Global, regional, and national prevalence of second-hand smoke and attributable disease burden in 204 countries and territories, 1990–2023: a systematic analysis for the Global Burden of Disease Study 2023

GBD 2023 Second-hand smoke Collaborators

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Summary

Background Second-hand smoke (SHS) exposure remains a major source of morbidity and mortality among non-smokers. This study presents the first dedicated Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) publication to systematically quantify SHS prevalence and evaluate its effect as a global risk factor across a broader range of outcomes.

Methods Using the GBD 2023 comparative risk assessment framework, we estimated SHS exposure prevalence and attributable disease burden across 204 countries and territories from 1990 to 2023, stratified by age and sex. Exposure estimates were derived by synthesising population-based surveys and household composition data through spatiotemporal Gaussian process regression. Relative risks for nine health outcomes, now including asthma, were estimated using the Burden of Proof methodology, and applied to calculate attributable deaths and disability-adjusted life-years (DALYs).

Findings In 2023, an estimated 2·71 billion (95% UI 2·44–3·02) people worldwide were exposed to SHS, including 767 million (687–858) children aged 0–14 years. Age-standardised prevalence was highest in southeast Asia, east Asia, and Oceania (48·4% [44·0–53·4]), with female individuals in some countries experiencing nearly 1·8 times the exposure prevalence of male individuals. Despite a 22·2% (10·6–32·4) decline in global age-standardised prevalence since 1990, this progress has not been sufficient to reduce the absolute number of exposed individuals, which has remained stable globally and has risen sharply in sub-Saharan Africa (98·5% [62·0–144·4] increase) and North Africa and the Middle East (72·1% [47·8–101·8] increase). In 2023, SHS exposure accounted for 1·66 million (1·33–2·07) deaths and 44·8 million (35·8–54·3) DALYs globally. Ischaemic heart disease was the leading contributor to SHS-attributable DALYs (12·0 million [9·31–15·2]) overall, while lower respiratory infections predominated among children (5·16 million [3·48–7·12]).

Interpretation We estimated that SHS remains a substantial driver of global health loss, particularly through cardiovascular and paediatric respiratory diseases. Persistent geographical disparities and growing absolute numbers of exposed individuals in several regions underscore the urgent need for accelerated implementation and enforcement of comprehensive tobacco control measures, particularly to protect women and children in both public and domestic environments.

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Introduction

Tobacco use remains a leading contributor to the global burden of disease, accounting for an estimated 8 million deaths in 2023.[1] A substantial part of this burden falls on non-smokers exposed to second-hand smoke (SHS) through mechanisms similar to those of active smoking. SHS combines the sidestream smoke from the burning tip of tobacco products with the smoke exhaled by smokers.[2] The sidestream component, which dominates the air non-smokers breathe, is unfiltered and incompletely combusted, carrying higher per-unit concentrations of the toxic and carcinogenic compounds than mainstream smoke inhaled by the smoker.[3] Through oxidative stress, endothelial dysfunction, and chronic inflammation, these exposures raise the risk of cardiovascular, respiratory, neoplastic, and metabolic disease.[4–6] Children are especially susceptible, owing to developing airways, an immature immune system, and higher minute ventilation per body mass.[7]

These adverse health effects have been recognised for decades, and the scientific consensus that no safe level of exposure exists has made SHS a central focus of tobacco control. This priority was formalised by the 2003 WHO Framework Convention on Tobacco Control (FCTC), an international public health treaty whose Article 8 calls for smoke-free legislation protecting non-smokers in

Research in context

Evidence before this study

Exposure to second-hand smoke (SHS) is a globally recognised health risk, with no safe level of inhalation. To assess the existing body of evidence on SHS exposure and disease burden, we searched PubMed for articles published from Jan 1, 2010 to Dec 31, 2025, using the terms ("second-hand smoke" OR "environmental smoke") AND ("prevalence" OR "epidemiology") AND ("disease burden" OR "mortality" OR "DALYs" OR "YLL" OR "disability-adjusted life-years") AND ("global" OR "national" OR "regional"). Previous studies have often focused on restricted geographies or specific populations, with many limited by narrow temporal scopes and substantial geographical gaps, particularly in low-income and middle-income countries. The landmark 2011 analysis by Öberg and colleagues provided the first comprehensive global estimate of SHS burden, attributing approximately 600 000 deaths and 10·9 million disability-adjusted life years (DALYs) annually to SHS. However, this assessment was restricted to a limited set of health outcomes among adults, excluding high-burden conditions such as stroke and chronic obstructive pulmonary disease. Earlier iterations of the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) and related publications included SHS as a risk factor but relied on relative risks in which SHS exposure intensity was approximated indirectly, using the mean number of cigarettes smoked per smoker per day as a proxy, rather than estimated directly from the dichotomous exposure reported by most studies. Furthermore, asthma was not included as an SHS-attributable outcome, potentially underestimating the burden, particularly among children.

Added value of this study

This study is the first dedicated GBD publication to systematically assess SHS as a distinct global risk factor, integrating prevalence estimates and attributable disease burden across 204 countries and territories from 1990 to 2023. To refine our estimates, we integrated 91 new sources of workplace exposure and 87 new sources of household composition data. Methodologically, we adopted a direct dichotomous exposure model (exposed *vs* unexposed), which better fits the way the available primary epidemiological evidence reports exposure (over 90% of identified studies report binary exposure) and removes the need for an auxiliary cigarette-equivalent proxy used to approximate average SHS exposure intensity at the country–year level. Using the burden of proof meta-regression framework, we updated relative risks for eight established outcomes and, for the first time in the GBD framework, included asthma as an attributable health outcome based on sufficient evidence of a risk–outcome association according to GBD established criteria. These advancements draw on comprehensive systematic reviews of literature on SHS health risks published from 1970 to 2022 across two major databases. In combination, these improvements allow for more reliable risk assessment and granular age–sex–location disaggregation of both prevalence and population-level disease burden over a 33-year period.

Implications of all the available evidence

In 2023, 2·71 billion people were estimated to be exposed to SHS, resulting in 1·66 million deaths and 44·8 million DALYs. Despite a 22·2% reduction in age-standardised prevalence since 1990, the absolute number of exposed individuals has remained stable owing to population growth, including a doubling of the exposed population in sub-Saharan Africa. Substantial demographic disparities persist, with female individuals and children disproportionately exposed. The inclusion of asthma shows a higher burden among children, who account for more than 12% of total SHS-attributable DALYs. As 70% of the global population remains unprotected by comprehensive smoke-free laws, these findings highlight the need for accelerated implementation of WHO Framework Convention on Tobacco Control Article 8, together with broader tobacco control measures to reduce active smoking. In the context of morbidity expansion, protecting non-smokers in both public and domestic environments is needed to mitigate long-term health inequities.

workplaces, public transport, and indoor public places. Yet, global enforcement and coverage remain inconsistent: approximately 70% of the world's population is not protected by comprehensive smoke-free laws, and domestic settings, where exposure tends to be most prolonged, remain largely unregulated.[8]

Harmonised, high-quality data on SHS exposure and its population-level consequences are essential for informing targeted responses and investment in tobacco control. The landmark 2011 analysis by Öberg and colleagues[9] attributed approximately 600 000 deaths and 10·9 million disability-adjusted life years (DALYs) to SHS annually but considered only a narrow set of SHS-related health outcomes. Since then, tobacco consumption and control policies have evolved, and substantial geographical gaps in exposure data persist, particularly in low-income and middle-income countries (LMICs), underscoring the need for systematic global evaluation by age and sex.

