367 465–1 839 764)	2 104 174 (1 797 633–2 401 170)	3 356 271 (2 917 520–3 782 483)
High total cholesterol	936 749 (767 684–1 128 051)	961 614 (714 774–1 236 023)	1 009 172 (829 163–1 218 442)	1 057 196 (793 595–1 350 633)	1 945 920 (1 625 929–2 318 054)	2 018 811 (1 572 853–2 479 097)
High blood pressure	3 412 588 (3 089 548–3 769 223)	4 750 581 (4 272 529–5 273 576)	3 880 598 (3 559 634–4 250 099)	4 645 279 (4 198 029–5 092 003)	7 293 185 (6 701 203–7 859 894)	9 395 860 (8 579 630–10 147 805)
High body-mass index	887 047 (698 599–1 079 235)	1 632 766 (1 328 501–1 941 988)	1 076 502 (878 065–1 286 482)	1 738 466 (1 454 008–2 036 059)	1 963 549 (1 590 282–2 345 133)	3 371 232 (2 817 774–3 951 127)
Low bone mineral density	52 816 (43 822–69 605)	103 440 (67 743–124 596)	50 455 (40 408–62 110)	84 146 (57 863–102 441)	103 270 (90 672–124 230)	187 586 (140 636–219 906)

(Continues on next page)

	Men		Women		Both sexes	
	1990	2010	1990	2010	1990	2010
(Continued from previous page)						
Dietary risk factors and physical inactivity	4473276 (4110262–4852556)	6687621 (6172230–7206283)	4057558 (3704325–4431571)	5815748 (5380274–6261225)	8530835 (7907898–9150862)	12503370 (11710741–13324770)
Diet low in fruits	2013415 (1570347–2435112)	2837481 (2203651–3414649)	1653787 (1269335–2006693)	2064761 (1593495–2507876)	3667202 (2870267–4394152)	4902242 (3818356–5881561)
Diet low in vegetables	779747 (535472–1041517)	1017500 (687787–1378721)	674309 (441649–910150)	779754 (521285–1040304)	1454057 (978665–1924334)	1797254 (1205059–2394366)
Diet low in whole grains	649676 (503984–787057)	963640 (748116–1162721)	580600 (447140–706303)	762171 (592879–919709)	1230276 (958136–1489812)	1725812 (1342896–2067224)
Diet low in nuts and seeds	1041726 (667481–1349266)	1389433 (890869–1817734)	872483 (541757–1147258)	1082390 (663158–1441054)	1914209 (1216363–2487874)	2471823 (1559603–3226994)
Diet low in milk	34838 (10464–58211)	54093 (16106–91527)	33312 (9745–57799)	46858 (13085–80413)	68150 (20479–114435)	100951 (29728–171340)
Diet high in red meat	13888 (3859–23763)	21330 (6175–37340)	12551 (3425–22054)	16762 (4306–29007)	26439 (7374–45232)	38092 (10749–65727)
Diet high in processed meat	397198 (85536–688905)	473562 (103608–842923)	334476 (71692–584050)	367296 (83446–637120)	731675 (158044–1257423)	840857 (188952–1460279)
Diet high in sugar-sweetened beverages	100250 (69485–134139)	161042 (111700–219563)	83548 (53949–117567)	138480 (91257–203236)	183799 (127938–240028)	299521 (212310–403716)
Diet low in fibre	333603 (149007–521712)	441895 (201062–693234)	250541 (111867–394088)	300994 (134201–470634)	584144 (260065–914729)	742888 (334379–1166933)
Diet low in calcium	48975 (32814–66562)	76413 (51653–103188)	33330 (23008–43904)	49181 (34016–63592)	82305 (57324–108535)	125594 (88323–164800)
Diet low in seafood omega-3 fatty acids	576646 (418376–735746)	793650 (574241–1010930)	466440 (337205–601988)	596246 (437287–764762)	1043085 (757418–1327627)	1389896 (1010300–1781401)
Diet low in polyunsaturated fatty acids	248677 (117929–381787)	306296 (140873–473149)	199388 (95418–305733)	227307 (108675–350194)	448065 (213262–687396)	533603 (245096–820854)
Diet high in trans fatty acids	202725 (144395–260843)	293087 (209155–371284)	164736 (117395–211588)	222173 (160511–283740)	367461 (265936–467609)	515260 (371081–649451)
Diet high in sodium	1197713 (776962–1589448)	1732870 (1122107–2301781)	1047642 (666779–1397486)	1371438 (878780–1834541)	2245355 (1459900–2966107)	3104308 (2016734–4105019)
Physical inactivity and low physical activity	..	1547833 (1264464–1835192)	..	1636107 (1369722–1899182)	..	3183940 (2657204–3718963)
Occupational risk factors	694403 (541113–858435)	749857 (580954–941322)	116743 (74642–164679)	102250 (68744–140097)	811146 (623674–1010107)	852107 (659652–1062443)
Occupational carcinogens	55306 (37867–80887)	92154 (57261–127678)	16766 (11866–24842)	25943 (15498–37074)	72073 (50753–101233)	118097 (77249–160431)
Occupational exposure to asbestos	17024 (11044–26605)	26563 (14454–36593)	6033 (4012–9397)	7047 (3312–9681)	23057 (16939–33009)	33610 (20317–43647)
Occupational exposure to arsenic	1155 (446–2210)	1915 (717–3496)	463 (176–915)	747 (275–1402)	1618 (622–3039)	2662 (1011–4860)
Occupational exposure to benzene	993 (426–1757)	1542 (618–2706)	770 (292–1422)	1189 (434–2156)	1764 (741–3085)	2731 (1111–4811)
Occupational exposure to beryllium	61 (24–110)	114 (44–192)	26 (10–47)	49 (19–86)	87 (35–152)	163 (65–276)
Occupational exposure to cadmium	214 (97–370)	410 (179–670)	74 (33–130)	145 (62–245)	288 (131–494)	555 (249–901)
Occupational exposure to chromium	729 (431–1133)	1361 (720–2014)	293 (171–490)	570 (295–858)	1022 (618–1578)	1931 (1140–2799)
Occupational exposure to diesel engine exhaust	10979 (6241–17555)	18773 (9641–28714)	2060 (1180–3422)	3413 (1709–5262)	13040 (7494–20486)	22187 (12180–33213)
Occupational exposure to second-hand smoke	10171 (6878–15272)	17189 (10127–23037)	3854 (2637–6207)	7046 (3935–9630)	14025 (10058–19715)	24235 (16094–31803)
Occupational exposure to formaldehyde	299 (117–584)	486 (185–939)	179 (77–325)	245 (97–456)	478 (202–877)	731 (301–1361)
Occupational exposure to nickel	3578 (935–7585)	6443 (1616–13317)	1425 (369–3031)	2702 (743–5679)	5004 (1331–10489)	9145 (2449–18834)

