Global, regional, and national burden of unintentional poisoning, 1990–2023: results from the Global Burden of Disease Study 2023

*GBD 2023 Unintentional Poisoning Collaborators**

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Summary

Background Unintentional poisoning is a preventable cause of injury-related morbidity and mortality, yet global patterns, trends, and inequalities remain incompletely characterised. Within the Global Burden of Disease (GBD) framework, unintentional poisoning includes poisoning by carbon monoxide and poisoning by other means, a category largely informed by pesticide poisoning codes plus some indirect capture of other poisoning as part of the GBD re-distribution process. Poisonings by pharmaceuticals and illicit substances are not captured in the GBD definition of poisoning. We aimed to quantify this GBD-defined burden and assess regional variation, sociodemographic gradients, and case fatality between 1990 and 2023.

Methods We analysed GBD 2023 estimates for 204 countries and territories, modelling deaths, incidence, and disability-adjusted life-years (DALYs) using standard GBD cause-of-death and non-fatal estimation methods with 95% uncertainty intervals. We stratified results by age, sex, region, and Socio-demographic Index (SDI), and derived case fatality from modelled deaths and incidence.

Findings In 2023, unintentional poisoning from carbon monoxide and other means caused 2·54 million incident poisonings, 69 805 deaths, and 3·68 million DALYs globally, with age-standardised DALY rates declining by 47·5% since 1990. Carbon monoxide accounted for 641 932 poisonings, 30 890 deaths and 1·34 million DALYs, with the highest burdens in central and eastern Europe and central Asia. Most regions showed substantial long-term declines, and the global age-standardised DALY rate for carbon monoxide poisoning declined by 58·2% since 1990. Poisoning by other means caused 1·90 million incident cases, 38 914 deaths, and 2·34 million DALYs, with the greatest burden in sub-Saharan Africa. Most regions showed declining age-standardised DALY rates for poisoning by other means; however, there was no clear change (with the 95% uncertainty interval including zero) in the global estimate, driven by wide uncertainty intervals in several regions (including sub-Saharan Africa). Mortality and DALYs were inversely associated with SDI, and derived case fatality was highest in low-SDI regions.

Interpretation Global reductions in GBD-defined unintentional poisoning by carbon monoxide and other means are consistent with decades of regulatory and environmental interventions. These include bans of highly toxic pesticides, improved heating and ventilation systems, emissions controls, and adoption of carbon monoxide alarms. Stark inequalities persist in some regions and in low-SDI settings. Compared with previous GBD publications, this study provides a detailed global assessment of unintentional poisoning by carbon monoxide and other means up to 2023, integrating incidence, DALYs, and comparative case fatality across regions.

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Introduction

Poisoning is a global public health challenge affecting people of all ages and contributing substantially to morbidity and mortality worldwide.[1,2] The term poisoning encompasses a wide range of exposures, including exposures to household chemicals, toxic gases, agricultural chemicals, industrial agents, pharmaceuticals, recreational drugs, heavy metals, and plant or animal toxins.[3] Most poisonings are preventable, yet their epidemiology is highly heterogeneous.[1] Poisoning scenarios include accidental exposures in children due to exploratory behaviours, medication dosing or administration errors, intentional self-poisoning, misadventure following recreational substance use, and occupational and environmental exposures. This results in a complex interplay of social, economic, environmental, and behavioural factors that shape poisoning risks and outcomes globally.

Poisoning risk is strongly influenced by modifiable factors. These include the availability and regulation of toxic substances (including pesticides, industrial chemicals, pharmaceuticals, and fuels),[4] product formulation and packaging standards,[2] occupational practices, and housing conditions such as ventilation and

Research in context

Evidence before this study

We searched MEDLINE via Ovid for studies published between Jan 1, 1990, and Dec 31, 2025, using the terms "unintentional poisoning", "carbon monoxide poisoning", "pesticide poisoning", "mortality", "incidence", and "global burden" without language restrictions. We focused on carbon monoxide and pesticide poisoning as these are the best-captured poisoning types in the GBD framework. We prioritised population-based and multicountry analyses. Most available evidence comprised national or subnational studies, frequently focused on single agents or specific age groups, with heterogeneous case definitions and coding practices that limit comparability. One multicountry study examined carbon monoxide poisoning in five high-income countries, but the only global study was from a previous GBD round, and reported on carbon monoxide poisoning only, up to 2021. However, no peer-reviewed study has provided comprehensive global estimates of unintentional poisoning up to 2023, integrating deaths, incidence, disability-adjusted life-years (DALYs), sociodemographic gradients, and case fatality across regions and over time.

Added value of this study

Using GBD 2023 data for 204 countries and territories between 1990 and 2023, we provide a comprehensive assessment of unintentional poisoning from carbon monoxide and poisoning by other means, a category largely informed by pesticide poisoning codes, although its composition varies across locations because some deaths are reassigned from non-specific poisoning categories. This global assessment of unintentional poisoning adds poisoning by other means to a global picture that previously only included carbon monoxide poisoning; integrates incidence, DALYs, and comparative case fatality across regions and over time; and applies updated redistribution and excess-mortality modelling. The incidence, deaths, and DALY rates were found to have declined globally for carbon monoxide poisoning between 1990 and 2023, with no clear global change for poisoning by other means; rates of decline differed substantially between countries and regions, and many inequalities were found to still exist. We show that for unintentional poisoning, poisoning incidence is positively associated with Socio-demographic Index (SDI), whereas deaths and DALYs are negatively associated with SDI. High-income countries have the lowest case fatality whereas sub-Saharan Africa has the highest case fatality. Case fatality was derived from independently modelled deaths and incidence, rather than observed clinical case fatality data. These gradients are unlikely due to incidence alone and probably reflect differential ascertainment of non-fatal events in higher-SDI settings, in addition to differences in exposure patterns, toxicity of agents involved, care-seeking behaviour, and access to timely care.

Implications of all the available evidence

Despite substantial global reductions in age-standardised DALY rates from GBD-defined unintentional poisoning, marked inequalities persist. Although regulatory interventions, emissions controls, and bans of highly hazardous pesticides are associated with reduced DALY burden in many settings, gaps remain in product regulation, safe storage, occupational protection, and access to emergency and critical care. Strengthened surveillance, enforcement of pesticide bans, and sustained investment in poisoning prevention are required to reduce preventable deaths and narrow regional disparities. Poisoning by carbon monoxide and the pesticide-dominated poisoning category captured within the GBD framework represent only a subset of the true poisoning burden: unintentional pharmaceutical, alcohol, and illicit-substance poisonings are reclassified to substance-use disorders, and intentional poisonings are aggregated with self-harm. There is a need for high-quality global data on poisonings by all means (including pharmaceuticals, chemicals, and illicit substances), and by other intent types (particularly deliberate self-poisoning), to guide and evaluate public health interventions targeting poisoning.

heating systems.[5] Public health measures, including pesticide regulations, emissions controls, and withdrawal of dangerous pharmaceuticals, have shown substantial reductions in harms from poisoning in many countries.[4] Broader determinants, such as poverty, agricultural activity, health literacy, and access to emergency care, further shape poisoning risks and clinical outcomes.

Global data on poisoning remain fragmented, inconsistent, and difficult to compare across regions and over time. Most available evidence comes from single-centre or single-country studies, with only a small number of multicountry analyses present in the literature, largely limited to carbon monoxide poisoning in a previous Global Burden of Disease (GBD) round.[5,6] There is little understanding of how the burden of poisoning has changed over time and how burden and outcomes differ across geographical regions and sociodemographic contexts.