In this study, we used the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2023 framework to provide a comprehensive, updated assessment of the prevalence and health effect of SHS exposure from 1990 to 2023 in 204 countries and territories. We introduce several methodological innovations, including the integration of expanded primary data sources, updated meta-regressions for risk–outcome pairs, and the inclusion of asthma as a newly attributable health outcome. By providing granular estimates by age, sex, and geography, this study elucidates the contemporary trajectory of the SHS burden and offers an empirical foundation for targeted

interventions and stronger smoke-free policies worldwide. This manuscript was produced with support from the GBD Collaborator Network and in accordance with the GBD Protocol.[10]

Methods

Overview

As part of GBD 2023, we estimated the burden of disease attributable to SHS exposure from 1990 to 2023 using the comparative risk assessment framework for 204 countries and territories, by age and sex. Exposure was defined as any current exposure to smoke from combustible tobacco products at home or in the workplace; exposure occurring exclusively in other settings (eg, bars, restaurants, public transport, and private vehicles) is not captured. The population at risk was restricted to non-smokers and occasional smokers; all daily smokers were classified as unexposed to avoid overlap with active smoking. The analysis comprised three steps: estimating prevalence of exposure to SHS by age, sex, geography, and time; determining the relative risk (RR) of nine health outcomes associated with SHS exposure; and calculating population-attributable fractions (PAFs) and attributable burden. This study adheres to GATHER (appendix, pp 16–17)[11] and GBD 2023 is registered with the University of Washington Institutional Review Board (study number 9060).

Data sources

To estimate prevalence of SHS exposure, we combined cross-sectional self-reported workplace exposure and household-level age and sex composition data with GBD 2023 daily smoking prevalence estimates to compute the probability of residing with at least one daily smoker (appendix pp 6–8). Following previous GBD iterations,[12] we assumed that all non-smokers or occasional smokers living with a daily smoker are exposed to SHS within the home. For workplace exposure, we extracted 395 population-based, representative sources (91 new in GBD 2023) covering 119 of 204 countries and territories. For household composition, we incorporated 938 sources (87 new) covering 173 of 204 locations. Geographical coverage and recency are provided in the appendix (pp 19–20). A complete list of data sources is available through the Global Health Data Exchange.

Modelling strategy

We implemented a modelling strategy similar to that described in the GBD 2021 Risk Factors Capstone.[12] Self-reported microdata on workplace SHS exposure were used in a spatiotemporal Gaussian process regression (ST-GPR)[1] to generate a complete time series of the proportion of the population aged 15–79 years exposed to SHS at work, by age, sex, and GBD location. Individual-level household composition data were combined with GBD 2023 daily smoking prevalence estimates to calculate, for each person, the probability that at least one other household member is a daily smoker. Workplace and household exposure probabilities were combined to estimate each individual's probability of SHS exposure at home or at work, multiplied by the probability of not being a daily smoker, then aggregated and modelled in ST-GPR to produce complete location-specific, year-specific, age-specific, and sex-specific estimates. Full algebraic specification of the exposure combination, the union set calculation for household exposure, and the ST-GPR parameterisation are provided in the appendix (pp 6–8).

Relative risk estimation

Updated RRs were generated for eight health outcomes associated with SHS exposure in previous iterations of the GBD study—lung and breast cancer, ischaemic heart disease, stroke, chronic obstructive pulmonary disease (COPD), lower respiratory infections, type 2 diabetes, and otitis media—along with asthma, added as an SHS-attributable condition in GBD 2023. We synthesised data from comprehensive systematic reviews of PubMed and Web of Science for studies published between Jan 1, 1970, and July 31, 2022, using the Burden of Proof meta-regression approach.[13] Criteria for outcome selection, detailed methodologies, and SHS-specific burden-of-proof results are published elsewhere[6] and are summarised in the appendix (pp 9–12).

See Online for appendix

In GBD 2023, risks associated with dichotomous SHS exposure (exposed *vs* not exposed) were estimated for all outcomes, a methodological shift from GBD 2021,[12] in which country-year-specific RRs for lung cancer, ischaemic heart disease, stroke, COPD, lower respiratory infections, and type 2 diabetes were derived from continuous curves evaluated at the mean cigarettes smoked per smoker per day, a proxy for SHS exposure intensity. This change reflects that over 90% of identified primary studies reported exposure in binary form, removes a layer of modelling assumption, and eliminates dependence on cigarette-consumption estimates (appendix pp 9–10). The resulting RRs differ most from the GBD 2021 for country-years whose exposure proxy fell on the steep, low-exposure portion of the curve; outcome-specific comparisons are provided in the appendix (pp 12–13). The risk–outcome effect sizes and associated uncertainty without between-study heterogeneity informed the calculation of SHS-attributable burden and are presented in the appendix (p 12). These effect sizes are applied uniformly across age, sex, location, and year, assuming the biological relationship between exposure and outcome does not vary materially by these dimensions. Sensitivity analyses examining sex-specific datapoints and child-only models for asthma did not produce substantively different effect sizes.[6] Additional details on included studies and results are available in the Burden of Proof visualisation tool.

For more on the **Global Health Data Exchange** see https://ghdx.healthdata.org/

For more on the **Burden of Proof visualisation tool** see https://vizhub.healthdata.org/burden-of-proof/

Population attributable fractions

PAFs for each risk–outcome pair were calculated as $PAF=P\times(RR-1)/(1+P\times[RR-1])$, where P is the prevalence of SHS exposure. The theoretical minimum risk exposure level for SHS is zero (no exposure), consistent with the absence of a known safe level of exposure. SHS-attributable burden was obtained by multiplying the calculated PAFs by the estimated deaths, years of life lost (YLLs), years lived with disability (YLDs), and DALYs from the health outcomes linked to SHS. Full PAF specifications are provided in the appendix (p 14).

Reporting of estimates

Results are presented globally, by GBD super-region, and for 204 countries and territories from 1990 to 2023. Standard GBD 5-year age groups were consolidated into children (0–14 years), the working-age population (15–64 years), and older adults (≥65 years). Estimates are presented by sex and for males and females combined. Disaggregation by race or ethnicity was not available. Age-standardised prevalence and rates per 100 000 population were calculated using the GBD 2023 world standard population.[14] SHS was ranked against other Level 3 risk factors by mean DALY rate, with the full ranking reported in the GBD 2023 risk factor capstone.[1] Point estimates represent the mean of 250 posterior draws, with 95% uncertainty intervals (UIs) given by the 2·5th and 97·5th percentiles; prevalence values used 1000 draws. Analyses were conducted in R (version 4.2.1) and Python (version 3.10.4).

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

In 2023, an estimated 2·71 billion (95% UI 2·44–3·02) individuals worldwide were exposed to SHS, of whom 1·49 billion (1·35–1·65) were female and 767 million (687–858) were children aged 0–14 years (table 1; appendix p 24). Age-standardised prevalence of SHS exposure was estimated at 33·9% (30·5–37·8) globally for both sexes combined, 37·3% (33·7–41·4) for females, and 30·6% (27·5–34·2) for males (table 1). Across the GBD super-regions, southeast Asia, east Asia, and Oceania observed the largest age-standardised prevalence at 48·4% (44·0–53·4), followed by North Africa and the Middle East at 38·8% (34·9–43·2), and central Europe, eastern Europe, and central Asia at 37·7% (33·5–42·5; table 1). The country with the most individuals exposed to SHS was China (664 million [592–751]), followed by India (444 million [395–497]) and Indonesia (142 million [134–150]; appendix pp 25–40). In contrast, Kiribati, Tuvalu, and the Federated States of Micronesia had among the highest age-standardised prevalence, each exceeding 60% (appendix pp 41–56).

Pronounced sex differences were observed, particularly in southeast Asia, east Asia, and Oceania, where age-standardised prevalence was 59·1% (95% UI 53·3–63·9) higher among females than males, compared with the global difference of 22·0% (19·9–24·1; appendix p 21). Conversely, prevalence in the high-income super-region and in Latin America and the Caribbean was slightly higher in males than females (table 1; appendix p 21). The largest relative female-to-male gap was in Timor-Leste, where SHS prevalence in female individuals was 68·0% (63·6–72·6), nearly 1·8 times that among males (37·9% [34·8–41·5]; figure 1). Similarly large gaps were estimated for Indonesia, Djibouti, Armenia, China, and Laos, where age-standardised SHS prevalence in female individuals was more than 1·6 times that in male individuals (appendix pp 41–56). Beyond sex, SHS prevalence generally declined with advancing age; among children, the highest exposure was in southeast Asia, east Asia, and Oceania (59·7% [54·5–65·3]) and central Europe, Eastern Europe, and central Asia (51·2% [46·4–56·5]; appendix p 24).