(Continues on next page)

	Men		Women		Both sexes	
	1990	2010	1990	2010	1990	2010
(Continued from previous page)						
Occupational exposure to polycyclic aromatic hydrocarbons	1638 (772–2817)	3092 (1394–5028)	492 (230–864)	993 (441–1661)	2130 (1018–3613)	4086 (1909–6567)
Occupational exposure to silica	7870 (5154–11 902)	14 205 (8244–19 702)	1185 (797–1975)	2072 (1102–2948)	9056 (6140–13 213)	16 277 (9875–22 272)
Occupational exposure to sulphuric acid	1964 (531–4383)	2606 (718–5761)	193 (55–452)	239 (74–509)	2157 (626–4707)	2845 (833–6109)
Occupational asthmagens	31 666 (15 305–62 856)	25 364 (15 642–48 748)	10 485 (5116–19 129)	8352 (4854–13 425)	42 151 (24 425–76 872)	33 716 (22 844–58 659)
Occupational particulate matter, gases, and fumes	207 366 (92 516–320 244)	171 553 (79 656–270 369)	68 281 (29 408–112 504)	47 311 (20 330–77 499)	275 647 (121 774–429 427)	218 864 (100 403–344 633)
Occupational noise	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Occupational risk factors for injuries	400 064 (308 482–507 787)	460 785 (343 904–618 319)	21 211 (16 479–27 705)	20 644 (15 628–27 414)	421 275 (329 209–529 004)	481 429 (363 778–639 590)
Occupational low back pain	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Sexual abuse and violence	..	37 429 (21 366–56 607)	..	200 930 (113 070–292 802)	..	238 359 (143 200–325 690)
Childhood sexual abuse	..	37 429 (21 366–56 607)	..	27 009 (14 290–43 424)	..	64 438 (37 339–94 174)
Intimate partner violence	..	..	..	186 365 (92 028–280 059)	..	186 365 (92 028–280 059)

No data indicates that attributable deaths were not quantified.

Table 3: **Deaths attributable to risk factors and risk factor clusters, worldwide**

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the combined effects of multiple risk factors, we have approximated the joint effects of clusters of risk factors assuming that risk factors included in each cluster are independent. However, risk factors included in a cluster are not necessarily independent; for example, a substantial part of the burden attributable to high body-mass index is mediated through high blood pressure and high fasting plasma glucose. Others act together and risk factor exposures might be correlated at the individual level,[155] especially household air pollution and ambient particulate matter pollution, which might have common sources.

For these reasons we have not computed the joint effects for physiological risk factors or air pollution. However, the combined effects of physiological risk factors are probably large, with high blood pressure the leading single risk factor globally, accounting for 9·4 million (95% UI 8·6 million to 10·1 million) deaths and 7·0% (6·2–7·7) of global DALYs in 2010, followed by high body-mass index (3·4 million [2·8 million to 4·0 million deaths] and 3·8% [3·1–4·4] of global DALYs in 2010), high fasting plasma glucose (3·4 million [2·9 million to 3·7 million] deaths and 3·6% [3·1–4·0] of DALYs), high total cholesterol (2·0 million [1·6 million to 2·5 million] deaths and 1·6% [1·3–2·0] of DALYs), and low bone mineral density (0·2 million [0·1 million to 0·2 million] deaths and 0·21% [0·17–0·25] of DALYs).

The joint effects of air pollution are also likely to be large. Household air pollution from solid fuels accounted for 3·5 million (2·7 million to 4·4 million) deaths and 4·5% (3·4–5·3) of global DALYs in 2010 and ambient particulate matter pollution accounted for 3·1 million (2·7 million to 3·5 million) deaths and 3·1% (2·7–3·4) of global DALYs. For ambient particulate matter pollution, we also did a post-hoc sensitivity analysis excluding the effects of dust, which had a small effect worldwide—attributable global DALYs decreased by 2%—but large effects in north Africa and Middle East. Household air pollution is an important contributor to ambient particulate matter pollution; we estimate that it accounted for 16% of the worldwide burden from ambient particulate matter pollution in 2010. The effects of ambient ozone pollution, which increases the risk of chronic obstructive pulmonary disease, were smaller than those of household air pollution from solid fuels or ambient particulate matter pollution (0·2 million [0·1 million to 0·3 million] deaths and 0·1% [0·03–0·2] of global DALYs in 2010).

For other clusters of risk factors for which we approximated the joint effects assuming independence, dietary risk factors and physical inactivity were responsible for the largest disease burden: 10·0% (9·2–10·8) of global DALYs in 2010. Of the individual dietary risk factors, the largest attributable burden in 2010 was associated with diets low in fruits (4·9 million [3·8 million to 5·9 million] deaths and 4·2% [3·3–5·0] of global DALYs), followed by diets high in sodium (4·0 million [3·4 million to 4·6 million]; 2·5% [1·7–3·3]), low in nuts and seeds (2·5 million [1·6 million to 3·2 million]; 2·1% [1·3–2·7]), low in whole grains (1·7 million [1·3 million to 2·1 million]; 1·6% [1·3–1·9]), low in vegetables (1·8 million [1·2 million to