This study aimed to present comprehensive global estimates of unintentional poisoning using GBD 2023 estimates, for 204 countries and territories, between 1990 and 2023. Within the GBD framework, poisoning is captured under unintentional injuries (noting that intentional poisonings are aggregated with other non-firearm self-harm methods). Unintentional poisonings captured by GBD 2023 include poisoning by carbon monoxide and poisoning by other means. The majority of unintentional pharmaceutical, alcohol, and illicit substance poisonings are reclassified into substance use disorders. Poisoning by other means predominantly includes pesticide poisoning codes, plus some redistribution from other codes. As a result, this work focuses on global trends in unintentional carbon monoxide and pesticide poisonings, which are two poisoning subtypes that have been the focus of substantial public health interventions over recent

decades. We aimed to analyse long-term trends in poisoning deaths, incidence, and disability adjusted life-years (DALYs), by region, country, and Socio-demographic Index (SDI); to describe patterns by age, sex, and poisoning subtype; and to estimate case fatality rates and how they have changed over time. This manuscript was produced as part of the GBD Collaborator Network and in accordance with the GBD Protocol.[7]

Methods

Study overview

The GBD 2023 study estimated incidence, prevalence, mortality, years of life lost (YLLs), years lived with disability (YLDs), and DALYs (the sum of YLLs and YLDs) for 292 diseases and injuries across 204 countries and territories. The GBD study uses the best available data to model estimates for disease burden from a range of sources. This study presents GBD 2023 estimates for unintentional poisoning, which is a subset of the injuries category in the GBD hierarchy. An international network of collaborators provided, reviewed, and assessed the available data used to generate GBD 2023 estimates; across all metrics, GBD 2023 drew on the expertise of more than 14000 collaborators from more than 160 countries and territories. Methods for the GBD study, including the burden of disease from injuries, have been published elsewhere.[8,9] GBD 2023 estimates for poisoning were originally produced by the GBD 2023 Causes of Death Collaborators[8] and GBD 2023 Disease and Injury and Risk Factor Collaborators,[9] and shared publicly in the GBD Results Tool. This study assessed and presents details of these findings specific to poisoning, as defined by GBD.

Data inclusions for poisoning

In the GBD 2023 cause hierarchy, poisoning sits under unintentional injuries, and is defined as X47-X48·9 (ICD-10) and E856-E857·09, E860·2-E865·99, E867-E869·99, and E929·2 (ICD-9). It is further split into poisoning by carbon monoxide (X47-X47·9 [ICD-10] and E868-E869 [ICD-9]) and poisoning by other means (X48-X48·9 [ICD-10] and E856-E857·09, E860·2-E865·99, E867-E867·09, E869·0-E869·99, and E929·2 [ICD-9]).

The range of codes included in the GBD definition of poisoning is notably different from the code definitions for poisonings commonly used: X40–49 (accidental poisoning), X60–69 (intentional poisoning), and Y10–Y19 (poisonings with undetermined intent), and T36–50 (more detailed substance or mechanism), per ICD-10.[10–14] The majority of codes in these ranges are not captured under the GBD poisoning definition. Most accidental and undetermined intent poisoning codes are treated as so-called garbage codes and are redistributed according to methods that have been described previously.[15] Redistribution of accidental poisoning codes in people aged 15 years or older occurs into substance use disorder codes, whereas codes for people younger than 15 years are redistributed across several different GBD causes, including but not limited to poisoning-related causes. Intentional poisoning codes are captured under self-harm in the GBD and are aggregated with non-firearm suicides as self-harm by other means. These are out of the scope of this Article. Envenomation (X20–29) and adverse drug reactions (Y40-Y59) are also beyond our scope. Nature of injury codes relating to poisoning (T36-T65) are not used in the GBD cause hierarchy as they relate to the agents causing poisoning and do not differentiate by intent, which is required for the redistribution process.

GBD 2023 data inclusions and the redistribution of codes commonly used to describe poisoning are provided in table 1 and appendix 1 (pp 5–6, 12–14).

See Online for appendix 1

The poisoning by carbon monoxide code range also includes poisoning from other gases (eg, non-medicinal nitrous oxide and hydrogen sulphide) and unspecified gases. The poisoning by other means code range only contains pesticide codes by direct assignment; however, some other poisonings are sometimes captured in this category as part of garbage code redistribution. For the purposes of this Article, we have kept the GBD terms for consistency but have noted these caveats when relevant.

Data sources and processing

The data sources used to produce the GBD 2023 estimates are listed in the GBD 2023 Sources Tool; metadata and citations for the input data sources specific to this study are available by selecting "Causes of Death" and "Nonfatal Health Outcomes" for components, "Poisonings" for causes, and "Global" for locations. The primary data source for estimation of fatal poisonings is vital registration data. For non-fatal estimates, main sources include administrative data (eg, hospital admissions) and surveys. Poisons Information Centre data are not part of the standard GBD input stream and are not uniformly available globally. These data were therefore not included. Other studies on causes of death[8] and disease and injury[9] provide details on how the input data were processed (appendix 1 pp 5–36).

For the **GBD 2023 Sources Tool** see https://ghdx.healthdata.org/gbd-2023/sources

For the **GBD Results Tool** see https://vizhub.healthdata.org/gbd-results/

Fatal estimates for unintentional poisoning were generated using the Cause of Death Ensemble model (CODEm), which uses a diverse set of predictive covariates, most notably the Healthcare Access and Quality Index and SDI, to estimate mortality in data-sparse regions. For the subcause of poisoning by other means, estimates also incorporated fatal discontinuities to account for stochastic, high-mortality events (eg, mass poisoning incidents) identified through international databases. A detailed description of the CODEm framework, covariate influence, and fatal discontinuity identification hierarchy is provided in appendix 1 (pp 5–11) and in another GBD report.[8] For non-fatal poisonings, disease modelling meta-regression version 2.1, a Bayesian meta-regression framework, was used as described in the GBD disease, injuries and risk factors capstone paper (appendix 1 pp 11–36).[9] GBD non-fatal incidence estimates were

	ICD-10 codes relating to poisoning	Included in this study (yes or no; with elaboration)	Primary allocation in GBD 2023
Accidental poisoning with non-opioid analgesics	X40 (accidental poisoning by and exposure to non-opioid analgesics, antipyretics, and antirheumatics; includes paracetamol [acetaminophen], non-steroidal anti-inflammatory drugs [eg, ibuprofen], and salicylates)	No; garbage code level 1*, redistributed	Substance use disorders (eg, alcohol, cocaine, opioids, amphetamines, other drugs)†
Accidental poisoning by psychotropics	X41 (accidental poisoning by and exposure to antiepileptic, sedative-hypnotic, antiparkinsonism, and psychotropic drugs, not elsewhere classified; includes antidepressants, antipsychotics, benzodiazepines, barbiturates, psychostimulants, and anticonvulsants)	No; garbage code level 1, redistributed	Substance use disorders (eg, alcohol, cocaine, opioids, amphetamines, and other drugs)
Accidental poisoning by narcotics and hallucinogens	X42 (accidental poisoning by and exposure to narcotics and psychodysleptics [hallucinogens], not elsewhere classified; includes pharmaceutical and illicit opioids, cannabis, cocaine, lysergic acid diethylamide, mescaline)	No; garbage code level 1, redistributed	Substance use disorders (eg, alcohol, cocaine, opioids, amphetamines, and other drugs)
Accidental poisoning by autonomic nervous system drugs	X43 (accidental poisoning by and exposure to other drugs acting on the autonomic nervous system; includes anticholinergics, antimuscarinics, cholinergics, antiadrenergics, and adrenergics)	No; garbage code level 1, redistributed	Substance use disorders (eg, alcohol, cocaine, opioids, amphetamines, and other drugs)
Accidental poisoning by other and unspecified drugs	X44 (accidental poisoning by and exposure to other and unspecified drugs, medicaments, and biological substance; includes drugs affecting the cardiovascular system, gastrointestinal system, respiratory system, local anaesthetics, hormones, anti-infectives, haematological agents, therapeutic gases, vaccines, topical preparations, and diuretics)	No; garbage code level 1, redistributed	Substance use disorders (eg, alcohol, cocaine, opioids, amphetamines, and other drugs)
Accidental poisoning by alcohol	X45 (accidental poisoning by and exposure to alcohol; includes ethanol, methanol, isopropanol, and other alcohols)	No; reclassified	Alcohol use disorder
Accidental poisoning by solvents, hydrocarbons, and their vapours	X46 (accidental poisoning by and exposure to organic solvents and halogenated hydrocarbons and their vapours; includes benzene, trichloromethane, chlorofluorocarbons, petroleum, and derivatives)	No; garbage code level 1, redistributed	Substance use disorders (eg, alcohol, cocaine, opioids, amphetamines, and other drugs)
Accidental poisoning by gases	X47·0 (accidental poisoning by and exposure to carbon monoxide from combustion engine exhaust); X47·1 (accidental poisoning by and exposure to carbon monoxide from utility gas); X47·2 (accidental poisoning by and exposure to carbon monoxide from other domestic fuels); X47·3 (accidental poisoning by and exposure to carbon monoxide from other sources); X47·4 (accidental poisoning by and exposure to carbon monoxide from unspecified sources); X47·8 (accidental poisoning by and exposure to other specified gases and vapours; includes non-medicinal helium, tear gas, nitrogen oxides, sulphur dioxide); X47·9 (accidental poisoning by and exposure to unspecified gases and vapours)	Yes; included in this study	Poisoning by carbon monoxide
Accidental poisoning by pesticides	X48·0–X48·9 (accidental poisoning by and exposure to pesticides)	Yes; included in this study	Poisoning by other means
Accidental poisoning by other and unspecified chemicals	X49·0–X49·9 (accidental poisoning by and exposure to other and unspecified chemicals and noxious substances; includes corrosives, adhesives, paints, dyes, fertilisers, detergents, poisonous plants)	No; garbage code level 1, redistributed	Substance use disorders (eg, alcohol, cocaine, opioids, amphetamines, and other drugs)
Envenomation	X20 (contact with venomous snakes and lizards); X21 (contact with venomous spiders); X22 (contact with scorpions); X23 (contact with hornets, wasps, and bees); X24 (contact with centipedes and venomous millipedes); X25 (contact with other venomous arthropods); X26 (contact with venomous marine animals and plants); X27 (contact with other specified venomous animals); X28 (contact with other specified venomous plants; includes injection through thorns or spines only; poisonous plant ingestion is X49); X29 (contact with unspecified venomous animal or plant)	No; out of scope for this study	Venomous animal contact