Between 1990 and 2023, global age-standardised prevalence declined by 22·2% (95% UI 10·6–32·4; table 1). This decline did not translate into a reduction in the absolute number of exposed, which remained approximately stable globally (13·6% change [–1·19–30·3]; table 1). Across age groups, the largest reduction was in the 0–14 years group, decreasing by 26·7% (16·2–36·1), from 51·7% (47·4–55·8) in 1990 to 37·9% (34·0–42·4) in 2023 (appendix p 24). Across super-regions, the largest prevalence reduction was estimated for Latin America and the Caribbean (–38·0% [–47·4 to –27·1]), driven by reductions among female individuals (–46·4% [–55·0 to –35·5]), followed by the high-income super-region (–32·0% [–40·3 to –22·6]); South Asia (–24·1% [–33·9 to –12·5]); and central Europe, eastern Europe, and central Asia (–16·9% [–29·0 to –2·8]; table 1). In contrast, prevalence did not change substantially in the remaining super-regions, and the absolute number of individuals exposed rose sharply in sub-Saharan Africa (98·5% [62·0–144·4]) and North Africa and the Middle East (72·1% [47·8–101·8]; table 1). At the country level, the largest reductions in age-standardised prevalence were in Denmark (–48·8% [–56·2 to –39·6]), Norway (–44·3% [–53·6 to –32·5]), Brazil (–43·4% [–50·1 to –35·6]), Mexico (–40·3% [–50·5 to –27·2]), and Canada (–40·2% [–49·6 to –28·4]; appendix pp 41–56), whereas the largest increases in the absolute number of exposed individuals were in Qatar (558·9% [427·4–730·0]), Afghanistan (375·5% [276·1–513·3]), United Arab Emirates (343·1% [251·2–456·9]), and Djibouti (320·6% [256·9–400·9]; appendix pp 25–40).

In 2023, an estimated 1·66 million deaths (95% UI 1·33–2·07) were attributable to SHS, accounting for 2·76% (2·20–3·39) of all-cause mortality globally (table 2). Of these deaths, 868 000 (689 000–1·08 million) were among female individuals and 59 000

(40 000–81 000) among children and adolescents. The most deaths occurred in southeast Asia, east Asia, and Oceania (689 000 [545 000–861 000]), followed by South Asia (428 000 [347 000–537 000]) and the high-income super-region (138 000 [107 000–175 000]; table 2). SHS ranked as the 11th leading GBD level 3 risk factor for mortality globally in 2023, and ninth in North Africa and the Middle East and southeast Asia, east Asia, and Oceania (appendix p 22); age-standardised SHS-attributable mortality rates reached 29·5 (23·5–36·5) per 100 000 in North Africa and the Middle East and 24·5 (19·3–30·7) per 100 000 in southeast Asia, east Asia, and Oceania. South Asia also had a high mortality rate (31·7 [25·7–40·2] per 100 000; table 2). At the country level, the highest age-standardised mortality rates were in Pacific Island nations, led by Nauru (126·9 [100·8–158·2] per 100 000), Solomon Islands (113·9 [92·4–140·4] per 100 000), and Tuvalu (100·5 [79·6–122·8] per 100 000). Outside southeast Asia, east Asia, and Oceania, the highest rates were in Egypt (53·5 [39·9–68·8] per 100 000), Bangladesh (49·3 [36·4–64·7] per 100 000), and Iraq (44·5 [35·3–54·5] per 100 000; appendix pp 57–72). Between 1990 and 2023, the global age-standardised SHS-attributable mortality rate decreased by 46·4% (36·9–55·9), from 35·0 (27·0–43·3) per 100 000 to 18·8 (15·0–23·4) per 100 000 (appendix pp 57–72). Although mortality rates declined across all super-regions, absolute deaths rose in North Africa and the Middle East (54·5% [29·1–85·3]); South Asia (48·6% [20·7–78·8]); southeast Asia, east Asia, and Oceania

	Female			Male			Both sexes		
	2023	1990	Percentage change	2023	1990	Percentage change	2023	1990	Percentage change
Age-standardised prevalence (95% UI)									
Global	37·3 (33·7 to 41·4)	50·6 (46·7 to 54·4)	−26·4% (−35·0 to −16·9)	30·6 (27·5 to 34·2)	36·6 (33·0 to 40·2)	−16·4% (−28·8 to −1·6)	33·9 (30·5 to 37·8)	43·6 (39·9 to 47·3)	−22·2% (−32·4 to −10·6)
Southeast Asia, East Asia, and Oceania	59·5 (54·7 to 64·7)	65·9 (61·2 to 70·2)	−9·7% (−18·5 to 0·2)	37·4 (33·3 to 42·2)	39·2 (34·9 to 43·5)	−4·5% (−17·7 to 11·8)	48·4 (44·0 to 53·4)	52·5 (48·1 to 56·9)	−7·8% (−18·3 to 4·4)
Central Europe, Eastern Europe, and central Asia	40·7 (36·3 to 45·6)	52·4 (47·6 to 57·4)	−22·4% (−33·1 to −10·0)	34·7 (30·7 to 39·3)	38·3 (34·1 to 42·9)	−9·4% (−23·6 to 7·6)	37·7 (33·5 to 42·5)	45·4 (40·8 to 50·2)	−16·9% (−29·0 to −2·8)
High income	27·5 (25·5 to 29·7)	45·3 (41·9 to 48·8)	−39·4% (−45·2 to −32·6)	30·6 (27·5 to 34·4)	40·1 (36·4 to 43·9)	−23·6% (−34·7 to −10·6)	29·0 (26·5 to 32·0)	42·7 (39·2 to 46·3)	−32·0% (−40·3 to −22·6)
Latin America and Caribbean	23·0 (19·8 to 27·0)	42·8 (39·3 to 46·6)	−46·4% (−55·0 to −35·5)	26·5 (23·8 to 29·6)	37·0 (33·7 to 40·7)	−28·3% (−38·8 to −16·2)	24·7 (21·9 to 28·1)	39·9 (36·5 to 43·6)	−38% (−47·4 to −27·1)
North Africa and Middle East	42·6 (38·4 to 47·2)	44·9 (40·7 to 49·3)	−5·2% (−18·2 to 10·8)	35·0 (31·3 to 39·2)	36·2 (32·3 to 40·2)	−3·3% (−18·0 to 14·9)	38·8 (34·9 to 43·2)	40·6 (36·5 to 44·8)	−4·4% (−18·1 to 12·7)
South Asia	34·2 (30·4 to 38·4)	50·2 (46·7 to 53·8)	−31·9% (−40·8 to −21·3)	33·0 (30·1 to 36·2)	38·3 (35·2 to 41·5)	−13·9% (−25·2 to −0·6)	33·6 (30·3 to 37·3)	44·3 (41·0 to 47·7)	−24·1% (−33·9 to −12·5)
Sub-Saharan Africa	19·9 (17·2 to 23·0)	26·0 (23·0 to 29·3)	−23·3% (−36·8 to −6·7)	18·4 (16·0 to 21·1)	21·0 (18·2 to 24·1)	−12·5% (−28·7 to 8·9)	19·1 (16·6 to 22·0)	23·5 (20·6 to 26·7)	−18·5% (−33·3 to 0·1)
Population exposed, millions (95% UI)									
Global	1490 (1350 to 1650)	1350 (1250 to 1450)	10·2% (−2·8 to 24·2)	1220 (1090 to 1360)	1030 (933 to 1130)	18·0% (0·7 to 38·4)	2710 (2440 to 3020)	2380 (2180 to 2590)	13·6% (−1·2 to 30·3)
Southeast Asia, East Asia, and Oceania	636 (584 to 692)	553 (515 to 589)	14·9% (3·8 to 27·3)	377 (333 to 429)	354 (317 to 392)	6·5% (−8·9 to 24·4)	1010 (917 to 1120)	907 (832 to 981)	11·6% (−1·4 to 26·2)
Central Europe, Eastern Europe, and central Asia	82·2 (72·9 to 92·8)	112 (102 to 124)	−27·2% (−37·6 to −14·9)	63·6 (55·8 to 72·6)	76·5 (67·9 to 85·8)	−17·3% (−30·7 to −1·3)	146 (129 to 165)	189 (170 to 209)	−23·2% (−34·8 to −9·5)
High income	133 (122 to 146)	197 (182 to 213)	−32·5% (−39·9 to −24·1)	149 (132 to 168)	170 (154 to 187)	−12·6% (−25·7 to 2·9)	282 (254 to 314)	367 (336 to 400)	−23·3% (−33·4 to −11·5)
Latin America and Caribbean	68·5 (59·2 to 80·5)	86·8 (79·8 to 94·4)	−21·1% (−33·5 to −5·4)	76·1 (68·4 to 84·8)	75·5 (68·9 to 82·8)	0·8% (−13·7 to 17·8)	145 (128 to 164)	162 (149 to 177)	−10·9% (−23·9 to 4·3)
North Africa and Middle East	131 (119 to 146)	75·6 (68·5 to 83·0)	73·7% (50·0 to 102·6)	116 (104 to 130)	68·2 (61·2 to 75·5)	70·3% (45·3 to 100·8)	247 (223 to 276)	144 (130 to 158)	72·1% (47·8 to 101·8)
South Asia	318 (283 to 357)	264 (245 to 283)	20·7% (5·0 to 39·4)	322 (295 to 353)	233 (215 to 252)	38·6% (20·8 to 59·5)	641 (578 to 709)	496 (460 to 534)	29·1% (12·8 to 48·5)
Sub-Saharan Africa	121 (105 to 140)	63·9 (56·4 to 72·3)	90·0% (55·8 to 132·1)	113 (97·8 to 130)	54·1 (46·9 to 62·2)	108·6% (69·5 to 159·6)	234 (202 to 270)	118 (103 to 135)	98·5% (62·0 to 144·4)