	Men		Women		Both sexes	
	1990	2010	1990	2010	1990	2010
Unimproved water and sanitation	27 045 (1409–49 439)	11 022 (458–21 162)	25 123 (1262–45 792)	10 165 (428–19 650)	52 169 (2700–93 073)	21 187 (866–40 957)
Unimproved water source	11 075 (792–21 250)	4080 (266–8172)	10 097 (722–19 424)	3694 (242–7511)	21 172 (1517–40 491)	7775 (514–15 705)
Unimproved sanitation	18 610 (593–35 486)	7735 (190–15 338)	17 441 (522–32 889)	7192 (187–14 099)	36 050 (1115–66 871)	14 927 (377–29 705)
Air pollution	..	..	..	..	..	..
Ambient particulate matter pollution	46 667 (40 185–53 381)	46 732 (41 393–52 602)	35 032 (29 974–40 402)	29 431 (25 722–33 273)	81 699 (71 012–92 859)	76 163 (68 086–85 171)
Household air pollution from solid fuels	94 276 (73 721–113 071)	61 645 (45 944–77 497)	81 632 (66 415–96 472)	49 317 (38 818–60 315)	175 909 (141 870–207 095)	110 962 (86 848–137 813)
Ambient ozone pollution	1409 (460–2456)	1440 (506–2563)	1125 (375–1990)	1016 (331–1758)	2534 (851–4426)	2456 (837–4299)
Other environmental risks	2876 (2406–3459)	9434 (7476–12 045)	2489 (1974–3015)	6617 (5322–7938)	5365 (4534–6279)	16 051 (13 212–19 503)
Residential radon	..	1514 (191–3383)	..	600 (84–1355)	..	2114 (273–4660)
Lead exposure	2876 (2406–3459)	7920 (6491–9683)	2489 (1974–3015)	6017 (4915–7231)	5365 (4534–6279)	13 936 (11 750–16 327)
Child and maternal undernutrition	175 366 (146 049–211 406)	83 202 (67 963–99 704)	164 599 (139 926–192 077)	82 894 (69 171–98 757)	339 965 (289 845–402 489)	166 095 (139 685–193 981)
Suboptimal breastfeeding	59 902 (36 953–84 059)	25 572 (15 540–37 260)	50 359 (32 186–70 526)	21 965 (13 717–31 340)	110 261 (69 615–153 539)	47 537 (29 868–67 518)
Non-exclusive breastfeeding	52 729 (30 540–75 288)	22 258 (12 464–32 936)	43 601 (26 173–62 072)	18 850 (10 926–27 569)	96 330 (57 274–135 861)	41 108 (23 668–58 913)
Discontinued breastfeeding	7173 (767–15 819)	3314 (324–7377)	6758 (696–14 710)	3114 (296–6915)	13 931 (1443–30 062)	6429 (605–14 426)
Childhood underweight	104 713 (87 668–128 697)	41 270 (33 478–50 007)	93 028 (78 656–112 766)	36 045 (29 430–43 394)	197 741 (169 224–238 276)	77 316 (64 497–91 943)
Iron deficiency	21 451 (14 947–30 321)	19 974 (13 595–28 289)	30 390 (22 473–40 703)	28 251 (20 195–39 063)	51 841 (37 477–71 202)	48 225 (33 769–67 592)
Vitamin A deficiency	15 689 (7475–29 165)	5672 (2904–9348)	14 598 (7068–25 637)	5098 (2566–8168)	30 288 (14 884–54 488)	10 770 (5625–17 149)
Zinc deficiency	12 666 (2938–23 883)	4880 (1203–9316)	11 709 (2640–22 049)	4256 (1131–7821)	24 375 (5385–45 685)	9136 (2458–16 903)
Tobacco smoking (including second-hand smoke)	104 840 (91 849–119 255)	115 496 (98 595–130 090)	46 926 (39 634–58 092)	41 342 (30 473–48 563)	151 766 (136 367–169 522)	156 838 (136 543–173 057)
Tobacco smoking	84 956 (73 038–97 937)	105 635 (88 332–120 347)	28 784 (21 829–40 090)	31 272 (19 859–38 467)	113 740 (100 454–131 675)	136 907 (117 201–153 778)
Second-hand smoke	19 884 (14 493–25 591)	9861 (7669–12 312)	18 142 (13 748–22 355)	10 070 (7931–12 429)	38 026 (28 832–47 544)	19 931 (15 707–24 223)
Alcohol and drug use	88 000 (79 774–96 333)	119 130 (107 244–130 842)	33 648 (30 426–37 108)	42 178 (38 018–46 786)	121 648 (111 426–132 342)	161 308 (146 934–175 282)
Alcohol use	77 550 (70 706–84 835)	101 875 (92 405–111 165)	28 479 (25 762–31 372)	34 188 (30 882–37 479)	106 029 (98 299–114 763)	136 063 (125 361–146 788)
Drug use	10 178 (7787–13 073)	16 248 (12 679–20 132)	4993 (3811–6417)	7562 (5922–9471)	15 171 (11 714–19 369)	23 810 (18 780–29 246)
Physiological risk factors	..	..	..	..	..	..
High fasting plasma glucose	30 177 (25 148–34 980)	49 148 (41 619–57 197)	26 181 (22 243–30 349)	39 864 (34 103–45 972)	56 358 (48 720–65 030)	89 012 (77 743–101 390)
High total cholesterol	22 519 (18 230–27 029)	23 179 (17 148–29 650)	17 006 (13 940–20 640)	17 721 (13 153–22 508)	39 526 (32 704–47 202)	40 900 (31 662–50 484)
High blood pressure	73 120 (65 538–81 302)	99 566 (88 193–110 943)	63 897 (57 903–70 789)	73 991 (66 161–81 931)	137 017 (124 360–149 366)	173 556 (155 939–189 025)
High body-mass index	25 391 (19 752–31 108)	48 310 (39 429–57 750)	26 174 (20 911–31 642)	45 300 (37 218–54 219)	51 565 (40 786–62 557)	93 609 (77 107–110 600)
Low bone mineral density	1764 (1448–2208)	3105 (2295–3831)	1361 (1102–1686)	2111 (1627–2618)	3125 (2589–3811)	5216 (4133–6418)

(Continues on next page)