(Table 1 continues on next page)

modelled using available hospital, outpatient, and survey data, and other data sources, with adjustments made for health-care access and care-seeking when applicable. These estimates should therefore be interpreted as modelled poisoning incidence rather than directly observed counts of all poisoning exposures.

Calculating uncertainty

Uncertainty was introduced throughout the estimation process. Mean estimates for all other metrics reported represent the mean value across 250 draws from the estimate's distribution, with 95% uncertainty intervals (UIs) calculated as the 2·5 and 97·5 percentile values across the draws. To reduce computing power and time across the estimation process, the number of draws was reduced from 500 in previous GBD iterations to 250 for GBD 2023. Simulations confirmed that estimates and uncertainty were not affected by this reduction.[9]

Data analysis

GBD estimates on poisonings were downloaded from the GBD results tool and analysed with R version 4.5.2. Outcome measures were absolute numbers and age-standardised rates per 100 000 of incidence, deaths, and DALYs. DALYs were used to quantify disease burden. One DALY represents the loss of the equivalent of 1 year of full health. DALYs are the sum of YLLs due to premature mortality and YLDs. Further information on the methodology are published elsewhere.[8,9] We stratified our analysis by age and sex, country, GBD super-region (related regions clustered on the basis of cause-of-death patterns),[16] and SDI (which indicates social and economic conditions that correlated with health outcomes),[17]

	ICD-10 codes relating to poisoning	Included in this study (yes or no; with elaboration)	Primary allocation in GBD 2023
(Continued from previous page)			
Intentional self-poisoning with pharmaceuticals, illicit drugs	X60 (intentional self-poisoning by and exposure to non-opioid analgesics, antipyretics, and antirheumatics); X61 (intentional self-poisoning by and exposure to antiepileptic, sedative-hypnotic, antiparkinsonism, and psychotropic drugs, not elsewhere classified); X62 (intentional self-poisoning by and exposure to narcotics and psychodysleptics [hallucinogens], not elsewhere classified); X63 (intentional self-poisoning by and exposure to other drugs acting on the autonomic nervous system); X64 (intentional self-poisoning by and exposure to other and unspecified drugs, medicaments, and biological substances)	No; poisoning not able to be disaggregated, combined with other non-firearm means of self-harm	Self-harm
Intentional self-poisoning with alcohols	X65 (intentional self-poisoning by and exposure to alcohol)	No; re-classified	Alcohol use disorder
Intentional self-poisoning with chemicals and gases	X66 (intentional self-poisoning by and exposure to organic solvents and halogenated hydrocarbons and their vapours); X67 (intentional self-poisoning by and exposure to carbon monoxide and other gases and vapours); X68 (intentional self-poisoning by and exposure to pesticides); X69 (intentional self-poisoning by and exposure to other and unspecified chemicals and noxious substances)	No; poisoning not able to be disaggregated, combined with other non-firearm means of self-harm	Self-harm
Poisonings of undetermined intent	Y10 (poisoning by and exposure to non-opioid analgesics, antipyretics, and antirheumatics, undetermined intent); Y11 (poisoning by and exposure to antiepileptic, sedative-hypnotic, antiparkinsonism, and psychotropic drugs, not elsewhere classified, undetermined intent); Y12 (poisoning by and exposure to narcotics and psychodysleptics [hallucinogens], not elsewhere classified, undetermined intent); Y13 (poisoning by and exposure to other drugs acting on the autonomic nervous system, undetermined intent); Y14 (poisoning by and exposure to other and unspecified drugs, medicaments, and biological substances, undetermined intent); Y15 (poisoning by and exposure to alcohol, undetermined intent); Y16 (poisoning by and exposure to organic solvents and halogenated hydrocarbons and their vapours, undetermined intent); Y17 (poisoning by and exposure to carbon monoxide and other gases and vapours, undetermined intent); Y18 (poisoning by and exposure to pesticides, undetermined intent); Y19 (poisoning by and exposure to other and unspecified chemicals and noxious substances, undetermined intent)	No; garbage code level 1, redistributed.	Redistributed amongst other external causes (including non-poisonings)‡
Adverse drug reactions	Y40–Y59 (drugs, medicaments, and biological substances causing adverse effects in therapeutic use; only includes adverse effects with correct dosing; dosing errors are captured under accidental poisonings); a full list of Y codes is available online	No; re-classified	Adverse effects of medical treatment

*In GBD methodology, class 1 garbage codes include all garbage codes for which a Level 1 GBD cause (ie, communicable, maternal, neonatal, and nutritional diseases; injuries; and non-communicable diseases) cannot be directly assigned. †Accidental poisonings in people aged 15 years or older are redistributed into the following substance use disorders: alcohol use disorders; cocaine use disorders; other drug use disorders; opioid use disorders; and amphetamine use disorders. For people younger than 15 years, accidental poisoning codes are redistributed across several different causes, including but not limited to poisoning-related causes. ‡Redistributed primarily into other injuries including: drowning; fire, heat, and hot substances; venomous animal contact; falls; pedestrian road injuries; physical violence; pulmonary aspiration and foreign body in airway; motor vehicle road injuries; other unintentional injuries; poisoning by other means; adverse effects of medical treatment; motorcyclist road injuries; environmental heat and cold exposure; other transport injuries; cyclist road injuries; non-venomous animal contact; physical violence by firearm; unintentional firearm injuries; poisoning by carbon monoxide; physical violence by sharp object; foreign body in other body part; and other exposure to mechanical forces; depending on age group of the decedent and GBD super-region.

Table 1: **ICD-10 codes relevant to poisoning, their classification or redistribution in GBD 2023, and their inclusion status for this study**

reported alongside 95% UIs. Trends over time were calculated as the percentage change in absolute numbers and rates between 1990 and 2023.

We derived case fatality using modelled deaths divided by modelled incidence (counts) for each GBD super-region, sex, and unintentional poisoning cause. We compared derived case fatalities in 1990 and 2023. Case fatality was derived because directly measured case fatalities are not globally available. Because GBD 2023 models deaths and non-fatal incidence independently, this measure should not be interpreted as observed patient-level clinical fatality; it is a model-derived fatality indicator that might reflect differences in exposure severity, access to acute care, surveillance, care-seeking behaviour, incidence ascertainment, and data completeness. Point estimates were calculated directly from the GBD mean estimates. We propagated uncertainty using a Monte Carlo simulation approach. We inferred log-normal parameters from the GBD-reported 95% UIs and generated 10 000 draws for deaths and incidence. We computed case fatality for each draw as deaths divided by incidence (counts), truncated to the plausible range (0–1). We reported the mean and 95% UI across draws. Derived case fatalities are presented as percentages.

GBD 2023 complies with the Guidelines for Accurate and Transparent Health Estimates Reporting (appendix 1 p 4).[18] The original GBD 2023 analyses were completed using Python versions 3.8.17 and 3.10.4, Stata version 15.1, and R versions 3.5 and 4.2. The statistical code used in GBD 2023 is publicly available online.