Count data are presented to 3 significant figures.

Table 1: **Second-hand smoke age-standardised prevalence (A) and population exposed (B) by sex and percentage change between 1990 and 2023**

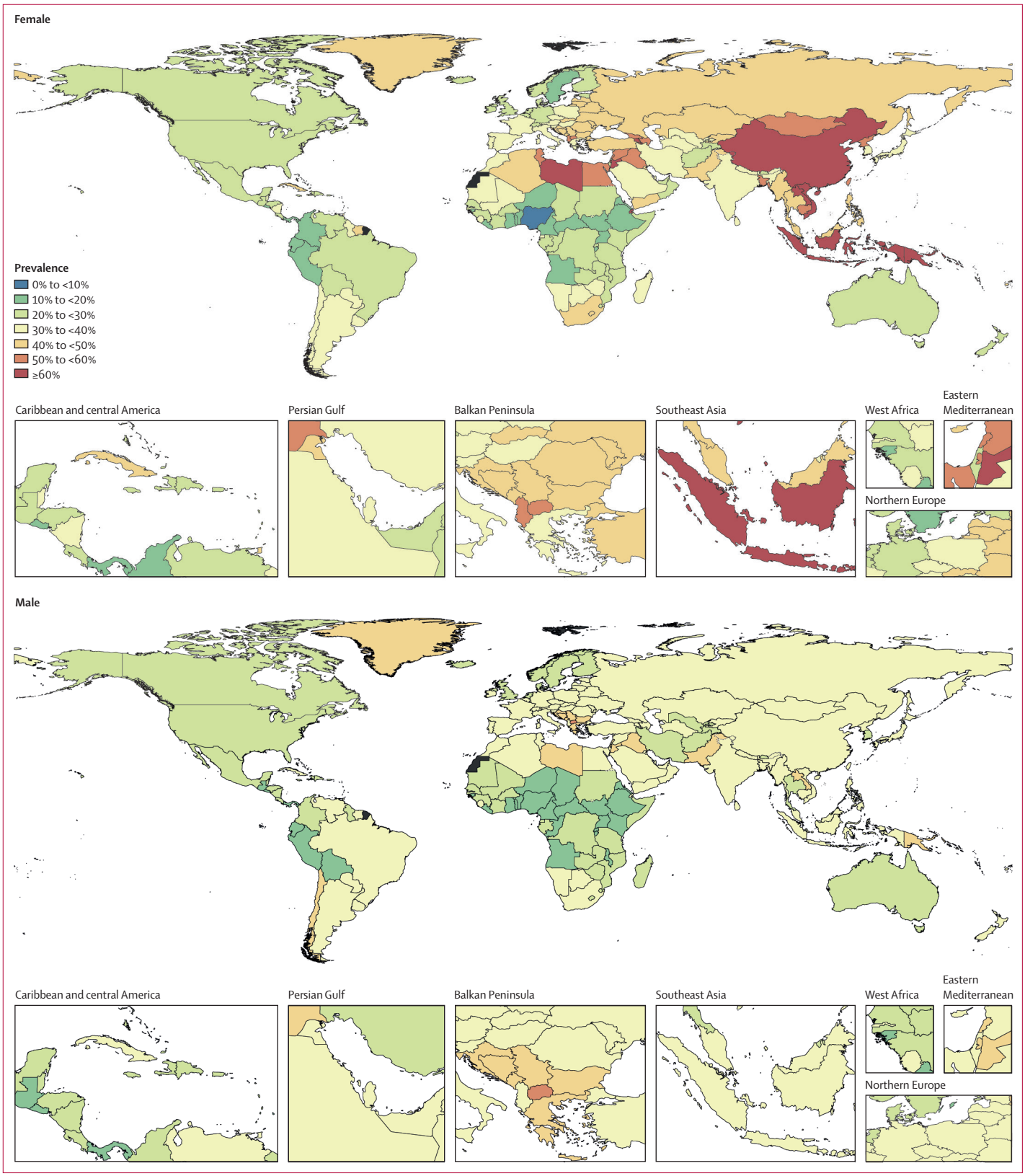

Figure 1: **Age-standardised prevalence of second-hand smoke by sex, in 2023**
Estimates are shown for 204 countries and territories, age-standardised to the GBD 2023 world standard population. GBD=The Global Burden of Diseases, Injuries, and Risk Factors Study.

(34·9% [8·8–61·2]); and sub-Saharan Africa (32·0% [0·4–68·4]; appendix pp 73–88).

SHS exposure was also associated with 39·1 million YLLs (95% UI 31·4–48·1), 5·73 million YLDs (3·83–7·50), and 44·8 million DALYs (35·8–54·3) globally in 2023 (table 2). Children and adolescents bore a substantial share: 5·21 million YLLs (3·53–7·16), 341 000 YLDs (204 000–547 000), and 5·55 million DALYs (3·85–7·47). Globally, SHS accounted for 1·60% (1·28–1·98) of all-age, all-cause DALYs and was the 16th leading risk factor for disease burden (appendix p 22), with an age-standardised DALY rate of 521·8 (416·6–633·3) per 100 000 (table 2). The highest age-standardised DALY rate was in South Asia (814·1 [649·9–1009·1] per 100 000), followed by North Africa and the Middle East (719·3 [579·5–871·5] per 100 000) and southeast Asia, east Asia, and Oceania (595·8 [474·9–724·2] per 100 000; table 2). In 2023, SHS ranked among the ten leading level 3 risk factors for DALYs in North Africa and the Middle East and among female individuals in southeast Asia, east Asia, and Oceania (appendix p 22).