	Men		Women		Both sexes	
	1990	2010	1990	2010	1990	2010
(Continued from previous page)						
Dietary risk factors and physical inactivity	102 663 (94 539–111 011)	149 576 (138 035–160 263)	74 611 (68 196–81 173)	104 757 (97 047–112 535)	177 274 (164 710–190 286)	254 333 (237 748–270 495)
Diet low in fruits	47 979 (37 530–57 842)	65 523 (51 056–78 959)	32 474 (25 061–39 155)	38 573 (29 923–46 512)	80 453 (63 298–95 763)	104 095 (81 833–124 169)
Diet low in vegetables	18 755 (12 859–24 939)	24 169 (16 503–32 480)	12 803 (8412–17 503)	14 389 (9434–19 284)	31 558 (21 349–41 921)	38 559 (26 006–51 658)
Diet low in whole grains	17 033 (13 513–20 522)	24 881 (19 486–29 709)	12 370 (9625–14 895)	15 881 (12 615–18 949)	29 404 (23 097–35 134)	40 762 (32 112–48 486)
Diet low in nuts and seeds	24 918 (16 268–31 946)	32 615 (21 258–41 958)	15 607 (9915–20 208)	18 674 (11 716–24 404)	40 525 (26 308–51 741)	51 289 (33 482–65 959)
Diet low in milk	818 (248–1366)	1171 (350–1977)	710 (210–1210)	931 (264–1605)	1527 (461–2555)	2101 (619–3544)
Diet high in red meat	642 (306–1014)	1026 (484–1629)	566 (263–903)	827 (374–1362)	1208 (571–1909)	1853 (870–2946)
Diet high in processed meat	10 477 (2801–17 479)	12 901 (4012–21 421)	6882 (2340–11 119)	8038 (2932–12 685)	17 359 (5137–27 949)	20 939 (6982–33 468)
Diet high in sugar-sweetened beverages	3085 (2120–4151)	4858 (3154–6549)	2358 (1586–3484)	3695 (2356–5255)	5443 (3769–7373)	8553 (5823–11 418)
Diet low in fibre	8485 (3787–13 262)	10 893 (4903–17 191)	4862 (2188–7562)	5559 (2500–8639)	13 347 (5970–20 751)	16 452 (7401–25 783)
Diet low in calcium	1083 (752–1406)	1570 (1113–2058)	753 (521–975)	1019 (720–1319)	1836 (1316–2368)	2590 (1873–3322)
Diet low in seafood omega-3 fatty acids	13 620 (9915–17 307)	18 300 (13 267–23 201)	8120 (5900–10 388)	9899 (7241–12 596)	21 740 (15 869–27 537)	28 199 (20 624–35 974)
Diet low in polyunsaturated fatty acids	6185 (2891–9362)	7521 (3455–11 583)	3727 (1788–5709)	4159 (1973–6396)	9912 (4655–14 976)	11 680 (5360–17 798)
Diet high in trans fatty acids	4979 (3571–6413)	7339 (5240–9300)	3085 (2226–3944)	4253 (3106–5416)	8064 (5893–10 305)	11 592 (8395–14 623)
Diet high in sodium	26 807 (17 646–35 273)	37 378 (24 639–49 428)	19 376 (12 521–25 596)	23 852 (15 544–31 682)	46 183 (30 363–60 604)	61 231 (40 124–80 342)
Physical inactivity and low physical activity	..	37 007 (30 583–43 466)	..	32 311 (27 698–37 217)	..	69 318 (58 646–80 182)
Occupational risk factors	42 660 (35 146–50 545)	48 317 (38 407–58 677)	12 754 (9357–16 658)	14 171 (10 344–18 842)	55 414 (45 312–66 718)	62 488 (49 471–76 240)
Occupational carcinogens	1346 (917–1958)	2087 (1315–2928)	412 (284–611)	594 (368–855)	1758 (1220–2477)	2681 (1773–3689)
Occupational exposure to asbestos	362 (236–555)	521 (279–709)	122 (78–189)	132 (61–184)	484 (354–695)	653 (389–840)
Occupational exposure to arsenic	29 (11–56)	45 (17–84)	12 (5–24)	18 (7–33)	41 (16–77)	63 (24–114)
Occupational exposure to benzene	36 (15–64)	52 (21–92)	28 (11–52)	40 (15–72)	65 (27–112)	92 (39–163)
Occupational exposure to beryllium	2 (1–3)	3 (1–5)	1 (0–1)	1 (0–2)	2 (1–4)	4 (2–6)
Occupational exposure to cadmium	5 (2–9)	10 (4–16)	2 (1–3)	3 (1–6)	7 (3–12)	13 (6–21)
Occupational exposure to chromium	18 (11–28)	32 (17–48)	8 (4–13)	13 (7–21)	26 (16–40)	45 (27–66)
Occupational exposure to diesel engine exhaust	278 (158–436)	442 (232–682)	54 (31–88)	81 (42–126)	332 (192–517)	523 (292–789)
Occupational exposure to second-hand smoke	257 (173–383)	405 (244–544)	100 (69–162)	167 (95–228)	358 (255–500)	572 (386–762)
Occupational exposure to formaldehyde	11 (4–20)	17 (6–31)	7 (3–13)	9 (4–16)	18 (8–32)	25 (11–47)
Occupational exposure to nickel	90 (24–191)	151 (38–312)	37 (10–79)	64 (18–132)	128 (34–266)	215 (58–443)

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	Men		Women		Both sexes	
	1990	2010	1990	2010	1990	2010
(Continued from previous page)						
Occupational exposure to polycyclic aromatic hydrocarbons	41 (19–71)	73 (33–119)	13 (6–23)	23 (10–39)	54 (26–92)	96 (45–156)
Occupational exposure to silica	199 (129–297)	333 (199–463)	31 (21–52)	49 (26–71)	230 (154–328)	382 (239–526)
Occupational exposure to sulphuric acid	52 (14–114)	66 (19–143)	5 (1–12)	6 (2–13)	57 (16–122)	71 (21–152)
Occupational asthmagens	1467 (874–2439)	1359 (917–2153)	662 (366–1062)	661 (407–994)	2129 (1419–3222)	2020 (1441–2871)
Occupational particulate matter, gases, and fumes	6808 (3162–10 425)	6682 (3293–10 311)	2745 (1216–4406)	2460 (1105–4025)	9552 (4385–14 636)	9142 (4377–14 250)
Occupational noise	1936 (1149–3103)	2284 (1348–3649)	933 (550–1489)	1167 (696–1870)	2869 (1698–4582)	3451 (2072–5574)
Occupational risk factors for injuries	20 175 (15 588–25 639)	22 434 (16 711–29 943)	1090 (836–1437)	1010 (771–1331)	21 265 (16 644–26 702)	23 444 (17 736–30 904)
Occupational low back pain	10 929 (7340–15 116)	13 471 (8968–18 945)	6912 (4487–9835)	8279 (5502–11 602)	17 841 (11 846–24 945)	21 750 (14 492–30 533)
Sexual abuse and violence	..	3588 (2669–4679)	..	19 931 (14 524–26 397)	..	23 519 (17 961–30 322)
Childhood sexual abuse	..	3588 (2669–4679)	..	4244 (3082–5533)	..	7833 (5964–10 005)
Intimate partner violence	..	..	..	16 794 (11 373–23 087)	..	16 794 (11 373–23 087)

No data indicates that attributable disability-adjusted life-years were not quantified. Total disability-adjusted life-years (in 1000s) in 1990 were 1 360 569 for men, 1 142 032 for women, and 2 502 601 for both. In 2010, they were 1 370 177 for men, 1 120 208 for women, and 2 490 385 for both.

Table 4: **Disability-adjusted life-years (1000s) attributable to risk factors and risk factor clusters, worldwide**

2·3 million]; 1·5% [1·0–2·1]), and low in seafood omega-3 fatty acids (1·4 million [1·0 million to 1·8 million]; 1·1% [0·8–1·5]). Our sensitivity analysis of omega-3 fatty acids using relative risks from randomised trials reduced the attributable burden by more than half, to 0·6 million (–0·6 million to 1·7 million) deaths, and 0·5% (–0·5 to 1·4) of global DALYs in 2010. Physical inactivity and low physical activity accounted for 3·2 million (2·7 million to 3·7 million) deaths, and 2·8% (2·4–3·2) of DALYs in 2010.

Child and maternal undernutrition was responsible for the next largest attributable burden of the risk factor clusters (1·4 million [1·2 million to 1·7 million] deaths; 6·7% [5·7–7·7] of global DALYs in 2010), with childhood underweight the largest individual contributor (0·9 million [0·7 million to 1·0 million]; 3·1% [2·6–3·7]), followed by iron deficiency (0·1 million [0·09 million to 0·14 million]; 1·9% [1·4–2·6]), and suboptimal breastfeeding (0·5 million [0·3 million to 0·8 million]; 1·9% [1·2–2·7]). Vitamin A and zinc deficiencies amongst children accounted for less than 0·8% of the disease burden.