For the **full list of Y codes** see https://icd.who.int/browse10/2019/en#/Y40

For the **GBD 2023 statistical code** see http://ghdx.healthdata.org/gbd-2023/code

Role of the funding source

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

Results

Summary

Globally, in 2023, unintentional poisoning accounted for 69 805 deaths (95% UI 54 280 to 91 617) and

	Deaths in 2023 (95% UI)	Change in age-standardised death rate, 1990–2023 (%)	Incidence in 2023 (95% UI)	Change in age-standardised incidence rate, 1990–2023 (%)	DALYs in 2023 (95% UI)	Change in age-standardised DALY rate, 1990–2023 (%)
Unintentional poisonings						
Global	**69 805 (54 280–91 617)**	**–45·4 (–60·1 to –18·2)**	**2 540 083 (2 093 595–3 173 462)**	**–36·9 (–38·0 to –35·7)**	**3 680 683 (2 808 575–5 003 439)**	**–47·5 (–63·5 to –16·4)**
Central Europe, eastern Europe, and central Asia	6801 (6146–7371)	–63·7 (–67·0 to –59·8)	301 627 (247 058–376 258)	–34·7 (–37·6 to –32·3)	311 811 (285 072–338 113)	–64·5 (–67·5 to –61·0)
High income	3010 (2659–3360)	–60·0 (–65·3 to –54·3)	888 320 (734 969–1 086 288)	–22·9 (–23·8 to –22·0)	265 699 (214 227–323 730)	–47·7 (–53·1 to –42·7)
Latin America and Caribbean	1793 (1597–1992)	–62·7 (–68·1 to –55·7)	268 951 (213 734–342 908)	–23·7 (–25·8 to –21·4)	134 887 (116 494–155 465)	–58·1 (–63·9 to –51·2)
North Africa and Middle East	4544 (3183–6527)	–60·2 (–76·2 to –27·2)	121 354 (94 976–158 730)	–29·8 (–32·2 to –27·1)	266 442 (186 686–390 360)	–62·8 (–78·0 to –30·0)
South Asia	10 365 (6629–16 085)	–37·7 (–66·9 to 46·2)*	156 798 (118 593–209 973)	–26·1 (–29·2 to –23·3)	578 538 (370 221–907 663)	–42·9 (–69·6 to 38·3)*
Southeast Asia, east Asia, and Oceania	24 119 (18 747–29 134)	–41·0 (–59·0 to –17·7)	579 026 (478 958–724 303)	–10·6 (–14·0 to –7·4)	959 116 (761 106–1 140 521)	–48·9 (–63·5 to –29·1)
Sub-Saharan Africa	19 171 (12 087–29 713)	–34·6 (–63·4 to 38·3)*	224 007 (169 073–293 668)	–30·2 (–32·5 to –28·3)	1 164 191 (714 279–1 872 271)	–40·2 (–68·0 to 27·2)*
Poisoning by carbon monoxide						
Global	**30 890 (24 383–39 850)**	**–53·8 (–64·3 to –37·2)**	**641 932 (453 035–876 401)**	**–31·9 (–34·0 to –29·7)**	**1 343 965 (1 067 027–1 804 089)**	**–58·2 (–68·9 to –40·4)**
Central Europe, eastern Europe, and central Asia	6611 (5969–7195)	–60·5 (–64·1 to –56·2)	111 500 (81 261–143 213)	–31·0 (–34·1 to –28·1)	266 738 (241 535–290 579)	–63·2 (–66·8 to –59·2)
High income	2410 (2110–2694)	–36·4 (–45·6 to –23·3)	170 878 (114 768–237 218)	–19·2 (–22·4 to –15·8)	113 828 (100 826–129 103)	–37·0 (–45·3 to –24·4)
Latin America and Caribbean	651 (549–768)	–31·4 (–42·6 to –14·6)	39 343 (23 903–60 842)	–21·5 (–27·5 to –12·9)	35 281 (29 827–42 034)	–34·7 (–45·3 to –19·0)
North Africa and Middle East	3084 (1943–4485)	–47·2 (–70·4 to –3·4)	40 647 (26 871–58 911)	–8·8 (–14·1 to –2·3)	166 361 (102 888–247 482)	–51·4 (–73·3 to –8·6)
South Asia	3706 (1918–6750)	3·7 (–59·7 to 256·5)*	40 959 (24 746–63 113)	–25·8 (–30·7 to –20·9)	203 092 (106 773–371 061)	–7·0 (–65·5 to 228·0)*
Southeast Asia, east Asia, and Oceania	13 124 (9416–18 129)	–48·7 (–64·8 to –16·8)	193 170 (140 236–254 203)	11·5 (4·9 to 20·3)*	484 532 (355 030–669 165)	–57·6 (–70·6 to –30·3)
Sub-Saharan Africa	1304 (496–3697)	–31·9 (–78·0 to 135·2)*	45 434 (29 636–65 551)	–19·3 (–24·6 to –13·2)	74 134 (29 739–203 054)	–38·7 (–79·7 to 100·2)*
Poisoning by other means						
Global	**38 914 (24 516–55 813)**	**–36·7 (–61·5 to 14·5)***	**1 898 151 (1 504 312–2 384 568)**	**–38·5 (–39·6 to –37·2)**	**2 336 718 (1 620 221–3 392 488)**	**–39·0 (–63·2 to 11·7)***
Central Europe, eastern Europe, and central Asia	190 (150–242)	–90·0 (–92·4 to –87·1)	190 127 (143 286–246 727)	–36·5 (–39·9 to –33·6)	45 073 (31 298–59 053)	–70·1 (–76·0 to –64·3)
High income	601 (495–720)	–84·9 (–87·9 to –81·7)	717 442 (589 722–874 676)	–23·7 (–24·7 to –22·7)	151 871 (106 995–203 310)	–53·8 (–60·2 to –48·0)
Latin America and Caribbean	1142 (997–1349)	–70·3 (–75·6 to –62·9)	229 607 (181 176–296 604)	–24·0 (–26·6 to –21·4)	99 606 (83 975–118 681)	–62·9 (–69·0 to –55·2)
North Africa and Middle East	1460 (669–2728)	–74·0 (–86·4 to –42·4)	80 707 (60 399–107 141)	–37·2 (–40·1 to –34·1)	100 081 (50 102–179 016)	–73·2 (–85·1 to –42·3)
South Asia	6659 (3672–10 605)	–48·9 (–73·8 to 17·1)*	115 838 (85 010–155 732)	–26·2 (–29·5 to –23·0)	375 446 (217 438–598 459)	–52·6 (–76·4 to 9·0)*
Southeast Asia, east Asia, and Oceania	10 995 (6045–14 484)	–28·3 (–69·5 to 23·9)*	385 857 (304 054–489 865)	–18·9 (–22·3 to –15·7)	474 584 (289 637–632 498)	–35·3 (–68·8 to 10·3)*
Sub-Saharan Africa	17 866 (10 941–27 848)	–34·8 (–64·0 to 36·9)*	178 573 (134 116–238 911)	–32·4 (–34·9 to –30·3)	1 090 057 (652 188–1 768 654)	–40·3 (–68·2 to 27·3)*

These estimates represent GBD-defined unintentional poisoning (ie, carbon monoxide and poisoning by other means) and do not capture all unintentional poisonings as defined in national surveillance systems. Poisoning by other means mainly captures pesticide poisonings by direct assignment. DALYs=disability-adjusted life-years. UI=uncertainty interval. *Estimate is highly uncertain, with a very wide uncertainty interval driven by sparse input data in some regions and should not be interpreted as a directional trend.