All ten countries with the highest age-standardised DALY rates were in southeast Asia, east Asia, and Oceania,

	N, millions (95% UI)			Age-standardised rate per 100 000 (95% UI)		
	Female	Male	Both sexes	Female	Male	Both sexes
Deaths						
Global	0·868 (0·689 to 1·080)	0·791 (0·633 to 0·991)	1·66 (1·33 to 2·07)	17·8 (14·1 to 22·1)	20·0 (15·9 to 25·1)	18·8 (15·0 to 23·4)
Southeast Asia, East Asia, and Oceania	0·393 (0·304 to 0·490)	0·296 (0·229 to 0·371)	0·689 (0·545 to 0·861)	25·4 (19·7 to 31·6)	23·3 (17·8 to 29·6)	24·5 (19·3 to 30·7)
Central Europe, Eastern Europe, and Central Asia	0·0664 (0·0494 to 0·0833)	0·0587 (0·0458 to 0·0730)	0·125 (0·0952 to 0·157)	16·4 (12·1 to 20·6)	24·0 (18·6 to 29·8)	19·6 (14·8 to 24·6)
High income	0·0569 (0·0423 to 0·0732)	0·0811 (0·0639 to 0·101)	0·138 (0·107 to 0·175)	4·1 (3·1 to 5·1)	8·0 (6·3 to 9·9)	5·8 (4·6 to 7·3)
Latin America and Caribbean	0·0339 (0·0255 to 0·0432)	0·0411 (0·0330 to 0·0502)	0·0750 (0·0593 to 0·0922)	9·5 (7·2 to 12·1)	14·6 (11·8 to 17·9)	11·8 (9·3 to 14·5)
North Africa and Middle East	0·0595 (0·0468 to 0·0740)	0·0604 (0·0482 to 0·0751)	0·120 (0·0965 to 0·147)	28·8 (22·2 to 35·7)	30·1 (23·7 to 37·7)	29·5 (23·5 to 36·5)
South Asia	0·216 (0·168 to 0·276)	0·212 (0·165 to 0·268)	0·428 (0·347 to 0·537)	30·9 (23·8 to 39·6)	32·6 (25·4 to 41·6)	31·7 (25·7 to 40·2)
Sub-Saharan Africa	0·0424 (0·0317 to 0·0555)	0·0416 (0·0307 to 0·0552)	0·084 (0·0620 to 0·108)	12·8 (9·6 to 16·4)	14·2 (10·7 to 18·5)	13·4 (10·2 to 17·2)
DALYs						
Global	22·8 (18·0 to 27·4)	22·1 (17·7 to 27·3)	44·8 (35·8 to 54·3)	506·1 (402·5 to 611·9)	540·3 (433·9 to 672·3)	521·8 (416·6 to 633·3)
Southeast Asia, East Asia, and Oceania	9·21 (7·41 to 11·0)	7·12 (5·59 to 8·84)	16·3 (13·0 to 19·7)	637·7 (512·9 to 761·0)	551·3 (430·6 to 686·8)	595·8 (474·9 to 724·2)
Central Europe, Eastern Europe, and Central Asia	1·46 (1·14 to 1·83)	1·58 (1·25 to 1·94)	3·04 (2·38 to 3·78)	444·2 (349·8 to 556·7)	643·8 (504·8 to 793·8)	531·7 (416·2 to 662·2)
High income	1·34 (1·03 to 1·66)	2·06 (1·65 to 2·51)	3·40 (2·68 to 4·17)	136·7 (105·1 to 163·5)	234·6 (187·6 to 283·0)	182·7 (144·1 to 219·4)
Latin America and Caribbean	0·903 (0·684 to 1·12)	1·16 (0·934 to 1·41)	2·06 (1·63 to 2·52)	266·3 (202·7 to 330·2)	394·1 (317·5 to 482·4)	325·5 (256·9 to 398·3)
North Africa and Middle East	1·75 (1·40 to 2·13)	1·86 (1·51 to 2·28)	3·61 (2·90 to 4·38)	705·5 (561·8 to 854·6)	732·5 (587·7 to 899·7)	719·3 (579·5 to 871·5)
South Asia	6·19 (4·81 to 7·76)	6·31 (4·96 to 7·91)	12·5 (9·95 to 15·5)	799·6 (624·5 to 999·5)	830·1 (654·5 to 1035·7)	814·1 (649·9 to 1009·1)
Sub-Saharan Africa	1·91 (1·41 to 2·55)	1·99 (1·42 to 2·78)	3·90 (2·85 to 5·13)	408·7 (304·3 to 527·8)	443·1 (335·9 to 582·3)	425·1 (322·7 to 543·1)
YLDs						
Global	3·23 (2·18 to 4·20)	2·51 (1·65 to 3·30)	5·73 (3·83 to 7·50)	70·3 (47·4 to 91·5)	59·0 (38·7 to 77·7)	64·7 (43·2 to 84·6)
Southeast Asia, East Asia, and Oceania	1·37 (0·941 to 1·76)	0·741 (0·477 to 1·00)	2·11 (1·42 to 2·75)	93·3 (63·7 to 121·7)	55·8 (35·9 to 75·3)	74·9 (50·2 to 98·9)
Central Europe, Eastern Europe, and Central Asia	0·225 (0·152 to 0·299)	0·157 (0·103 to 0·212)	0·382 (0·255 to 0·516)	66·4 (44·0 to 87·9)	61·1 (39·6 to 81·7)	63·4 (41·7 to 85·2)
High income	0·341 (0·229 to 0·448)	0·419 (0·278 to 0·558)	0·760 (0·506 to 1·00)	43·8 (29·5 to 57·6)	56·4 (37·0 to 75·1)	49·8 (33·0 to 66·4)
Latin America and Caribbean	0·171 (0·111 to 0·241)	0·163 (0·106 to 0·225)	0·334 (0·217 to 0·464)	50·8 (32·8 to 72·0)	54·6 (35·4 to 75·9)	52·5 (33·9 to 73·7)
North Africa and Middle East	0·310 (0·206 to 0·424)	0·257 (0·169 to 0·359)	0·567 (0·376 to 0·783)	112·2 (75 to 153·0)	88·6 (58·7 to 122·7)	100·0 (66·7 to 137·2)
South Asia	0·664 (0·444 to 0·890)	0·646 (0·428 to 0·865)	1·31 (0·867 to 1·75)	81·1 (54·0 to 109·4)	80·4 (53·1 to 110·3)	80·7 (53·6 to 109·4)
Sub-Saharan Africa	0·149 (0·0990 to 0·198)	0·124 (0·0824 to 0·165)	0·273 (0·182 to 0·363)	37·6 (25·3 to 49·4)	34·2 (22·7 to 44·5)	36·0 (24·1 to 47·0)

(Table 2 continues on next page)

	N, millions (95% UI)			Age-standardised rate per 100 000 (95% UI)		
	Female	Male	Both sexes	Female	Male	Both sexes
(Continued from previous page)						
YLLs						
Global	19·5 (15·4 to 23·9)	19·6 (15·5 to 24·5)	39·1 (31·4 to 48·1)	435·9 (340·8 to 534·9)	481·3 (379·5 to 606·1)	457·1 (369·9 to 561·4)
Southeast Asia, East Asia, and Oceania	7·85 (6·27 to 9·52)	6·37 (5·01 to 7·91)	14·2 (11·4 to 17·4)	544·4 (432·2 to 657·3)	495·5 (390·1 to 622·1)	520·9 (417·3 to 637·0)
Central Europe, Eastern Europe, and Central Asia	1·24 (0·935 to 1·56)	1·42 (1·12 to 1·76)	2·66 (2·06 to 3·33)	377·9 (281·7 to 478·0)	582·8 (454·1 to 727·1)	468·3 (357·7 to 587·2)
High income	0·999 (0·768 to 1·25)	1·64 (1·32 to 2·01)	2·64 (2·10 to 3·27)	92·9 (73·6 to 114·4)	178·2 (144·3 to 217·7)	132·9 (107·2 to 161·7)
Latin America and Caribbean	0·732 (0·558 to 0·920)	0·994 (0·801 to 1·22)	1·73 (1·36 to 2·14)	215·5 (165·1 to 271·4)	339·5 (273·0 to 417·8)	273·0 (214·4 to 338·7)
North Africa and Middle East	1·44 (1·14 to 1·79)	1·60 (1·25 to 2·01)	3·05 (2·45 to 3·77)	593·3 (473·1 to 736·7)	643·9 (508·1 to 802·4)	619·3 (496·0 to 762·5)
South Asia	5·52 (4·31 to 6·96)	5·66 (4·42 to 7·23)	11·2 (9·05 to 13·8)	718·5 (565·3 to 907·2)	749·7 (583·5 to 951·7)	733·4 (588·8 to 911·9)
Sub-Saharan Africa	1·76 (1·29 to 2·38)	1·87 (1·30 to 2·66)	3·63 (2·58 to 4·83)	371·1 (275·2 to 488·8)	408·9 (302·5 to 539·8)	389·1 (286 to 502·0)