The burdens of disease attributable to tobacco smoking including second-hand smoke (6·3 million [5·4 million to 7·0 million] deaths and 6·3% [5·5–7·0] of DALYs) as well as alcohol and drug use (5·0 million [4·7 million to 5·3 million] deaths and 6·5% [6·0–7·0] of DALYs) were substantial in 2010. These burdens are mainly driven by active smoking, which accounts for 87% of the combined burden with second-hand smoke, and alcohol use which accounted for 4·9 million (4·5 million to 5·2 million) deaths and 5·5% (5·0–5·9) of global DALYs in 2010. Of the remaining risk factor clusters, occupational risk factors accounted for 0·9 million (0·7 million to 1·1 million) deaths and 2·5% (2·0–3·0) of global DALYs in 2010, followed by sexual abuse and violence (0·2 million [0·1 million to 0·3 million] deaths and 0·9% [0·7–1·2] DALYs), unimproved water and sanitation, (0·3 million [0 to 0·6 million] deaths and 0·9% [0·04–1·6] DALYs), and other environmental risks (0·7 million [0·6 million to 0·9 million] deaths and 0·6% [0·5–0·8] DALYs).

The rest of the results section refers to the 43 risk factors and clusters of risk factors in the rank list. The predominance of non-communicable disease risks in 2010 highlights the global epidemiological transition that has occurred since 1990 (figures 1, 2, 3). In 1990, the leading risks were childhood underweight (7·9% [6·8–9·4] of global DALYs), household air pollution from solid fuels (7·0% [5·6–8·3]), and tobacco smoking including second-hand smoke (6·1% [5·4-6·8]), high blood pressure (5·5% [4·9–6·0]), and suboptimal breastfeeding (4·4% [2·8–6·1]). With the exception of household air pollution, which is a significant contributor to childhood lower respiratory tract infections, the five leading risk factors in 2010 (high

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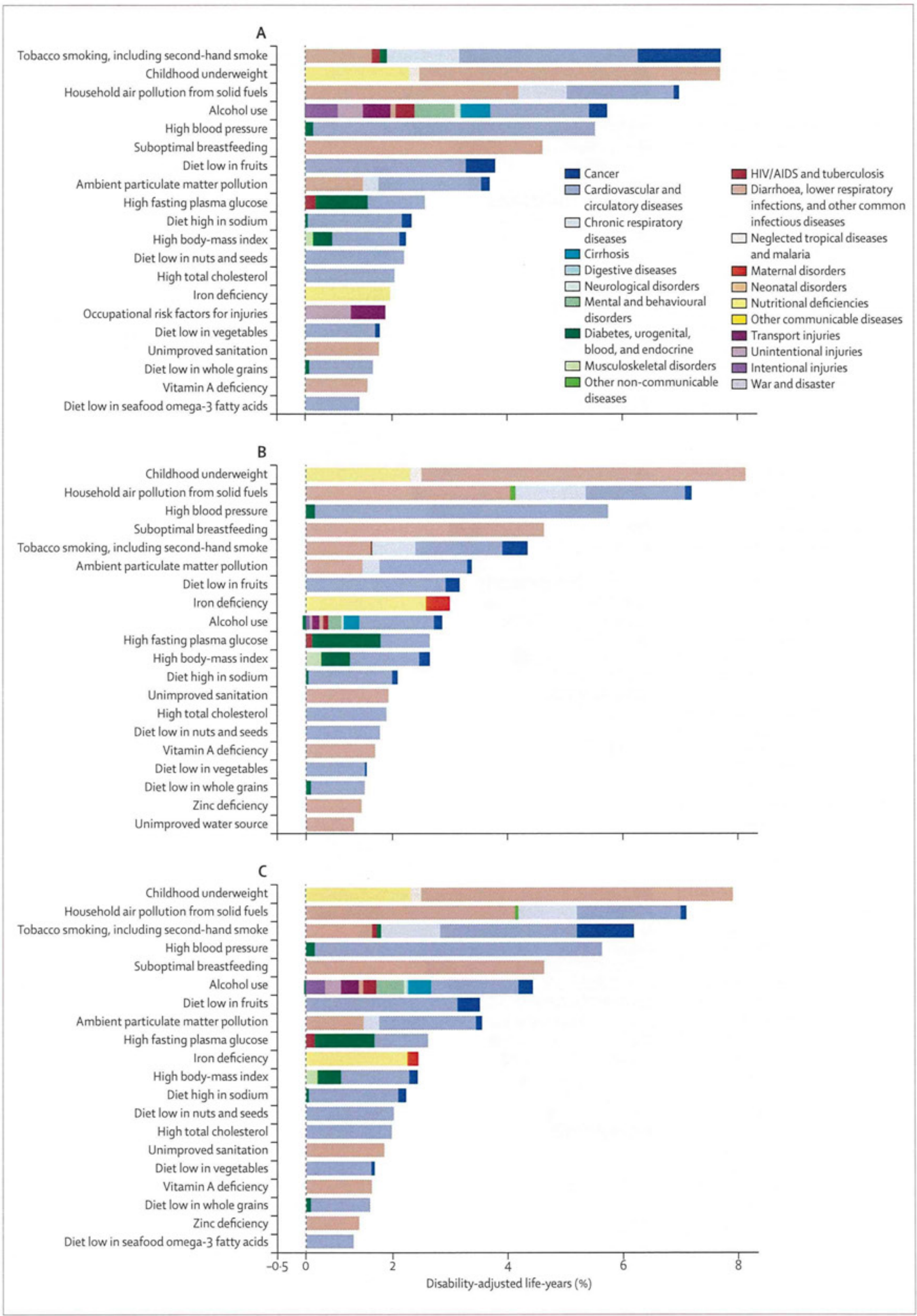

***Figure 1:* Burden of disease attributable to 20 leading risk factors in 1990, expressed as a percentage of global disability-adjusted life-years**

For men (A), women (B), and both sexes (C).