***Table 2*: Deaths, incidence, and DALYs from unintentional poisoning, expressed as numbers (for 2023), and percentage change in age-standardised rates (1990–2023), overall (ie, all GBD-defined poisonings) and by subcause**

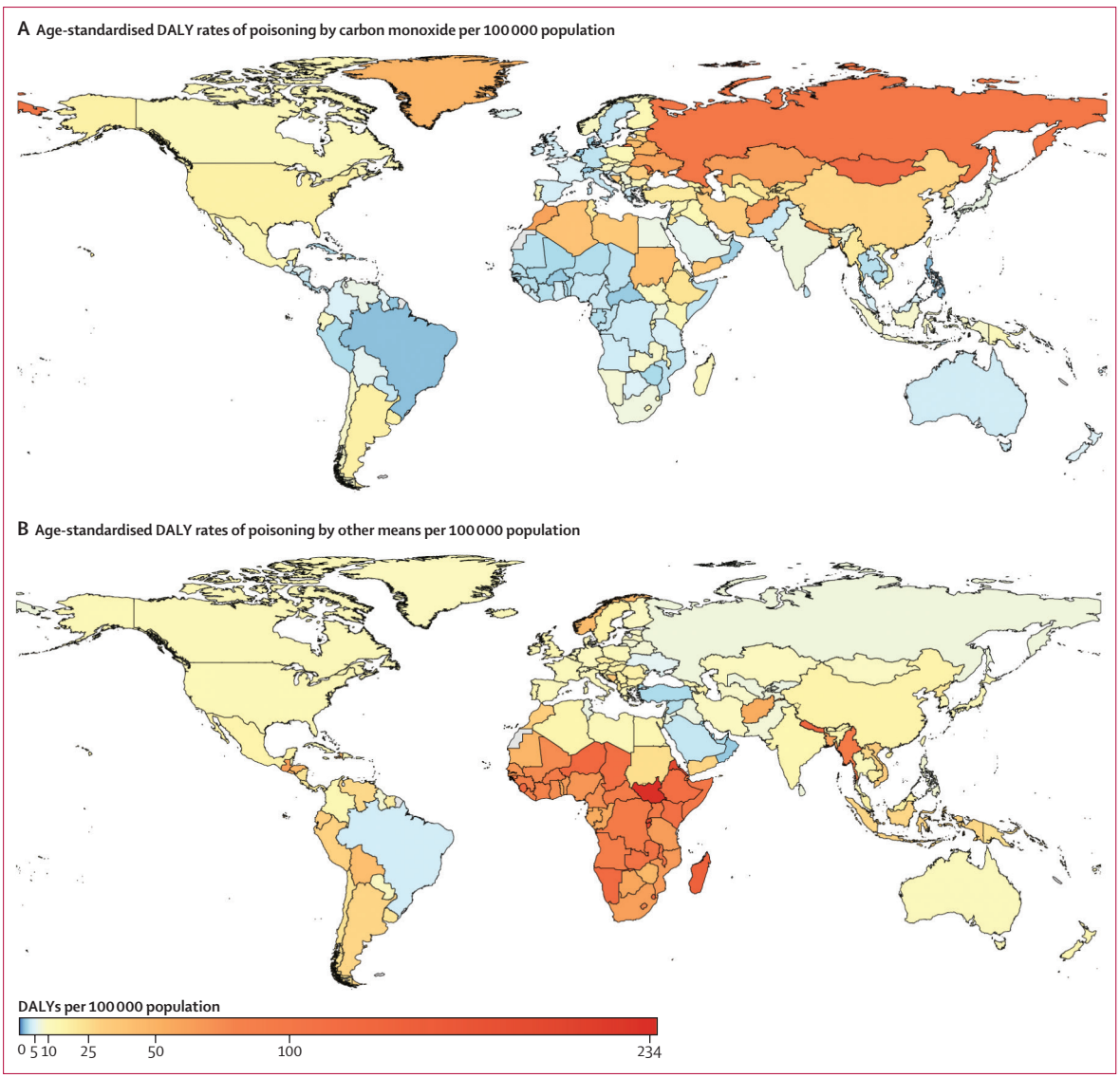


Figure 1: **Age-standardised DALYs per 100 000 for unintentional poisoning (both sexes and all ages), by subtype in 2023**
(A) Poisoning by carbon monoxide. (B) Poisoning by other means. Poisoning by other means is largely informed by pesticide poisoning codes, but also includes deaths reassigned through the GBD re-distribution process. DALY=disability-adjusted life-year.

3 680 683 DALYs (2 808 575 to 5 003 439), or 46·7 DALYs per 100 000 (35·0 to 64·2; table 2; appendix 2 pp 5–13, 83–84). Sub-Saharan Africa had the highest rate of DALYs from unintentional poisoning in 2023 at 96·8 DALYs per 100 000 (95% UI 62·2 to 148·3), whereas Latin America and the Caribbean had the lowest rates at 23·0 DALYs per 100 000 (19·9 to 26·3). Between 1990 and 2023, global DALY rates from unintentional poisoning decreased by 47·5% (95% UI –63·5 to –16·4). The largest decrease was seen in central Europe, eastern Europe, and central Asia (–64·5% [95% UI –67·5 to –61·0]). There was no clear change in sub-Saharan Africa (–40·2% [95% UI –68·0 to 27·2; ie, with a UI spanning zero]; table 2). For numbers and rates of deaths, incidence, and DALYs, by super-region and country, see appendix 2 (pp 5–13). For time trends, between 1990 and 2023, by GBD super-region and country, see appendix 2 (pp 14–34, 85–86). For age-specific rates and numbers of deaths, incidence, and DALYs, see appendix 2 (pp 35–37). The highest rates of DALYs globally were seen in infants younger than 1 year (190·4 DALYs per 100 000 [95% UI 97·4 to 368·6]), with males having higher rates than females across all age bands (appendix 2 p 37).

See **Online** for appendix 2

Because carbon monoxide and other poisonings have distinct determinants, risk profiles, and geographic patterns, the remainder of the results focus on these two subcauses, analysed separately. Summary estimates

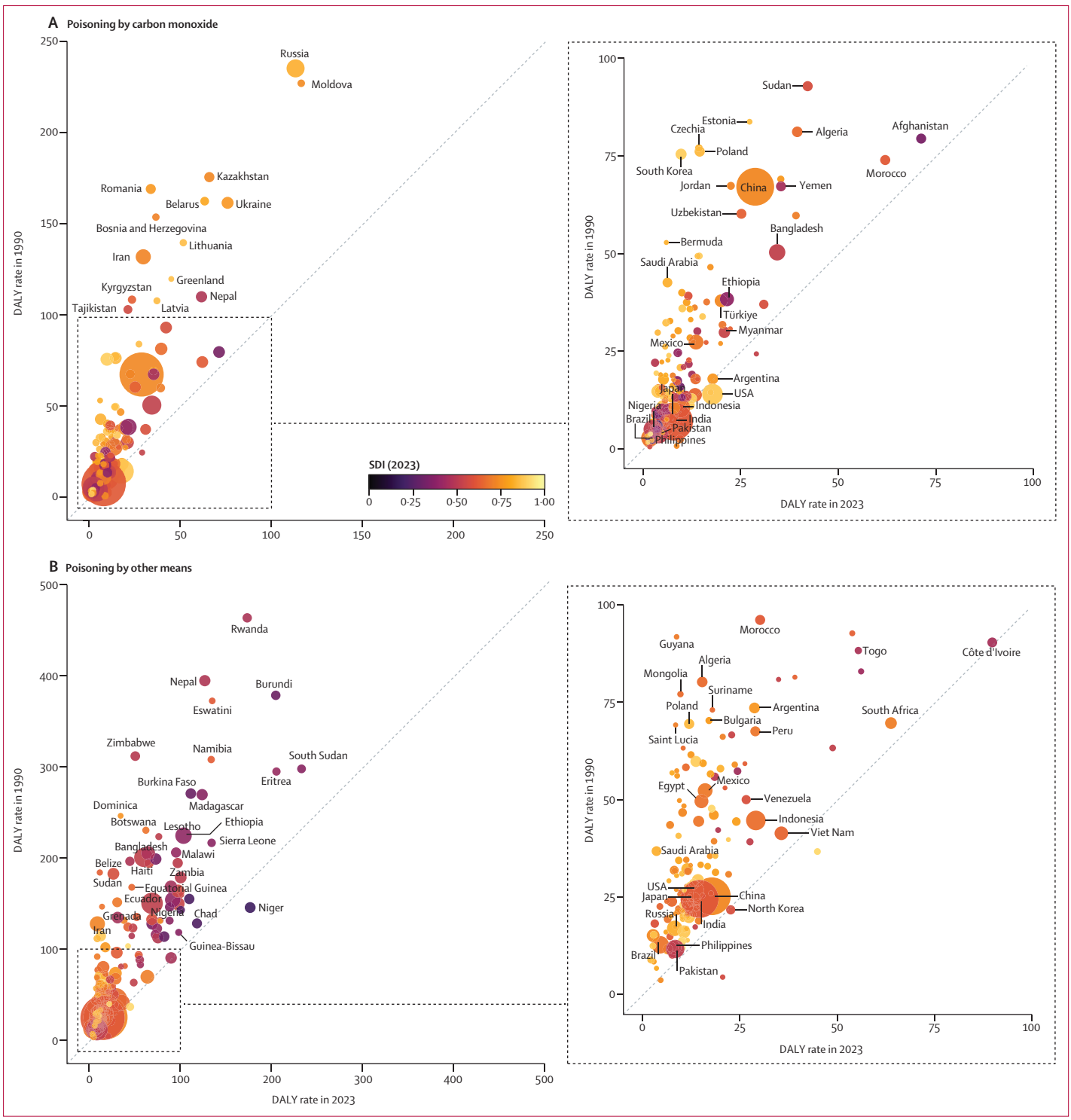


Figure 2: **Unintentional poisoning, comparing DALYs per 100 000 from 1990 and 2023 (both sexes and all ages)**
(A) Poisoning by carbon monoxide. (B) Poisoning by other means. Zoomed insets on right show countries clustered in the lower left corner. Bubbles are coloured by SDI (2023 value) and bubble size scales relative to 2023 population size. Poisoning by other means is largely informed by pesticide poisoning codes, but also includes deaths reassigned through the GBD re-distribution process. Not shown on graph (outside of axis limits): carbon monoxide poisoning DALYs in Mongolia (810 DALYs per 100 000 in 1990; 122 DALYs per 100 000 in 2023). DALY=disability-adjusted life-year. SDI=Socio-demographic Index.

for total unintentional poisonings are reported in appendix 2 (pp 5–37, 82–91, 104).