Count data are presented to 3 significant figures. DALY=disability-adjusted life-year. YLD=years lived with disability. YLL=years of life lost.

Table 2: **Number and age-standardised rate of deaths, DALYs, YLDs, and YLLs attributable to second-hand smoke by sex in 2023**

led by Nauru (3429·1 [2703·1–4267·9] per 100 000), Solomon Islands (2823·9 [2296·6–3459·8] per 100 000), and Tuvalu (2514·3 [2015·2–3052·6] per 100 000). Outside this super-region, the highest rates were in Azerbaijan (1304·8 [988·4–1610·3] per 100 000), Egypt (1226·4 [939·4–1536·9] per 100 000), and Bangladesh (1148·8 [893·9–1433·9] per 100 000; appendix pp 89–104). Despite higher female exposure prevalence, DALYs were approximately equally distributed between sexes (22·8 million [18·0–27·4] among females; 22·1 million [17·7–27·3] among males), reflecting sex-specific differences in the background burden of the diseases linked to SHS (table 2). However, country-level patterns varied: when ranked by age-standardised SHS-attributable DALY rate, Timor-Leste, Bangladesh, Indonesia, Pakistan, and Maldives were among the top 20 countries by female rates but not by male rates, while Palau, Vanuatu, Turkmenistan, Lesotho, and Uzbekistan were among the top 20 by male rates but not by female rates (figure 2; appendix pp 89–104).

The global age-standardised DALY rate decreased by 53·1% (44·9–60·9) between 1990 and 2023, with reductions across all super-regions (appendix pp 89–104), and the absolute number of DALYs declined by 15·8% (0·5–30·5). Absolute DALYs declined across all super-regions except South Asia, sub-Saharan Africa, and North Africa and the Middle East, where they remained stable (appendix pp 105–120). The global DALY decline was driven primarily by YLLs: the age-standardised rate declined 56·0% (48·6–63·5), with a corresponding reduction in absolute YLLs of 21·8% (7·2–35·3). In contrast, the age-standardised YLD rate did not change substantially over the same period (–12·9% [–25·5 to 2·1]) and the absolute number of YLDs rose by 74·5% (49·8 to 106·3; appendix p 121). With these trends, the share of total SHS-attributable DALYs accounted for by YLLs declined from 93·3% in 1990 to 87·6% in 2023, reflecting both lower mortality from the major SHS-attributable conditions and increased survivorship with morbidity.

Among the nine outcomes, ischaemic heart disease had the largest age-standardised DALY rate in 2023 at 132·5 (102·8–167·5) per 100 000, representing 12·0 million (9·31–15·2 million) DALYs in total, followed by lower respiratory infections (114·3 per 100 000 [78·8–154·3]), COPD (85·3 [43·2–130·4]), and stroke (71·5 [48·4–94·0]; figure 3; appendix pp 122–125). The leading causes of global SHS-attributable DALY burden were similar for males and females (appendix pp 122–125). Among children and adolescents, three outcomes contributed to DALYs: lower respiratory infections led at 254·6 (171·8–351·4) per 100 000, followed by asthma (17·3 [10·3–27·4] per 100 000) and otitis media (2·1 [0·9–3·9] per 100 000; figure 3). Asthma accounted for 3·4% of total SHS-attributable DALYs globally, with a higher contribution among children and adolescents (6·3%). Cause-specific patterns varied across super-regions: in southeast Asia, east Asia, and Oceania, ischaemic heart disease contributed the largest share of DALYs, followed by stroke. In the high-income super-region, tracheal, bronchus, and lung cancer was the second leading cause after ischaemic heart disease. In South Asia, COPD was the leading cause (226·2 per 100 000 [114·3–352·1]); and in sub-Saharan Africa, lower respiratory infections accounted for the largest burden (174·7 per 100 000 [116·0–244·3]; figure 3; appendix pp 122–125). From the cause side, over 10% of global COPD DALYs and over 8% of tracheal, bronchus, and lung cancer DALYs were attributable to SHS in 2023, the largest proportional contributions among the major