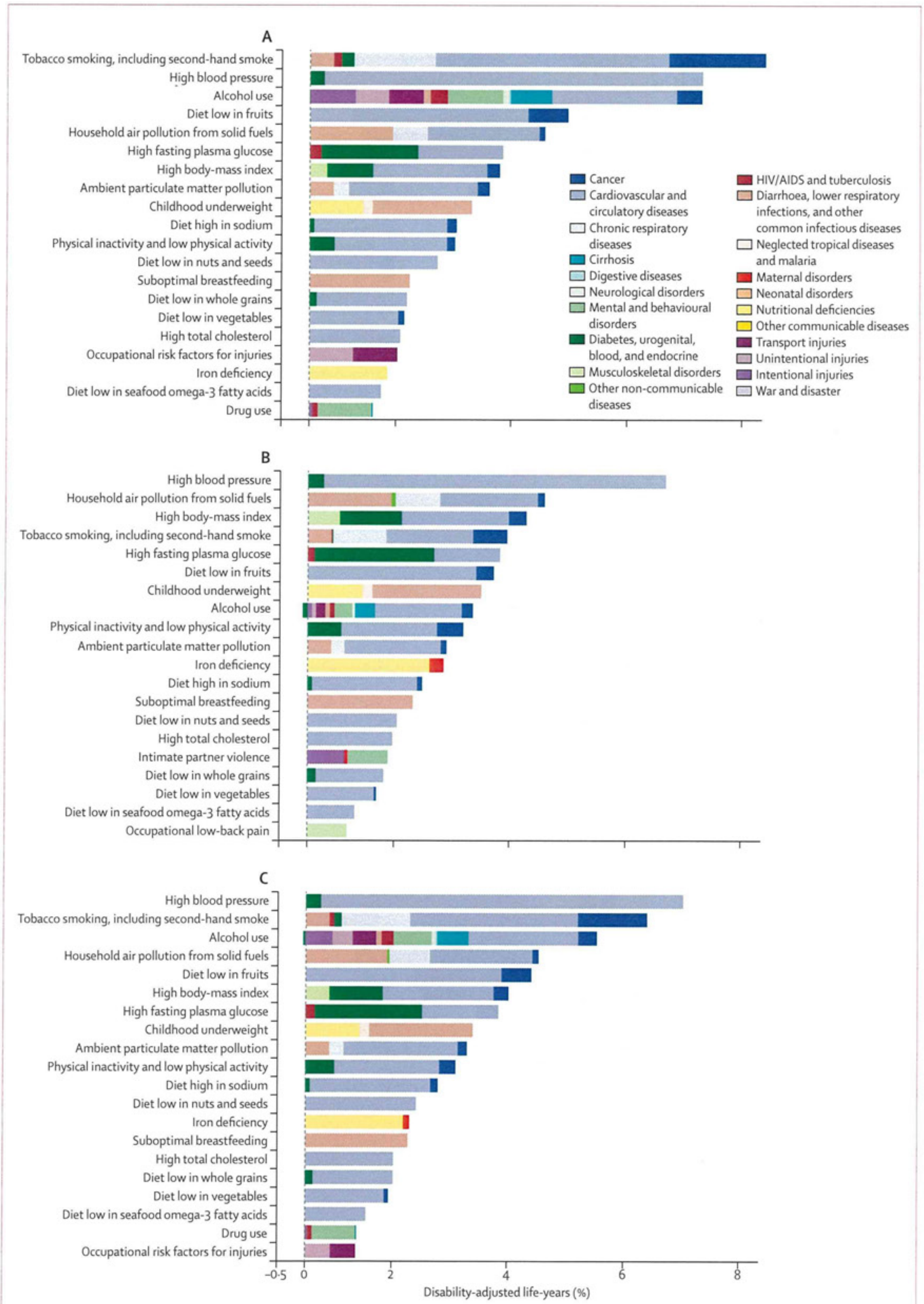

Figure 2: **Burden of disease attributable to 20 leading risk factors in 2010, expressed as a percentage of global disability-adjusted life-years**

For men (A), women (B), and both sexes (C).

blood pressure, tobacco smoking including second-hand smoke, alcohol use, household air pollution, and diets low in fruits) are mainly causes of adult chronic disease, especially cardiovascular diseases and cancers (figures 1, 2). The burden of disease attributable to other chronic disease risk factors also increased substantially between 1990 and 2010; for example, the global disease burden attributable to high body-mass index increased from 52 million to 94 million DALYs and that of high fasting plasma glucose increased from 56 million to 89 million DALYs over this period.

The rise in global disease burden attributable to chronic disease risk factors has been accompanied by a decrease in the relative importance of risk factors that largely or exclusively cause communicable diseases in children. The global disease burden attributable to childhood underweight halved between 1990 (7·9% [6·8–9·4] of global DALYs) and 2010 (3·1% [2·6–3·7]; table 3). Although the fraction of disease burden attributable to iron deficiency fell relatively little, suboptimal breastfeeding, unimproved water, unimproved sanitation, vitamin A deficiency, and zinc deficiency all decreased substantially between 1990, and 2010.

The transition from childhood communicable to non-communicable disease burden is also exemplified by the fall in DALYs caused by household air pollution from solid fuels (despite the rise in its effects on cardiovascular diseases). Although the burden attributable to ambient particulate matter pollution has largely remained unchanged (3·2% [2·8–3·7] of global DALYs in 1990 *vs* 3·0% [2·6–3·4] in 2010), the contribution of lower respiratory tract infections had fallen sharply by 2010, with chronic diseases of adults being the dominant health outcome caused by this exposure.

Figure 4 shows the 95% uncertainty interval in global DALYs attributable to each risk factor and the overall rank for each risk factor. The uncertainty intervals for many risk factors overlap, especially those not in the top five. Unimproved water, unimproved sanitation, vitamin A deficiency, and zinc deficiency have large uncertainty, which reflects the substantial uncertainty in the estimates of etiological effect sizes for these risks.