Unintentional poisoning with carbon monoxide: trends over time, by region and SDI

Globally, in 2023, there were 30 890 deaths (95% UI 24 383 to 39 850), 1 343 965 DALYs (1 067 027 to 1 804 089), and 16·4 DALYs per 100 000 (12·9 to 22·4) due to unintentional poisoning with carbon monoxide. DALYs for poisonings with carbon monoxide were highest in central Europe, eastern Europe, and central Asia (56·8 DALYs per 100 000 [95% UI 51·5 to 62·0]), and the lowest in Latin America and the Caribbean (6·0 DALYs per 100 000 [5·0 to 7·2]; table 2; figure 1A).

Globally, DALYs from unintentional carbon monoxide poisoning have decreased substantially since 1990 (table 2; figure 2A; appendix 2 pp 91–92). DALY rates decreased by 58·2% (95% UI –68·9 to –40·4), with central Europe, eastern Europe, and central Asia having the biggest percentage decrease (–63·2% [–66·8 to –59·2]; table 2). These trends are largely reflected in deaths (appendix 2 pp 89, 92). Trends in incidence of unintentional carbon monoxide poisoning show decreases in most parts of the world, but increases in east Asia, Oceania, Andean Latin America, southern Latin America, and the Caribbean (appendix 2 pp 90, 93). When analysed by SDI, high and high-middle SDI quintiles had the biggest decreases in deaths and DALYs (figure 2; appendix 2 pp 89, 91). Deaths, incidence, and DALY rates from carbon monoxide poisoning by country are provided in appendix 2 (pp 38–58).

Unintentional poisoning with carbon monoxide: age and sex patterns

DALYs from carbon monoxide poisoning were highest in adult males (figure 3C). Deaths and incidence followed markedly different distributional patterns, across both geography and by age (figure 3). Deaths from carbon monoxide occurred most frequently in male individuals, and rates were highest in older adults, particularly those older than 80 years (figure 3A). In contrast, incidence of poisoning with carbon monoxide was highest in female individuals, particularly the age groups of 10–14 years and 15–19 years (figure 3B). When DALYs were broken down by GBD super-region, age, and sex, trends differed with sub-Saharan Africa and south Asia having a much greater male-to-female ratio than other regions; and high-income regions, and central Europe, eastern Europe, and central Asia having more pronounced peaks in DALYs among male adults (appendix 2 p 94). This was mirrored in deaths estimates (appendix 2 p 95). Incidence estimates showed greater incidence in people younger than 40 years, except for the southeast Asia, east Asia and Oceania super-region where older adults had the highest incidence of carbon monoxide poisoning (appendix 2 p 96).

Unintentional poisoning with carbon monoxide: case fatality

The overall derived case fatality for unintentional poisoning with carbon monoxide was 5·51% (95% UI 3·71 to 8·43) in 1990 and 4·81% (3·28 to 7·43) in 2023. There was substantial regional disparity in case fatality, with high-income countries having the lowest case fatality in 2023 (1·41% [95% UI 0·98 to 2·11]) and south Asia having the highest (9·05% [4·11 to 19·46]; appendix 2 p 80). Global case fatality from unintentional carbon monoxide poisoning in 2023 was higher for male individuals (7·00% [95% UI 4·95 to 11·17]) than female individuals (2·71% [1·45 to 4·66]). A full breakdown by sex, region, and year is provided in appendix 2 (pp 80, 102).

Unintentional poisoning by other means (largely informed by pesticide poisoning codes): trends over time, by region and SDI

Globally, in 2023, there were 38 914 deaths (95% UI 24 516 to 55 813), 2 336 718 DALYs (1 620 221 to 3 392 488), and 30·3 DALYs per 100 000 (20·5 to 44·8) from unintentional poisoning by other means (which predominantly captures pesticides by direct assignment). The highest rates of DALYs were seen in sub-Saharan Africa (89·8 per 100 000 [55·8 to 138·5]), and the lowest were in the GBD high-income super-region (13·1 DALYs per 100 000 [9·2 to 17·7]; table 2; figure 1B).

DALY rates from poisoning by other means changed by –39·0% (95% UI –63·2 to 11·7 [ie, with a UI spanning zero]) between 1990 and 2023, with decreases seen in the majority of countries and regions (table 2; figure 2B; appendix 2 pp 73–79). North Africa and the Middle East had the biggest decrease in DALY rates (–73·2% [95% UI –85·1 to –42·3]), whereas sub-Saharan Africa and southeast Asia, east Asia and Oceania had unclear directional trends, with UIs spanning zero (–40·3% [–68·2 to 27·3] and –35·3% [–68·8 to 10·3], respectively; table 2). When stratified by SDI, the countries with the highest SDIs had the largest annualised decreases in DALYs between 1990 and 2023 (figure 2; appendix 2 p 91). Similarly, death rates decreased globally over the same time period, with the highest rates of decreases in age-standardised death rates in central Europe, eastern Europe, and central Asia, high-income regions, and the North Africa and the Middle East super-region (appendix 2 pp 89, 97). Incidence decreased globally and across SDIs (appendix 2 pp 90, 98). Deaths, incidence, and DALY rates from poisoning by other means, by country are provided in appendix 2 (pp 59–79).

Unintentional poisoning by other means (largely informed by pesticide poisoning codes): age and sex patterns

Infants younger than 1 year dominated DALYs for unintentional poisoning by other means, with male individuals predominating (figure 3C). Conversely, incidence rates were typically higher in female