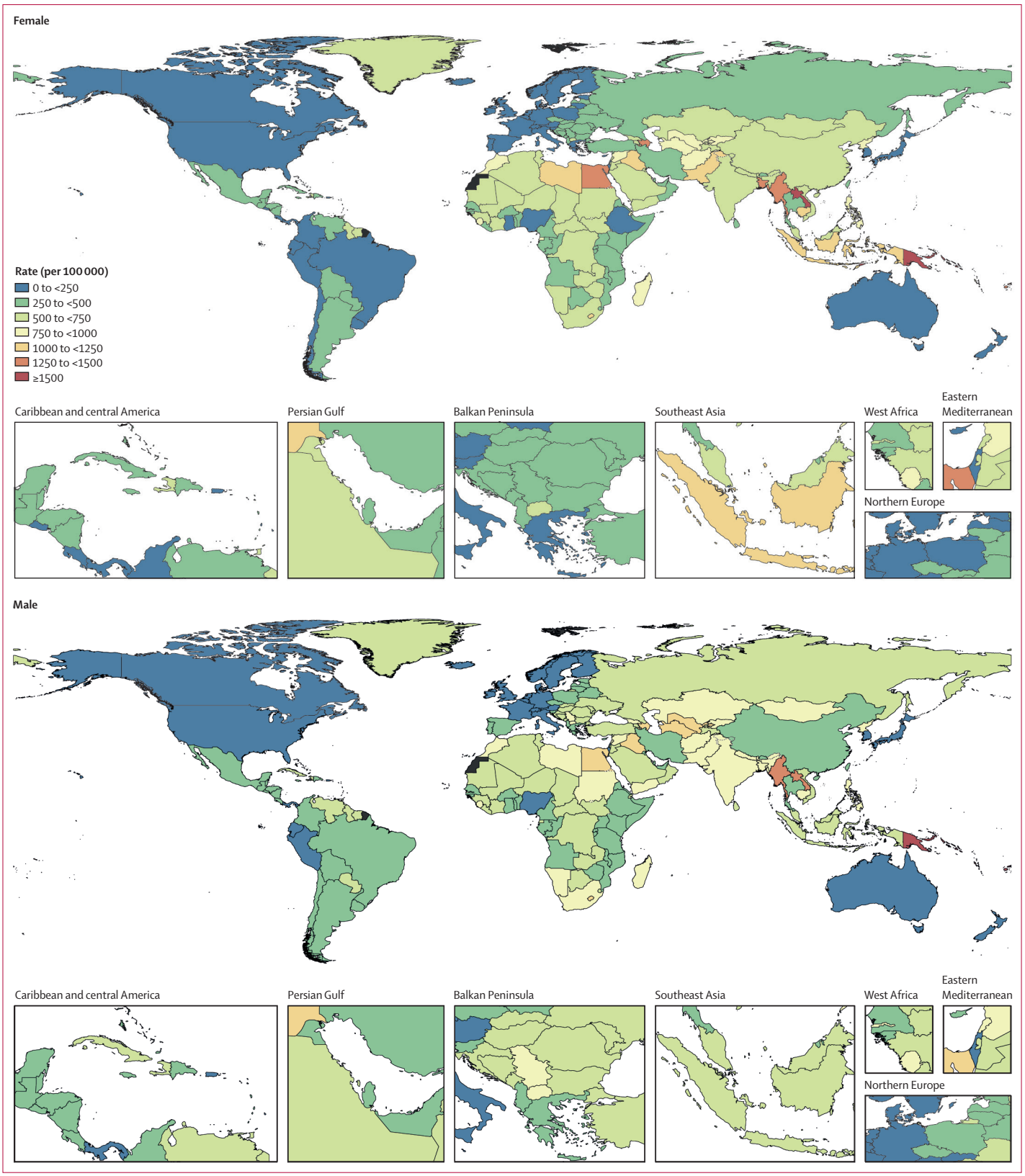

Figure 2: **Age-standardised rate of DALYs attributable to second-hand smoke by sex, in 2023**
Estimates are shown for 204 countries and territories, age-standardised to the GBD 2023 world standard population. GBD=The Global Burden of Diseases, Injuries, and Risk Factors Study.

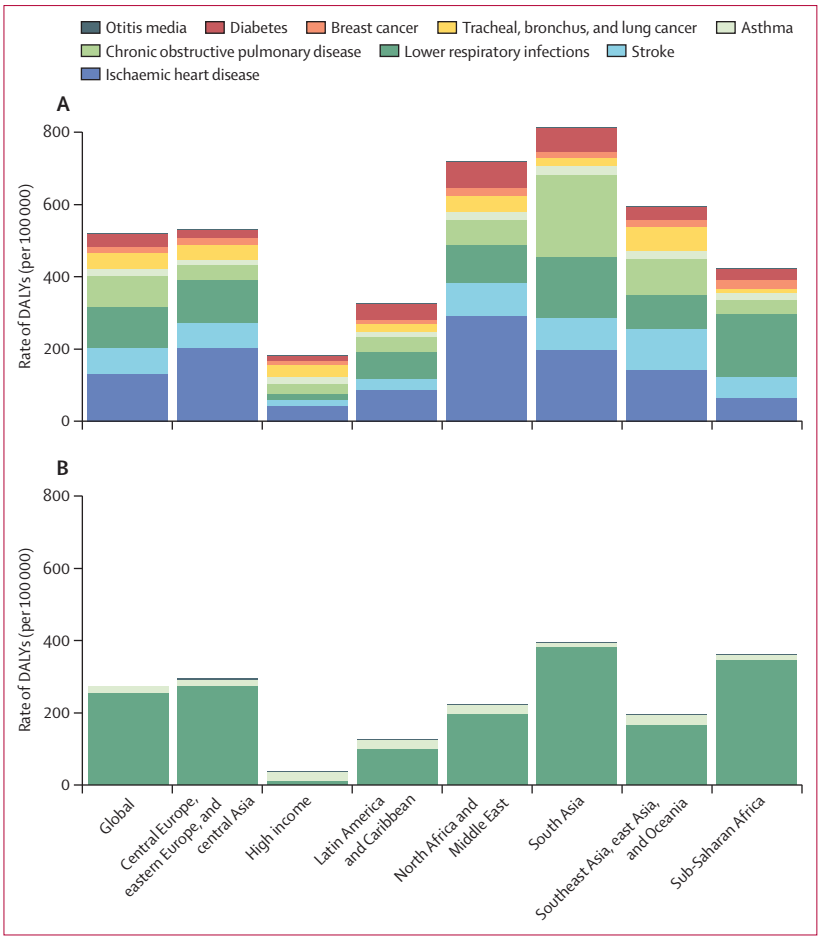

Figure 3: **Global and regional DALY rates attributable to second-hand smoke by cause, 2023: age-standardised rates for all ages (A) and age-specific rates for children aged 0–14 years (B)**
Bar heights represent cause-specific DALY rates attributable to second-hand smoke in the respective populations, globally and in each of the seven GBD super-regions. DALY=disability-adjusted life year. GBD=The Global Burden of Diseases, Injuries, and Risk Factors Study.

SHS-attributable conditions (appendix p 23). For mortality, ischaemic heart disease was again the leading cause of SHS-attributable deaths (537 000 [416 000–675 000]), followed by COPD (354 000 [175 000–551 000]); stroke (278 000 [188 000–364 000]); lower respiratory disease (185 000 [127 000–246 000]); and tracheal, bronchus, and lung cancer (161 000 [128 000–198 000]), with a similar ordering between male and female individuals.

Discussion

This study provides updated quantitative insights into the global prevalence, mortality, and disability associated with SHS exposure by age and sex from 1990 to 2023. Over these 33 years, age-standardised prevalence declined from 43·6% (39·9–47·3) to 33·9% (30·5–37·8), a relative reduction of 22·2% (10·6–32·4), yet population growth kept the absolute number of individuals exposed broadly stable. Marked geographical disparities persist, with prevalence approaching 50% in southeast Asia, east Asia, and Oceania. Children and female individuals also remain disproportionately exposed—767 million (687–858) children aged 0–14 years and 1·49 billion (1·35–1·65) female individuals were exposed to SHS in 2023. SHS exposure was associated with ischaemic heart disease, lower respiratory infections, COPD, and other diseases, accounting for 1·66 million (1·33–2·07) deaths, 39·1 million (31·4–48·1) YLLs, 5·73 million (3·83–7·50) YLDs, and 44·8 million (35·8–54·3) DALYs in 2023. The age-standardised DALY rate fell more than twice as fast as exposure prevalence, reflecting concurrent declines in the background rates of the SHS-attributable diseases rather than reduced exposure alone. These findings underscore the persistent gap in protecting non-smokers from the harms of SHS.

Reducing population exposure to SHS is a cornerstone of global tobacco control efforts. Progress under Article 8 of the FCTC and the WHO MPOWER framework, whose protect component directly addresses SHS, has been measurable but uneven.[15] As of 2024, 79 countries have achieved the highest standard in the protect measure, with all public places completely smoke-free or at least 90% of the population covered by comprehensive subnational legislation, despite ongoing variability in compliance. Consequently, the proportion of the global population covered by comprehensive smoke-free legislation has increased from 3% in 2007 to 33% in 2024, now covering 2·6 billion people.[8]

The Americas stand out for both the scale of policy implementation and the magnitude of estimated reductions in exposure. Of the 79 countries attaining the highest level of achievement in smoke-free protections globally, 24 are in the Americas, approximately 70% of the countries in that region.[8] In this study, we estimated the greatest age-standardised reduction in SHS exposure prevalence for Latin America and the Caribbean, at –38·0% (–47·4 to –27·1) since 1990. These reductions coincide with the progressive adoption of comprehensive smoke-free legislation following WHO FCTC ratification and, although this study is not a formal policy impact evaluation, the timing of these reductions is consistent with regional evidence linking smoke-free laws to lower SHS exposure and fewer tobacco-attributable hospitalisations,[16–19] a trend also observed across high-income countries.[20]

Beyond smoke-free legislation, broader tobacco control measures are needed to reduce SHS exposure, offset population growth, and lessen the resulting public health burden. SHS exposure prevalence mirrors the rates and trends of active smoking, with persistently high, and in some cases increasing, numbers of smokers in many LMICs. China, India, and Indonesia, which together account for almost half of the global population exposed to SHS, have the highest smoking prevalences globally.[21] Accelerating the decline in smoking would lower future SHS exposure and its largely preventable burden.[22] Although smoke-free policies directly reduce SHS exposure and indirectly support smoking cessation by

shifting social norms,[23,24] additional measures such as tobacco taxation, marketing bans, plain packaging, and cessation programmes are needed to deter smoking initiation and lower smoking prevalence.[25,26] Investment and policy innovation in LMICs have advanced in recent years,[27] but many countries continue to face ongoing industry interference that exploits weak regulatory systems.[28]

Accelerating this broader agenda is important to ensure that declines in age-standardised exposure translate into reductions in the absolute SHS-attributable burden. Although age-standardised prevalence declined globally, population growth has expanded the absolute number exposed in several super-regions—most notably sub-Saharan Africa, where the absolute number of individuals exposed has nearly doubled. Reductions in exposure have contributed to falling burden rates, but the same demographic shifts have sustained, and in some regions expanded, the absolute SHS-attributable burden. Interpreting progress therefore requires both metrics: the decline in age-standardised prevalence reflects success in lowering individual risk, whereas the stable or rising absolute number of people exposed defines the scale of the remaining public health task and should guide priority setting. Sustaining progress will require continued and accelerated action on both exposure reduction and the strengthening of health systems that treat SHS-attributable diseases.