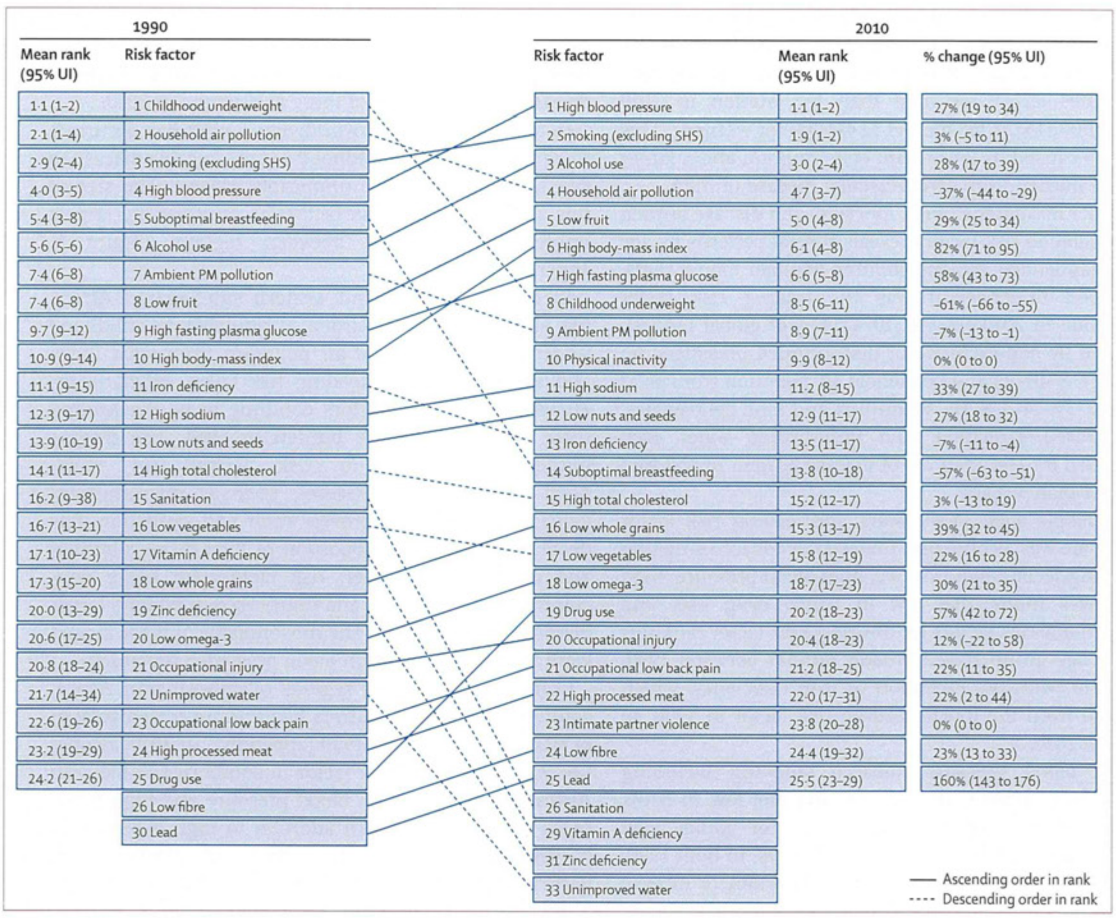

Figure 3: **Global risk factor ranks with 95% UI for all ages and sexes combined in 1990, and 2010, and percentage change**
PM=particulate matter. UI=uncertainty interval. SHS=second-hand smoke. An interactive version of this figure is available online at http://healthmetricsandevaluation.org/gbd/visualizations/regional.

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Some risks were quantified for women only—for example, intimate partner violence, which accounted for 1·5% (1·0—2·1) of DALYs among women in 2010. Important differences between men and women also exist for disease burden attributable to other risk factors, most notably, for tobacco smoking including second-hand smoke and alcohol use (figures 1, 2). These risks cause substantially lower burden in women than in men, because women drink less and in less harmful ways than do men, and fewer smoke or have smoked for a shorter time than have men in most regions.[157] In 2010, tobacco smoking including second-hand smoke accounted for 8·4% of worldwide disease burden among men (the leading risk factor) compared with 3·7% among women (fourth highest risk factor). For alcohol use, these sex differences were similarly substantial: 7·4% (third) versus 3·0% (eighth). The effect of occupational risk factors on population health also differed between sexes—for example, the fraction of disease burden attributable to occupational risk factors for injuries was 18·5 times higher for men than for women in 2010 (20 175 000 DALYs for men *vs* 1 090 000 for women). Dietary risk factors had broadly similar effects for men and women with the exception of diet low in fruits, for which the fraction of disease burden attributable was 1·5 times larger for men than for women in 2010 (47 979 000 DALYs for men *vs* 32 474 000 for women). This effect is caused by lower fruit consumption and a larger disease burden from cardiovascular disease in men.

Further disaggregation of mortality and disease burden attributable to risk factors reveals several patterns by age group (appendix). Among children younger than 5 years, childhood underweight was the leading risk factor worldwide in 2010 (12·4% [10·4–14·7] of global DALYs), followed by non-exclusive or discontinued breastfeeding (7·6% [4·8–10·9]) and household air pollution from solid fuels (6·3% [4·4–8·1]). Vitamin A and zinc deficiencies, unimproved sanitation, and unimproved water each accounted for less than 2% of disease burden in children younger than 5 years.

For people aged 15–49 years, the leading risk factor worldwide was alcohol use, followed by tobacco smoking including second-hand smoke, high blood pressure, high body-mass index, diet low in fruits, drug use, and occupational risk factors for injuries. Risk factor rankings in this age group stayed broadly similar between 1990, and 2010, with the exception of iron deficiency, which dropped from the fourth leading risk factor in 1990, to ninth in 2010.

High blood pressure, tobacco smoking including second-hand smoke, alcohol use, and diet low in fruits were all in the top five risk factors for adults aged 50–69 years and adults older than 70 years, in both 1990, and 2010, accounting for a large proportion of disease burden in both age groups. Globally, high blood pressure accounted for more than 20% of all health loss in adults aged 70 years and older in 2010, and around 15% in those aged 50–69 years. Tobacco smoking including second-hand smoke accounted for more than 10% of global disease burden in each of these age groups in 2010.

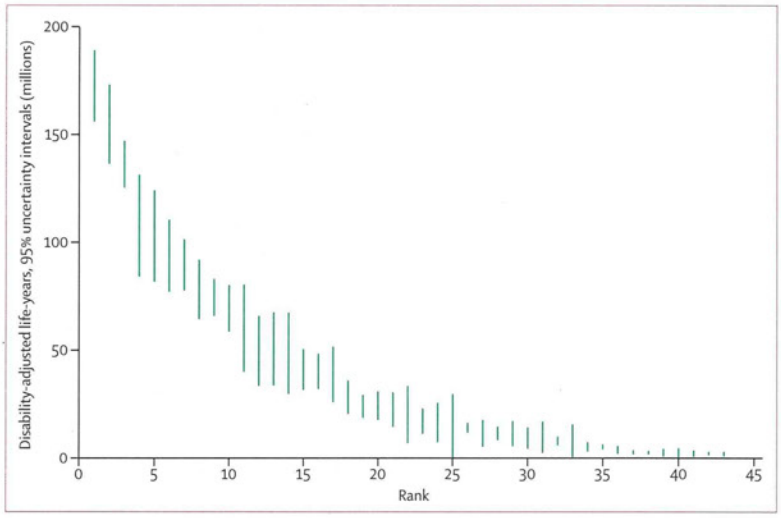

***Figure 4:* 95% uncertainty intervals for risk factors ranked by global attributable disability-adjusted life-years, 2010**

An interactive version of this figure is available online at http://healthmetricsandevaluation.org/gbd/visualizations/regional

In all 21 regions, and worldwide, a shift has occurred, from risk factors for childhood communicable disease to risk factors for non-communicable disease. The size of this shift and which risk factors account for the largest burden varies highly between regions (figure 5, appendix).

In central, eastern, and western sub-Saharan Africa, the share of disease burden attributable to childhood underweight, household air pollution from solid fuels, and suboptimal breastfeeding has fallen substantially. However, these risk factors continue to be the leading three causes of disease burden in 2010. The disease burden attributable to risk factors for childhood communicable diseases, such as micronutrient deficiencies and unimproved water and sanitation, has decreased, both as a proportion of total disease burden and in their rank order: risk factors for some non-communicable diseases and injury accounted for a larger disease burden in 2010. The most notable of these factors were alcohol use and high blood pressure (appendix).

Compared with other regions of sub-Saharan Africa, southern sub-Saharan Africa had a more mixed pattern of risk factor burden in 1990 (appendix). In 2010, alcohol use was the leading risk factor in southern sub-Saharan Africa, followed by high blood pressure and high body-mass index (figure 6). In addition to high exposure to harmful alcohol use, the effects of alcohol were particularly large because it increases the risk of road traffic and other unintentional and intentional injuries, as well as of tuberculosis,[47] all of which are large causes of disease and injury burden in this region.