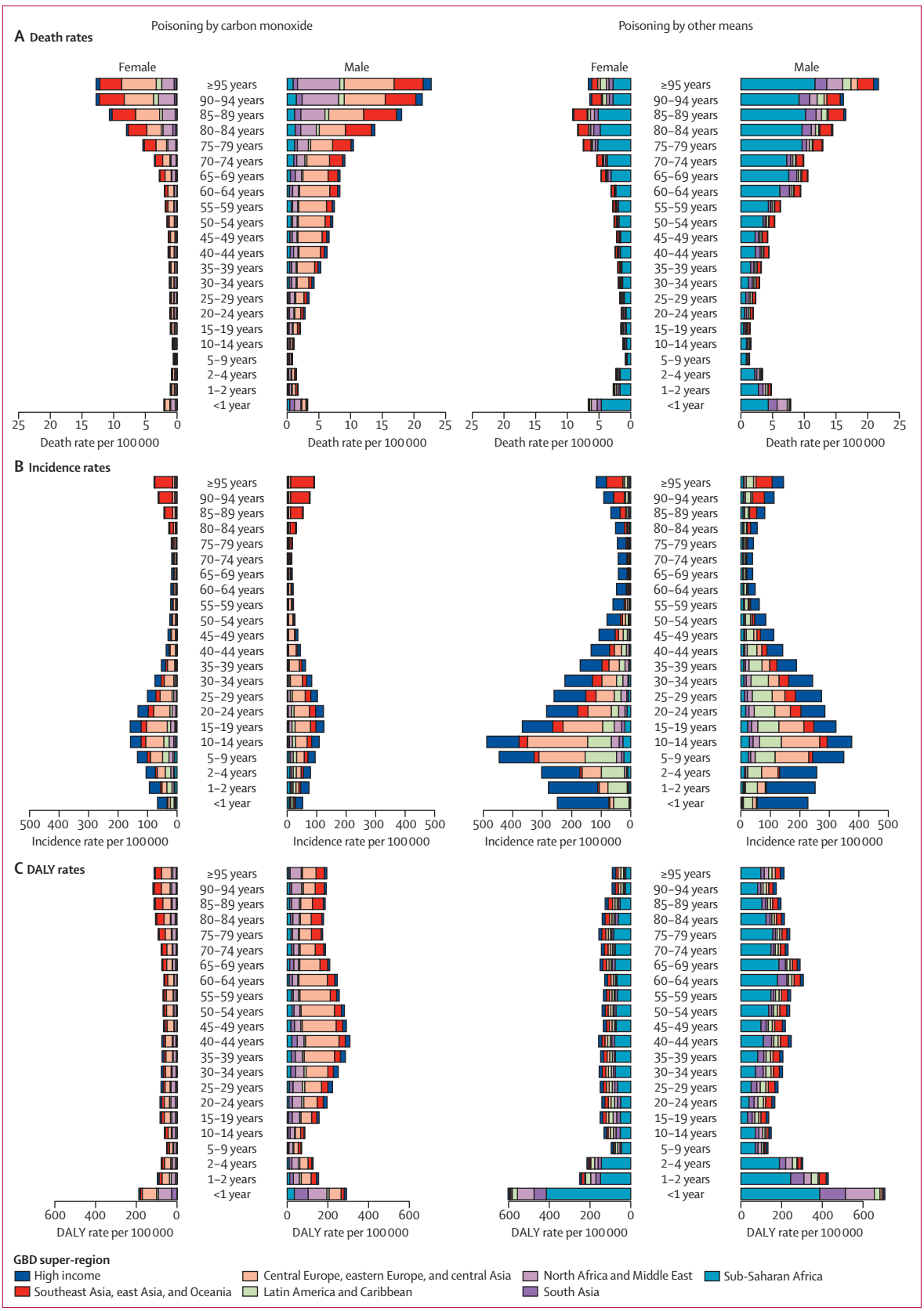


Figure 3: **Unintentional poisoning from carbon monoxide and other means, by age, sex, and GBD super-region in 2023**
(A) Death rates. (B) Incidence rates. (C) DALY rates. Poisoning by other means is largely informed by pesticide poisoning codes, but also includes deaths reassigned through the GBD re-distribution process. DALY=disability-adjusted life-year.

individuals, and the peak was in children aged 10–14 years (figure 3B). Deaths from unintentional poisoning by other means were highest in male individuals, with peak rates showing a bimodal distribution, first peaking in early childhood (ie, aged <5 years), dropping in later childhood or adolescence, and then climbing again through adulthood (figure 3A). Deaths and incidence showed different patterns across regions and age groups. When broken down by GBD super-region, age and sex patterns revealed substantial burdens in terms of deaths and DALYs in sub-Saharan Africa compared with all other regions (appendix 2 pp 99–100). In contrast, incidence estimates show diverse patterns. In the high-income regions, the highest rates were observed in children younger than 2 years (particularly boys), whereas in the central Europe, eastern Europe, and central Asia super-region, and Latin America and the Caribbean super-region, the highest rates were in older children (aged 5–14 years; appendix 2 p 101).

Unintentional poisoning by other means (largely informed by pesticide poisoning codes): case fatality

The overall derived case fatality for unintentional poisoning by other means was 1·77% (95% UI 1·06 to 2·79) in 1990 and 2·05% (1·22 to 3·16) in 2023 (appendix 2 p 81). The lowest 2023 case fatality was observed in high-income regions (0·08% [95% UI 0·06 to 0·11]) and central Europe, eastern Europe, and central Asia (0·10% [0·07 to 0·15]), with sub-Saharan Africa having the highest case fatality in 2023 (10·01% [5·62 to 16·85]). Case fatality was higher for male individuals (2·54% [95% UI 1·40 to 4·29]) than female individuals (1·56% [0·81 to 2·78]). A full breakdown by sex, region, and year is provided in appendix 2 (pp 81, 103).

Discussion

Between 1990 and 2023, the global burden of GBD-defined unintentional poisoning declined substantially. This GBD cause captures poisoning by carbon monoxide and poisoning by other means, the latter directly assigned from pesticide poisoning codes but not synonymous with all pesticide or chemical poisonings. Our estimates should therefore not be interpreted as representing all accidental, pharmaceutical, alcohol, or illicit drug poisonings, adverse drug reactions, or poisonings with undetermined intent. Within the GBD-defined scope, we found large decreases in DALY and death rates; however, marked regional variation and sociodemographic inequalities persisted. The clearest evidence for burden decline was for carbon monoxide poisoning. Poisonings by other means also declined in many regions, but remained concentrated in settings with lower sociodemographic development in 2023.

Unintentional poisoning with carbon monoxide is largely preventable. The long-term decline in deaths, incidence, and DALYs from carbon monoxide poisoning observed in most regions is a positive finding, and has also been documented in many single-country studies.[19–22] Although GBD estimates are descriptive and cannot establish causality, this decline is consistent with global progress through layered prevention, including increased use of carbon monoxide alarms,[20] detoxification of the domestic gas supply, changing fuel sources for indoor heating,[19,21,23] and emissions controls for cars.[24] However, prevention gains from some exposure pathways can coexist with emerging or episodic risks from others. The increases in deaths and DALYs (appendix 2 pp 89–91) observed in high-income north America highlight the continuing importance of prevention strategies addressing severe weather, power disruption, generator use, and household ventilation.[25] Carbon monoxide poisoning incidence peaked in individuals aged 10–40 years, whereas mortality increased with age, consistent with greater vulnerability to hypoxic stress among older adults and people with underlying cardiovascular disease.[26] Exposure circumstances probably also differ by age; we hypothesise that younger individuals are more likely to be exposed in occupational settings where early detection is more likely, compared with domestic exposures in older adults. Male individuals had disproportionately higher mortality and DALY rates despite similar sex-specific incidence, which might reflect differences in exposure circumstances, occupational risks, care-seeking behaviours, or classification of intent.

Many countries have moved to ban or restrict highly toxic pesticides, an approach associated with declining poisoning fatalities.[27] Most published evidence focuses on intentional poisonings;[28,29] however, these measures also affect unintentional poisonings. For example, in the USA, serious unintentional poisonings from pesticides have been declining over the past few decades, with the steepest declines seen for highly toxic agents, including paraquat, organophosphates, carbamates, and strychnine (all decreasing by over 60% between 1995 and 2004). These agents were largely withdrawn from domestic use, phased out, and reformulated. In comparison, exposures to pyrethroids (which are far less toxic) only declined by 3% over the same period.[30] Similarly, restrictions on dangerous organophosphate, paraquat, and diquat sales in Japan were introduced to address intentional self-poisoning, but were also associated with a steep decline (83·8%) in unintentional pesticide poisoning deaths.[31] Pesticide bans have been associated with reductions in poisonings and deaths elsewhere, including Sri Lanka[32] and Ireland.[33]

Despite these gains, there are stark inequalities in the burden of poisoning by other means, a GBD category that contains pesticide poisoning codes by direct assignment. There is a disproportionate burden in lower-SDI regions, particularly sub-Saharan Africa, which had high DALY rates and high derived case fatality. Pesticide markets in Africa have rapidly expanded in the past few decades, with agricultural intensification, falling prices of pesticides, rising costs of hand-weeding, and the introduction of new pests.[34] Extensive use of hazardous pesticides has been

recorded, including in domestic settings,[34,35] and a recent systematic review revealed that half of all surveyed pesticide applicators in Africa store pesticides in their living rooms—a major risk for childhood poisoning.[36] Some countries have banned highly hazardous pesticides (eg, paraquat) but enforcement is inconsistent, and labelling and packaging are sometimes inadequate.[35] Occupational risk is heightened by unsafe handling practices and inadequate control measures.[34,36] High death rates in sub-Saharan Africa are probably influenced by agent toxicity and access to emergency and critical care.[37] However, derived case fatality should be interpreted cautiously because regional differences might also partly reflect sparse non-fatal data and differences in care-seeking behaviour, incidence ascertainment, and surveillance completeness.