Recognising the magnitude of the SHS-attributable health burden is important to direct protections towards populations at greatest risk, given the marked demographic inequalities in how this burden is distributed. Children aged 0–14 years accounted for more than 12% of SHS-attributable DALYs in 2023. Although we estimated the largest relative reduction in age-standardised prevalence among children, exposure in this age group remains widespread, reflecting persistent gaps in protecting children in the settings where they spend most of their time. Young children are most often exposed in private settings such as homes and vehicles,[29,30] where legislation is limited and exposure is largely driven by individuals' knowledge, awareness, and perceived norms,[31] whereas adolescents are more frequently exposed in public places,[32] where compliance with smoke-free measures remains insufficient.[8] Exposure to SHS among children and adolescents is closely correlated with parental and peer smoking,[33,34] pointing to the importance of targeted cessation interventions in paediatric care and community settings,[35] alongside school-based health-education programmes that address both SHS exposure awareness and smoking prevention.

Female individuals are also disproportionately exposed, comprising more than half of those exposed globally.[36] Particularly in locations where active smoking prevalence among women remains low,[21] SHS represents a substantial component of the tobacco-related health risk profile for women. This sex gap in exposure reflects both high male household smoking and the limited agency many women have to enforce smoke-free rules in private settings. As noted, total SHS-attributable DALYs in 2023 were approximately balanced between sexes, a near-parity resulting from sex-specific differences in the background mortality and morbidity of the SHS-linked diseases, rather than equivalence in exposure. Globally, the absolute health loss attributable to SHS among women is comparable to the burden of active smoking and larger than that attributable to other major risk factors such as low physical activity and high alcohol use.[1] For specific outcomes, the female SHS burden exceeded the smoking-attributable burden: SHS-attributable DALYs from lower respiratory infections in female individuals were nearly five times those attributable to active smoking, and for cardiovascular disease (ischaemic heart disease and stroke combined), the estimated nine million DALYs in female individuals were 1·4 times the smoking-attributable number.[1] These comparisons reflect the distribution of exposure rather than any intrinsic difference in toxicity. Despite this substantial burden, SHS exposure remains rarely acknowledged as a major risk factor for female health.[37,38] Two policy implications follow. First, persistent industry efforts to recruit female smokers through gender-targeted marketing and product design, especially in emerging markets and LMICs,[39] need to be countered: narrowing the sex gap in exposure by turning non-smoking women into active smokers would replace one form of tobacco harm with another. Second, because SHS exposure ultimately reflects the smoking of others, sustained reductions in overall active smoking remain necessary to protecting women from SHS-attributable harm.

Several limitations of this study should be considered. First, SHS exposure in this study was operationalised as current exposure at home or at work, so exposure occurring exclusively in other settings is not captured.[40,41] Most surveys rely on self-reported data, which are subject to recall bias and under-reporting, particularly in transient settings where exposure might be sporadic or perceived as less consequential. RRs associated with intermittent exposure in public venues are unlikely to follow the patterns observed for sustained exposure at home or work. Objective biomarkers such as cotinine are rarely used at scale; therefore, exposure data, especially for public venues, are subject to misclassification and might underestimate the associated health risks.

Second, home exposure was estimated from household composition, assuming that all non-smokers and occasional smokers living with a daily smoker were exposed. This conservative assumption might over-estimate exposure where voluntary smoke-free home rules are common, although objective measurements show such rules do not reliably eliminate exposure.[42,43] Across European countries, the self-reported prevalence of smoke-free homes with at least one smoker has ranged from approximately 26% in Spain to 60% in England.[44] Conversely, our estimate might understate exposure

in multi-generational or extended-family households common in many LMICs, where the survey-defined household can miss exposure from non-resident relatives or shared housing areas.[36] The net direction of bias therefore probably differs across settings. Classifying occasional smokers within the at-risk population is unlikely to bias the headline estimates materially, as the RRs were derived predominantly from never-smokers,[6] isolating SHS from active-smoking risk, and occasional smokers represent only a small share of the at-risk population.

Third, in the absence of a scalable method for measuring continuous exposure, we operationalised SHS exposure as a dichotomous variable, which does not capture duration, frequency, or intensity. Because the typical SHS dose–response curve is steepest at low exposure, this approach attributes a relatively larger share of risk to individuals at the low end of the distribution. Additionally, a single uniform RR is applied across age, sex, and location for each risk–outcome pair, so between-location and between-year differences in burden are driven by variation in prevalence, whereas variation in biological susceptibility by age and sex is reflected in background disease rates.

Fourth, lagged exposure histories are not available in the GBD framework for SHS. Therefore, PAFs apply current-year exposure to current-year outcome rates. For outcomes with substantial latency—particularly lung cancer, and to a lesser extent ischaemic heart disease, stroke, and COPD—this attributes burden to current exposure that accumulated over decades, probably underattributing present-year burden where exposure has been declining.

Fifth, we examined nine health outcomes meeting the GBD inclusion threshold under the Burden of Proof framework,[6] which might not capture the total health loss from SHS; adverse pregnancy outcomes[47] and other outcomes such as cognitive impairment[45,46] are not included and warrant future work. This analysis also excludes involuntary exposure to aerosol from electronic nicotine delivery systems or heated tobacco products and to third-hand smoke residues.[48]

Finally, as across the GBD framework, data availability for SHS exposure varies across countries and time, with sparser coverage and greater uncertainty in many low-income and middle-income settings; therefore, estimates should be interpreted within their uncertainty intervals. Moreover, direct comparison across GBD cycles is not advised, as this cycle introduced multiple concurrent methodological improvements and the underlying cause-of-death and non-fatal estimates are also refined each cycle.

SHS exposure remains a substantial and inequitable contributor to the global disease burden. Although age-standardised exposure has declined over the past three decades, population growth has offset these improvements in several regions, sustaining the absolute population at risk. The SHS-attributable burden falls disproportionately on children, primarily through lower respiratory infections, and on women in settings where active smoking remains concentrated among men. Accelerated and sustained implementation and enforcement of comprehensive smoke-free legislation under FCTC Article 8, together with broader tobacco control measures to reduce active smoking, will be needed to translate progress in exposure prevalence into reductions in absolute disease burden, particularly in LMICs where exposure remains widespread.

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See the appendix (pp 155–165) for more detailed information about individual author contributions to the research, divided into the following categories: managing the overall research enterprise; writing the first draft of the manuscript; primary responsibility for applying analytical methods to produce estimates; primary responsibility for seeking, cataloguing, extracting, or cleaning data; designing or coding figures and tables; providing data or critical feedback on data sources; developing methods or computational machinery; providing critical feedback on methods or results; drafting the manuscript or revising it critically for important intellectual content; and managing the estimation or publications process. The lead (L S Flor) and senior (E Gakidou) authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.
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Data sharing

This study follows GATHER. For detailed information on data sources and estimates, please visit the Global Health Data Exchange GBD 2023 website at http://ghdx.healthdata.org/gbd-2023.

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