Ranking legend
1–5 | 6–10 | 11–15 | 16–20 | 21–25 | 26–30 | 31–35 | 36–40 | >40

Risk factor	Global	High-income Asia Pacific	Western Europe	Australasia	High-income North America	Central Europe	Southern Latin America	Eastern Europe	East Asia	Tropical Latin America	Central Latin America	Southeast Asia	Central Asia	Andean Latin America	North Africa and Middle East	Caribbean	South Asia	Oceania	Southern sub-Saharan Africa	Eastern sub-Saharan Africa	Central sub-Saharan Africa	Western sub-Saharan Africa
High blood pressure	1	1	2	3	4	1	2	2	1	2	4	1	1	2	1	1	3	6	2	6	5	6
Tobacco smoking, including second-hand smoke	2	2	1	2	1	3	3	3	2	4	5	2	3	5	3	3	2	3	5	7	12	10
Alcohol use	3	3	4	4	3	2	4	1	6	1	1	6	2	1	11	5	8	5	1	5	6	5
Household air pollution from solid fuels	4	42	..	..	..	14	23	20	5	18	11	3	12	7	13	9	1	4	7	2	2	2
Diet low in fruits	5	5	7	7	7	5	6	5	3	6	7	4	5	10	6	8	5	9	8	8	11	13
High body-mass index	6	8	3	1	2	4	1	4	9	3	2	9	4	3	2	2	17	2	3	14	18	15
High fasting plasma glucose	7	7	6	6	5	7	5	10	8	5	3	5	7	6	4	4	7	1	6	10	13	11
Childhood underweight	8	39	38	37	39	38	38	38	38	32	23	13	25	18	21	14	4	8	9	1	1	1
Ambient particulate matter pollution	9	9	11	26	14	12	24	14	4	27	19	11	10	24	7	19	6	32	25	16	14	7
Physical inactivity and low physical activity	10	4	5	5	6	6	7	7	10	8	6	8	9	8	5	7	11	7	11	15	15	16
Diet high in sodium	11	6	10	11	11	9	11	9	7	9	13	7	6	13	8	15	14	16	13	21	17	18
Diet low in nuts and seeds	12	11	9	8	8	8	8	8	12	10	8	15	8	12	9	10	13	13	16	22	16	21
Iron deficiency	13	20	32	21	35	22	17	21	19	14	12	12	17	4	12	6	9	11	10	4	4	4
Suboptimal breastfeeding	14	..	..	..	..	..	27	..	24	22	15	14	16	9	15	13	10	10	4	3	3	3
High total cholesterol	15	12	8	9	9	10	9	6	13	11	10	16	14	16	10	16	20	14	19	28	27	30
Diet low in whole grains	16	10	16	16	17	11	12	11	11	12	14	26	13	17	14	12	15	15	32	24	19	24
Diet low in vegetables	17	14	13	12	13	13	10	12	15	16	20	10	11	14	18	11	16	12	15	23	23	20
Diet low in seafood omega-3 fatty acids	18	17	15	13	16	16	14	13	17	17	18	19	15	23	16	17	18	20	23	27	25	25
Drug use	19	13	14	10	10	20	13	17	18	13	16	18	20	11	19	18	22	19	12	19	24	22
Occupational risk factors for injuries	20	24	24	20	25	26	16	25	20	19	22	23	21	21	23	31	12	22	22	20	22	17
Occupational low back pain	21	15	17	15	23	18	20	24	14	15	24	17	24	22	20	26	23	17	24	17	21	19
Diet high in processed meat	22	22	12	14	12	15	18	15	29	7	9	27	19	15	27	24	25	27	28	31	28	28
Intimate partner violence	23	18	22	23	22	25	21	22	21	23	26	22	27	19	25	23	21	25	14	18	20	23
Diet low in fibre	24	16	18	18	18	19	15	16	16	25	28	20	18	28	22	22	33	21	33	36	34	36
Unimproved sanitation	25	38	39	39	41	42	40	40	40	40	38	30	37	31	32	28	19	18	18	9	8	9
Lead exposure	26	23	21	19	24	17	19	23	22	20	25	24	23	20	26	21	24	30	20	25	26	26
Diet low in polyunsaturated fatty acids	27	19	19	17	20	21	22	18	26	24	27	21	22	29	24	25	32	23	30	33	30	29
Diet high in trans fatty acids	28	29	23	24	15	23	28	19	28	21	21	33	26	27	17	38	28	34	35	37	36	37
Vitamin A deficiency	29	40	40	38	40	41	41	42	43	41	37	32	34	34	37	33	30	31	17	11	7	8
Occupational particulate matter, gases, and fumes	30	34	33	32	28	32	33	31	23	29	32	28	29	33	31	34	26	33	29	29	29	31
Zinc deficiency	31	37	37	36	37	39	39	39	39	39	29	29	28	25	35	27	31	28	21	13	10	14
Diet high in sugar-sweetened beverages	32	28	31	31	19	33	26	27	37	26	17	25	32	30	28	20	27	26	26	32	32	34
Childhood sexual abuse	33	26	25	22	21	30	25	26	30	28	30	37	30	26	29	30	29	35	31	26	31	27
Unimproved water source	34	41	41	40	38	40	42	41	42	42	40	31	36	35	30	29	34	24	27	12	9	12
Low bone mineral density	35	21	20	25	26	24	30	28	25	30	33	35	35	36	34	32	36	37	38	35	37	33
Occupational noise	36	33	35	34	36	35	35	35	33	33	31	34	31	32	36	35	37	36	34	30	33	32
Occupational carcinogens	37	31	26	29	31	34	32	34	27	38	35	38	33	40	38	40	39	41	37	41	42	42
Diet low in calcium	38	25	28	27	29	27	29	30	31	34	39	39	39	39	40	37	40	39	39	38	39	38
Ambient ozone pollution	39	36	36	41	33	36	43	37	34	43	43	43	43	43	43	43	35	43	43	42	38	41
Residential radon	40	32	27	35	27	28	36	33	32	36	41	41	38	42	41	42	41	42	42	43	43	43
Diet low in milk	41	27	29	30	30	29	34	32	35	37	42	40	41	41	42	39	42	40	41	39	41	39
Occupational asthmagens	42	35	34	33	34	37	37	36	41	35	36	36	42	37	39	36	38	29	36	34	35	35
Diet high in red meat	43	30	30	28	32	31	31	29	36	31	34	42	40	38	33	41	43	38	40	40	40	40

Figure 5: **Risk factors ranked by attributable burden of disease, 2010**
Regions are ordered by mean life expectancy. No data=attributable disability-adjusted life-years were not quantified.

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