Differences between GBD estimates and previous global estimates of pesticide poisoning also reflect divergent case definitions, data sources, and modelling approaches. A now-retracted 2020 systematic review estimated 385 million annual cases of acute unintentional pesticide poisonings globally, and 11 000 fatalities. The paper was retracted primarily due to concerns over how the non-fatal estimate was generated: the fatality estimate was not mentioned in the retraction note.[38] We report 38 914 deaths coded as poisoning by other means, which includes pesticide deaths by direct assignment plus some other deaths by redistribution. Differences between these estimates probably reflect differences in case definitions, underlying data sources, and modelling methodologies. In particular, the retracted paper relied heavily on the WHO Mortality Database, with data for many countries lacking the granular ICD-10 coding needed to ascertain accidental pesticide deaths.

Unintentional poisoning and suicide prevention are closely intertwined. Several interventions discussed above were introduced primarily to reduce intentional self-poisoning or environmental exposure but might also reduce accidental poisoning burden. Conversely, interventions aimed at improving air quality and reducing the risk of unintentional poisoning from carbon monoxide[39] have reduced carbon monoxide suicide.[4] These dual benefit interventions manifest differently by region. For example, carbon monoxide poisoning has historically been a common suicide method in high-income settings, whereas in low-income and middle-income countries, pesticide exposure represents a major driver of intentional self-harm. The implications of public health interventions on the combined burden of intentional and accidental injury vary substantially by regional context.

Apart from carbon monoxide, GBD cause hierarchy does not resolve specific poisoning agents, so other means cannot be disaggregated into individual substances. Although pesticide ICD codes contribute directly to this category, the underlying cause group also includes deaths reassigned through GBD garbage-code redistribution, a process that varies considerably by region.[15] Consequently, the results largely reflect patterns of carbon monoxide and pesticide poisoning, particularly in lower-SDI settings where these exposures remain common.

Importantly, many forms of poisoning are not included within the GBD unintentional poisoning cause hierarchy. This is best shown in countries experiencing rising mortality from pharmaceuticals and illicit drugs. Official rates of unintentional poisoning deaths in the USA (per 100 000 population, all ages) have climbed from 2·3 per 100 000 in 1990 to 29·9 per 100 000 in 2023.[40] In comparison, GBD unintentional poisoning estimates in the USA have remained essentially unchanged (0·49 to 0·44 per 100 000). Under the current GBD cause hierarchy, most drug overdose deaths are classified within substance use disorders rather than unintentional poisoning, which explains the divergence between national surveillance categories and GBD injury estimates. Accordingly, GBD estimates for substance use disorder deaths in the USA increased from 5·2 per 100 000 in 1990 to 35·8 per 100 000 in 2023. Therefore, in high-income settings, particularly north America, declining or stable GBD unintentional poisoning estimates should not be interpreted as evidence that the poisoning burden is well controlled overall, because contemporary pharmaceutical, alcohol, and illicit drug poisonings, and poisonings with undetermined intent are largely captured outside the GBD poisoning cause used in this analysis. These are distinct and important poisoning mechanisms.

These classification decisions are embedded in the GBD cause hierarchy and redistribution algorithms and could not be changed for this analysis, but they should be reviewed in future GBD iterations. This would align with the commitment to disaggregation of suicide by other means to capture poisoning mechanisms, as previously signalled by the GBD collaborators.[41] If intentional poisonings are disaggregated from suicide, and unintentional poisonings are disaggregated from substance use disorder, this would allow these types of poisoning to be studied together, as in previous GBD work on firearms.[42]

There is an intrinsic difficulty in assigning intent for poisoning events, as this requires contextual information, which is often unavailable, particularly in fatal cases. In settings with weak death-registration and medico-legal investigation systems, some intentional self-poisoning might be misclassified as unintentional. This is compounded by the effect of social stigma, religious considerations, and legal implications associated with suicide, which can lead to under-reporting of intentional poisoning and code-shifting to unintentional poisoning. This might lead to overestimation of unintentional poisonings in jurisdictions where suicide is stigmatised or criminalised.[43] This is particularly important for low-income and middle-income countries, especially where

pesticide self-poisoning is a leading suicide method. This is most consequential for the regions with the least complete vital registration and should be borne in mind when interpreting regional differences.

Data availability and quality vary by region and over time. The GBD framework relies exclusively on external-cause codes to define poisonings (eg, ICD-9 E codes and ICD-10 X codes), without using the T codes, which describe the nature of the injury and often provide richer information on the specific agent involved. Ideally, a combination of external cause codes with nature-of-injury T codes would be used to gain insight into the substance and intent behind poisonings. However, T codes cannot be used to assign intent (a requirement of GBD algorithms), and global coverage of T-code capture is poor and uneven.[44]

For data-sparse locations, the use of CODEm and predictive covariates represents a strength of the GBD methodology, as it allows for the generation of global estimates in regions where primary mortality data records are lacking in detail or coverage. However, this reliance on modelling is also a limitation, as estimates in these areas are driven by ecological associations with factors such as health-care access and socioeconomic development rather than direct observations.

The 100-times higher incidence of early childhood poisoning in high-income regions relative to some other regions is very unlikely to represent a real difference of that magnitude in the incidence of childhood poisoning. Furthermore, the incidence of poisoning by other means in girls younger than 1 year in sub-Saharan Africa is similar to the death rate for poisoning by other means, suggesting the hospital and death data might be in conflict. There are very few data in this region at this level of granularity to inform estimates, resulting in increased uncertainty.

The increase in global case fatality for poisoning by other means between 1990 and 2023 should be interpreted cautiously. Although deaths declined over this period, case fatality can rise when modelled incidence declines proportionally faster than modelled mortality. Several factors might contribute to this pattern. First, there might have been changes in the composition of exposures captured within the broad other means category over time, although this appears less likely given evidence of declining pesticide lethality in other studies.[28] Second, deaths and incidence are modelled independently in the GBD framework, meaning derived case fatality estimates carry additional uncertainty and might show counterintuitive trends. Third, differential ascertainment of non-fatal poisonings across time and between SDI levels might influence both temporal trends and observed regional case fatality gradients. Incidence estimates are likely to be systematically better captured in high-SDI settings that show lower derived case fatality. Consequently, apparent differences in case fatality cannot be fully disentangled from differences in data capture and reporting practices and should be interpreted alongside the uncertainty surrounding the underlying incidence and mortality estimates.

Our findings have implications for equity, policy, and adaptation. Mortality and DALY rates were consistently higher in low-SDI settings, and derived case fatality was markedly elevated, probably reflecting systemic differences in poisoning exposures, regulation, timely access to emergency care, and data capture. These disparities point to several practical, scalable interventions. Enforcement of bans on highly toxic pesticides remains one of the most effective levers for preventing lethal poisonings. Broader poisoning prevention also requires safer storage and packaging of pharmaceuticals and household chemicals, particularly to prevent childhood exposures.[45] WHO emphasises that every country should have access to at least one poison centre as part of core poisoning safety and emergency response capacity, yet fewer than half of WHO Member States currently have access to a poison centre.[46] Strengthening poison centres and bedside clinical toxicology capacity remains a cornerstone for improving survivability globally. However, the efficacy of enhanced clinical management is limited in the context of the most toxic agents, where exposures are frequently fatal irrespective of the quality of medical care, emphasising the ongoing role for bans. Poison centres also collect valuable toxicovigilance data, which could be incorporated into GBD estimates. In high-income settings, widespread adoption of carbon monoxide detectors and regulatory mandates for installation continue to be low-cost, high-impact measures. Together, these strategies show how investments in regulation, safer product design, and clinical toxicology infrastructure can offer a pathway to reducing poisoning deaths and addressing persistent global inequities.

Over the past three decades, GBD-defined unintentional poisoning due to carbon monoxide and other means has declined globally. This progress is consistent with the benefits of layered public health measures and regulation that have created safer environments for many. However, stark disparities remain, with burden remaining concentrated in regions with lower SDIs. These deaths are largely preventable and highlight the need to sustain proven measures for reducing carbon monoxide poisoning and expand bans on highly hazardous pesticides. Most other forms of poisoning remain poorly measured from a global perspective; and prioritising which should be targeted with similar interventions is difficult. Improving data quality and granularity would allow detection of emerging poisoning threats, evaluation of policy impacts, and evidence-based prevention strategies.

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Please see appendix 3 (pp 23–31) 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, corresponding, and senior authors had full access to the data in the study and had final responsibility for the decision to submit for publication.

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Data sharing

To download citations and metadata for the input data sources used in the GBD 2023 analyses presented in this study, please visit the GBD 2023 Sources Tool at https://ghdx.healthdata.org/gbd-2023/sources.

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